

A review of Cuvier's beaked whale strandings in the Mediterranean Sea

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ABSTRACT

Cuvier's beaked whale (*Ziphius cavirostris*) is the only species of beaked whale commonly found in the Mediterranean Sea, a deep, semi-enclosed basin. Beaked whales are generally an offshore family often found in association with the canyons and steep escarpments common to the area. Much of the current knowledge of this species has been derived from strandings data. Historically, strandings data for the Mediterranean Sea has been collected by individual researchers and more recently, over the last two decades, by national strandings networks. We reviewed strandings data collected by strandings networks from Italy, Greece, Spain and France. Additionally, we compiled strandings information gleaned from the literature, personal communications, regional newspapers and the world wide web from countries that border the Mediterranean Sea. While this review is certainly not exhaustive, it has allowed the creation of an extensive geo-referenced basin wide database using a geographic information system (GIS) of over 300 stranding events. The acquired data permit documentation of the number of mass stranding events, allow general observations about distribution and chronology of stranding events dating back to 1803 and enables evaluation of strandings based on several different criteria. The first recorded mass stranding event was in 1963 off Genova, Italy. Analysis shows that specific geographic stranding areas can be identified, even though the level of effort undertaken in the different countries may vary.

KEYWORDS: CUVIER'S BEAKED WHALE; STRANDINGS; EUROPE; MEDITERRANEAN SEA; DISTRIBUTION

INTRODUCTION

Cuvier's beaked whale (*Ziphius cavirostris*) is a pelagic, deep-diving species and the only beaked whale commonly found in the Mediterranean Sea (Notarbartolo di Sciara and Demma, 1994). The species was first described by G. Cuvier, using a partial skull collected in 1803 near Fos-sur-Mer, on the Mediterranean coast of France (Cuvier, 1823). Beaked whales generally live offshore (although see Ferguson *et al.*, 2006) and are often associated with regions characterised by canyons or steep escarpments (Heyning, 1989), as typically found in this basin.

In recent years, sightings of Cuvier's beaked whales have been reported more frequently in some areas of the Mediterranean, such as the Ligurian Sea (Ballardini *et al.*, 2005), where studies of habitat use and diving behaviour have also been carried out (Azzellino *et al.*, 2003; Johnson *et al.*, 2004).

The Mediterranean Sea is an elongated semi-enclosed deep basin that is virtually landlocked. It is divided into two sub-basins, linked via the Sicilian Channel, whose shallow depth separates the hydrological and ecological conditions of the two sub-basins. The external exchanges of the sub-basins are with each other, with the Atlantic Ocean via the Straits of Gibraltar on the western side and with the Black Sea via the Dardanelles and Bosphorus Straits on the eastern side. Elevated chlorophyll-a concentrations related to coastal upwelling and mesoscale features characterise the western basin, while the eastern basin is influenced by cyclonic and anticyclonic patterns (Crise *et al.*, 1999).

Although mass strandings of this species are not usual (e.g. Heyning, 1989; Brownell *et al.*, 2006), in the last fifteen years, several authors have suggested that some atypical beaked whale mass stranding events have been associated with naval activities (Simmonds and Lopez-Jurado, 1991; D'Amico and Verboom, 1998; Frantzis, 1998 and Frantzis, 2004; Anon., 2001; Martín, 2002; Freitas, 2004; Martín *et al.*, 2004, Fernández *et al.*, 2004). Assessing the cause and mitigating against any impacts is currently limited by the lack of scientific knowledge of beaked whale physiology, behaviour, distribution and habitat use (Cox *et al.*, 2006).

This paper reviews and documents Cuvier's beaked whale stranding events recorded in the Mediterranean Sea, including those that may not have been previously reported in the literature, i.e. those only available in relatively inaccessible sources (e.g. national stranding networks, local museums archives and newspapers). Inconsistencies between references for the same event reported in different papers are discussed in order to give certainty and avoid errors and duplication of data. Anomalous stranding patterns for the Mediterranean Sea have been identified, but the causes of these strandings are beyond the scope of this paper. Cox *et al.* (2006) provide a good review of that subject.

While this review has probably not resulted in a definitive list, given the limited verification available for some records, we believe it is the most complete list of Cuvier's beaked whale strandings now available for the Mediterranean Sea. This database is a subset of the

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Mediterranean and Black Sea Cetacean database developed within the North Atlantic Treaty Organisation (NATO) Undersea Research Centre's (NURC), Sound Ocean and Living Marine Resources (SOLMAR) project, which contains sighting and stranding data for all species commonly found in the Mediterranean Sea (Fossati *et al.*, 1999).

METHODS

Data collection and georeferencing

Stranding data were acquired from a variety of sources. A review was conducted of stranding data collected by the Italian (CSC – Centro Studi Cetacei: yearly reports 1986-2003), Greek (ARION – Cetacean Rescue and Rehabilitation Research Society and DELPHIS – Hellenic Cetacean Research and Conservation Society: Drougas, 1996; 1998; Drougas and Komnenou, 2001; unpublished data for years 2001-03) and French (CRMM – Centre de Recherche sur les Mammifères Marins, La Rochelle: 1971-2003) national stranding networks. Additionally, stranding information was compiled from scientific literature, personal communications and archives, regional newspapers and the World Wide Web from the 20 countries that border the Mediterranean Sea. The data listed in Table 1 contain stranding information until December 2003. Bycaught and dead animals found floating in the open sea are also included.

The database includes information (when available) about the number of animals, the species, size and sex, the status observed when the animals were found (alive, dead, level of decay), any injuries observed on bodies, the presumed cause of death and the treatment and release condition in cases of animals found alive. Additional information related to the location of biological samples (tissue, skeletons, etc.) and the final disposition of the bodies is included. The Italian historical literature was verified with additional information available from the Italian Museums.

All data have been georeferenced; in many cases the exact latitude and longitude was not known so the geo-referenced location of the beach, village, or town where the stranding occurred was used. Datasets were then transferred to a Geographic Information System (*ESRI ArcView 8*) for validation of locations and display. The coastline and bathymetric data used for the Mediterranean Sea is the IBCM bathymetric contours distributed by the British Oceanographic Data Centre (BODC, UK).

Data analysis

Mass strandings are defined as two or more animals that are not a cow-calf pair (Geraci and Lounsbury, 1993). Potential mass strandings may often be recorded as isolated events if animals do not come ashore in close proximity. Mass strandings in the last decade, however, have demonstrated that a single mass stranding event may occur over several days and be spread over many miles of coastline (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998 and Frantzis, 2004; Anon., 2001; Martín, 2002; Freitas, 2004).

For this analysis, each mass stranding originally reported as one event, even if carcasses were found spread over many miles of coast, was retained (e.g. Tortonese, 1963). In some cases, some 'single' stranded animals were reclassified into one mass stranding event, based on the spread of the May 1963 mass stranding described by Tortonese (1963), the morphology of the coastline and the direction of the surface currents.

Mass stranding events were separated into two categories, stranding events with two animals and stranding events with three or more animals. Distances between stranded animals were calculated based on the GIS display. Strandings resulting from fishery bycatches were identified and were not included in the calculation of mass stranding of three or more animals. Due to the unreliability of data on level of decay, in only a few cases were we able to use this information to increase the confidence that the single strandings were likely related or not.

RESULTS

A total of 232 stranding events representing 316 animals was reported, based on analysis of the accumulated beaked whale stranding records (Table 1), with eight events (9 animals) lacking sufficient documentation and not included in the other tables and maps. For all the stranding events combined, 132 animals were able to be categorised by sex (71 females, 61 males). Table 1 contains a chronological list of all stranding events with mass stranding events indicated by total number of animals (≥ 2) and date range, where applicable. Original source references documenting each stranding event are also included. The corresponding locations of all Cuvier's beaked whale strandings in the Mediterranean Sea are shown in Fig. 1.

In addition to Cuvier's beaked whale, four *Mesoplodon* specimens have been reported stranded in the Mediterranean Sea. One animal reported as Sowerby's beaked whale (*M. bidens*) stranded in Italy in 1927 (Brunelli and Fasella, 1928) but it was not preserved, and no clear species description was given. Based on the morphological description provided, it was certainly not a Cuvier's beaked whale ['the teeth are not on the tip of the lower jaw']. Another stranding that occurred in Italy in 2001 was the first finding of a Gervais' beaked whale (*M. europaeus*) for Mediterranean waters (Podesta *et al.*, 2005). A Sowerby's beaked whale stranded in Greece in 1989 (Drougas and Komnenou, 2001) and a Blainville's beaked whale (*M. densirostris*) stranded in Spain in 1980 (Casinos and Filella, 1981; Grau *et al.*, 1986). Given the focus of this paper and their limited presence, all *Mesoplodon* spp. events have been excluded from the present analysis and are not incorporated into Table 1.

Stranding events were reported for Albania, Algeria, Croatia, Egypt, France, Greece, Israel, Italy, Malta, Spain and Turkey. No strandings are known for Cyprus, Lebanon, Libya, Monaco, Morocco, Slovenia, Syria, Tunisia or Yugoslavia. Table 2 shows the number of events, number of animals, and associated percentages by country, with 15 stranding events of two animals (three of which were bycatch) and 12 events of three or more animals. Mass strandings of three or more animals by area and date are listed in Table 3 and the detailed location of each event is shown in Figs 2 and 3. Fig. 4 shows the number of animals stranded in five years intervals along with the total number of strandings of three or more animals. Fig. 5 shows the monthly distribution of the individual strandings.

The analysis of historical literature performed for this paper, together with cross-referencing and examining specimens held by regional museums, clarified a number of inconsistent reports from earlier papers. For example, Paulus (1962) described a stranding event that occurred in Livorno around 1871, reporting that the skeleton was preserved in the Pisa Museum. Richiardi (1873), cited in Paulus (1962) was never published, but two unpublished tables from Richiardi with specimen drawings were

Table 1
Chronological list of Cuvier's beaked whale strandings. *Indicates bycatch.

ID	Date range	No. of animals	Country	References	ID	Date range	No. of animals	Country	References
1	1803	1	France	Cuvier (1823); Vinciguerra (1926); Paulus (1962)	114	6 Jul. 1989	1*	Italy	Centro Studi Cetacei (1991)
2	19 Sep. 1823	1	Italy	Richiardi (1875)	115	15 Jul. 1989	1	Italy	Centro Studi Cetacei (1991)
3	23 Sep. 1840	1	Italy	Cocco (1846); Bauer (1978)	116	29 Jul. 1989	1*	Italy	Centro Studi Cetacei (1991)
4	1842	1	France	Vinciguerra (1926); Paulus (1962)	117	13 Aug. 1989	1*	Italy	Centro Studi Cetacei (1991)
5	15 May 1850	1	France	Vinciguerra (1926); Paulus (1962)	118	14 Aug. 1989	1*	Italy	Centro Studi Cetacei (1991)
6	1866	1	France	Vinciguerra (1926); Paulus (1962)	119	13 Mar. 1990	1	Italy	Centro Studi Cetacei (1992)
7	1867	1	Italy	Giglioli (1880); Carruccio (1913)	120	1 Jun. 1990	1	Spain	Borrell <i>et al.</i> (2000)
8	4 Sep. 1878	1	France	Giglioli (1880); Vinciguerra (1926); Paulus (1962)	121	5 Jul. 1990	1*	Italy	Centro Studi Cetacei (1992)
9	15 Aug. 1879	1	France	Paulus (1962)	122	13 Dec. 1991	1	Spain	Borrell <i>et al.</i> (2000)
10	15 Oct. 1889	1	France	Paulus (1962)	123	24 Jan. 1992	3	Italy	Centro Studi Cetacei (1995)
11	24 Sep. 1900	1	Italy	Mezzana (1900); Vinciguerra (1926); Paulus (1962)	124	4 Feb. 1992	1	Italy	Centro Studi Cetacei (1995)
12	9 Sep. 1913	1	France	Vinciguerra (1926); Paulus (1962)	125	21 May 1992	1	Italy	Centro Studi Cetacei (1995)
13	15 Dec. 1918	1	Spain	Aguilar-Amat (1918); Casinos and Vericad (1976)	126	26 Aug. 1992	1*	Italy	Centro Studi Cetacei (1995)
14	3 Mar. 1919	1	Spain	Cabrera (1919); Casinos and Vericad (1976)	127	12 Oct. 1992	1	Italy	Centro Studi Cetacei (1995)
15	25 May 1919	1*	Spain	Cabrera (1919); Casinos and Vericad (1976)	128	7 Dec. 1992	1	Greece	Drougas and Kommenou (2001)
16	13 Nov. 1925	1	Italy	Vinciguerra (1926); Paulus (1962); Arbocco (1969)	129	21 Mar. 1993	1	Greece	Drougas and Kommenou (2001)
17	21 Aug. 1927	1	France	Paulus (1962)	130	20 Apr. 1993	3	Greece	Drougas and Kommenou (2001)
18	1930-1940	1	Italy	Littardi <i>et al.</i> (2004)	131	15 Jun. 1993	1	Italy	Centro Studi Cetacei (1996)
19	24 Nov. 1931	1	France	Paulus (1962)	132	10 Nov. 1993	1	Italy	Storelli <i>et al.</i> (1999)
20	1933	1*	Algeria	Boutiba (1994)	133	11 Nov. 1993	1	Greece	Drougas and Kommenou (2001)
21	11 Dec. 1934	1*	Italy	Tortonese (1957); Paulus (1962); Arbocco (1969)	134	19-20 Nov. 1993	2	Greece	Drougas and Kommenou (2001)
22	1938	1	Algeria	Boutiba (1994)	135	8-9 Feb. 1994	2	Greece	Drougas and Kommenou (2001)
23	8 Oct. 1939	1	Croatia	Hirtz (1940); Holcer <i>et al.</i> (2004)	136	28 Feb. 1994	1	Italy	Centro Studi Cetacei (1996)
24	5 Jun. 1940	1	Spain	A. Canadas (Alnitak) (pers. comm.)	137	13 Apr. 1994	1	Italy	Centro Studi Cetacei (1996)
25	18 Nov. 1940	1	Spain	Casinos and Vericad (1976)	138	15 Jul. 1994	1	Turkey	Ozturk and Ozturk (1998)
26	16 Mar. 1943	1	Spain	Casinos and Vericad (1976)	139	6 Aug. 1994	1*	Italy	Centro Studi Cetacei (1996)
27	29 Jan. 1944	1	Spain	Casinos and Vericad (1976)	140	11 Aug. 1994	1*	Italy	Centro Studi Cetacei (1996)
28	5 Jun. 1944	1	Spain	Casinos and Vericad (1976)	141	21 Nov. 1994	1	Algeria	Boutiba <i>et al.</i> (1997)
29	5 Sep. 1944	1*	Spain	Casinos and Vericad (1976)	142	14 Jan. 1995	1	Greece	Drougas and Kommenou (2001)
30	1945	1	Israel	Marchessaux (1980)	143	8 Feb. 1995	1	Greece	Drougas and Kommenou (2001)
31	15 Sep. 1954	1	Greece	Kinzelbach (1985)	144	1 Jun. 1995	1*	Italy	Centro Studi Cetacei (1997)
32	18 Sep. 1955	1	Italy	Tortonese (1957); Paulus (1962)	145	3 Jun. 1995	1*	Italy	Centro Studi Cetacei (1997)
33	28 Dec. 1956	1*	Italy	Tortonese (1957); Paulus (1962); Arbocco (1969)	146	5 Jun. 1995	1*	Italy	Centro Studi Cetacei (1997)
34	9 Feb. 1957	1	Italy	Tortonese (1957); Paulus (1962); Arbocco (1969)	147	15 Jun. 1995	1	Turkey	Ozturk and Ozturk (1998)
35	9 Mar. 1957	1*	Italy	Tamino (1957)	148	3 Dec. 1995	1	Malta	F. Bowman and S. Muscat (pers. comm.)
36	1958	1	Italy	Littardi <i>et al.</i> (2004)	149	3 Feb. 1996	1	Greece	Drougas and Kommenou (2001)
37	16 Mar. 1961	1	France	Paulus (1962)	150	3 Feb. 1996	1	Italy	Centro Studi Cetacei (1997)
38	30 Mar.-2 Apr. 1961	2	Italy	Paulus (1962)	151	25-26 Feb. 1996	2	Spain	Blanco <i>et al.</i> (1997); Blanco and Raga (2000)
39	10 Jun. 1961	1	France	Paulus (1962)	152	12 Apr. 1996	2	Greece	Drougas and Kommenou (2001)
40	15 Jul. 1961	1	Italy	Paulus (1962)	153	19 Apr. 1996	1	Italy	Centro Studi Cetacei (1997)
41	15-20 Jul. 1961	2	France	Paulus (1962)	154	12-13 May 1996	14	Greece	Frantzis (1998); Lefkaditou and Pouloupoulos (1998); Drougas and Kommenou (2001)
42	7 Nov. 1961	1	Spain	Casinos and Vericad (1976)	155	15 May 1996	2*	Greece	Drougas and Kommenou (2001)
43	24 Nov. 1961	1	France	Paulus (1962)	156	28 May 1996	1	Greece	Drougas and Kommenou (2001)
44	5 Jan. 1963	1	Italy	Littardi <i>et al.</i> (2004)	157	12 Jun. 1996	1	Greece	Drougas and Kommenou (2001)
45	13 Jan. 1963	1	Italy	Littardi <i>et al.</i> (2004)	158	16 Aug. 1996	2	France	Oliver <i>et al.</i> (1997); Van Canneyt <i>et al.</i> (1998)
46	Jan.-Feb. 1963	5	Italy	Tortonese (1963)					

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ID	Date range	No. of animals	Country	References	ID	Date range	No. of animals	Country	References
47	11 May 1963	15	Italy	Tortonese (1963)	159	18 Aug. 1996	1	Italy	Centro Studi Cetacei (1997)
48	9 Nov. 1963	15	Italy	Anon. (1963); Littardi <i>et al.</i> (2004)	160	18 Dec. 1996	1*	Italy	Centro Studi Cetacei (1997)
49	10 Nov. 1963	1	Israel	Marchessaux (1980)	161	22 Dec. 1996	1	France	Oliver <i>et al.</i> (1997); Van Canneyt <i>et al.</i> (1998)
50	1963	2*	Greece	Marchessaux and Duguay (1978); Marchessaux (1980)	162	27 Jan. 1997	1	France	Oliver and Rigollet (1998); Collet <i>et al.</i> (1999); Frodello <i>et al.</i> (2002)
51	8 Mar. 1964	1	Turkey	Marchessaux and Duguay (1978); Marchessaux (1980)	163	18 Mar. 1997	1	Greece	Drougas and Kommenou (2001)
52	20 Apr. 1964	1	Italy	Cagnolaro (1965); Arbocco (1969)	164	12 Apr. 1997	1	Spain	A. Cañadas (Aliniak) (pers. comm.)
53	15 Aug. 1964	1	Spain	Casinos and Vericad (1976)	165	14 Apr. 1997	1*	Greece	Drougas and Kommenou (2001)
54	1964-1965	1	Italy	Littardi <i>et al.</i> (2004)	166	15 Apr. 1997	1	Turkey	Ozturk and Ozturk (1998)
55	7 Apr. 1965	1	Spain	Casinos and Vericad (1976)	167	24 Apr. 1997	1	Greece	Drougas and Kommenou (2001)
56	10 Apr. 1965	1	Greece	Kinzelbach (1985)	168	27 May 1997	1	Spain	A. Cañadas (Aliniak) (pers. comm.)
57	26 Dec. 1965	1*	Greece	Kinzelbach (1985)	169	18 Jun. 1997	1	Greece	Drougas and Kommenou (2001)
58	15 Jul. 1966	1	Israel	Marchessaux (1980)	170	28 Jul. 1997	1	Greece	Drougas and Kommenou (2001)
59	15 Nov. 1966	3	Italy	Littardi <i>et al.</i> (2004)	171	26 Aug. 1997	3	Greece	Drougas and Kommenou (2001)
60	1968	1	Greece	Kinzelbach (1985)	172	24 Sep. 1997	1	Italy	Centro Studi Cetacei (1998)
61	1968	1	Greece	Marchessaux and Duguay (1978); Marchessaux (1980)	173	26 Sep. 1997	1	Spain	A. Cañadas (Aliniak) (pers. comm.)
62	20 Mar. 1970	1*	Spain	Filella Cornado (1971); Casinos and Vericad (1976)	174	25 Oct. 1997	8	Greece	Drougas and Kommenou (2001)
63	22 Nov. 1971	1	France	Duguay and Budker (1972)	175	2-5 Oct. 1997	4	Greece	Drougas and Kommenou (2001)
64	15 Mar. 1972	1	Italy	Progetto Cetacei 1972-1985 (unpublished data)	176	3 Oct. 1997	1*	Italy	Centro Studi Cetacei (1998)
65	2 Jul. 1972	1	Spain	Casinos and Vericad (1976)	177	4 Oct. 1997	2	Greece	Drougas and Kommenou (2001)
66	29 Jan. 1973	1	Spain	Casinos and Filella (1975)	178	6-14 Oct. 1997	1	Greece	Drougas and Kommenou (2001)
67	15 Mar. 1973	1	Italy	Progetto Cetacei 1972-1985 (unpublished data)	179	14 Oct. 1997	1	Italy	Drougas and Kommenou (2001)
68	25 Mar. 1973	1	Spain	Casinos and Filella (1975); Filella Cornado (1976)	180	20 Oct. 1997	1	Greece	Centro Studi Cetacei (1998)
69	13 Jun. 1973	1	Spain	Casinos and Filella (1975)	181	25 Nov. 1997	1	Greece	Drougas and Kommenou (2001)
70	19 Dec. 1973	1	Spain	Casinos and Filella (1975)	182	13 Jan. 1998	1	Greece	Drougas and Kommenou (2001)
71	16-22 Dec. 1974	4	France	Duguay (1975); Viale (1975)	183	17 May 1998	1	Spain	A. Cañadas (Aliniak) (pers. comm.)
72	23 Oct. 1975	1	Albania	Lamani <i>et al.</i> (1976)	184	2 Oct. 1998	1	Greece	Drougas and Kommenou (2001)
73	15 Nov. 1975	1	France	Duguay (1976); Besson (1976)	185	5 Oct. 1998	1	Greece	Drougas and Kommenou (2001)
74	1975	1	Greece	Bauer (1978)	186	26 Nov. 1998	1	Spain	A. Cañadas (Aliniak) (pers. comm.)
75	15 Jul. 1976	1	Italy	Progetto Cetacei 1972-1985 (unpublished data)	187	14-16 Jan. 1999	3	Greece	Drougas and Kommenou (2001)
76	10 Apr. 1977	1	Algeria	Lioze (1980); Boutiba <i>et al.</i> (1997)	188	12 Mar. 1999	1	Italy	Centro Studi Cetacei (2001)
77	6 Oct. 1977	1*	France	Duguay (1978)	189	15 Mar. 1999	1	Israel	Goffman <i>et al.</i> (2000) (and ECS Newsletter)
78	22 May 1978	1	Algeria	Lioze (1980); Boutiba <i>et al.</i> (1997)	190	12 May 1999	1	Greece	Drougas and Kommenou (2001)
79	15 Jun. 1979	1	Israel	Marchessaux (1980)	191	21 May 1999	1	Italy	Centro Studi Cetacei (2001)
80	10 Nov. 1979	1	Algeria	Lioze (1980); Boutiba <i>et al.</i> (1997)	192	17 Jun. 1999	1	Spain	A. Cañadas (Aliniak) (pers. comm.)
81	10 Nov. 1979	1	Algeria	Lioze (1980); Boutiba <i>et al.</i> (1997)	193	23 Jun. 1999	1	Greece	Drougas and Kommenou (2001)
82	2 Dec. 1979	1	Spain	Grau <i>et al.</i> (1980)	194	30 Oct. 1999	1	Greece	Drougas and Kommenou (2001)
83	16 May 1981	1	Italy	Progetto Cetacei 1972-1985 (unpublished data)	195	3 Jan. 2000	1	Italy	Centro Studi Cetacei (2002)
84	9 Aug. 1981	1	Spain	Grau <i>et al.</i> (1986)	196	13 Feb. 2000	2*	Greece	Drougas and Kommenou (2001)
85	11 Oct. 1981	1	Spain	Grau <i>et al.</i> (1986)	197	15 Feb. 2000	1	Italy	Centro Studi Cetacei (2002)
86	4 Nov. 1981	1	Spain	A. Cañadas (Aliniak) (pers. comm.)	198	23 Feb. 2000	1	Greece	Drougas and Kommenou (2001)
87	15 Feb. 1982	1	Italy	Progetto Cetacei 1972-1985 (unpublished data)	199	30 Mar. 2000	1	Spain	A. Cañadas (Aliniak) (pers. comm.)
88	22 Apr. 1982	1	Spain	Raga <i>et al.</i> (1991)	200	1 Jun. 2000	1*	Greece	Drougas and Kommenou (2001)
89	8 Jul. 1982	1	Algeria	Boutiba (1994); Boutiba <i>et al.</i> (1997); Boutiba <i>et al.</i> (2001)	201	7 Feb. 2001	2	Algeria	Boutiba <i>et al.</i> (2001)
90	13 Sep. 1982	1	Turkey	Kinzelbach (1985)	202	5 Apr. 2001	1	Italy	Centro Studi Cetacei (2003)
91	18 May 1983	1	Italy	Cagnolaro <i>et al.</i> (1986)	203	12 Apr. 2001	1	Croatia	Holcer <i>et al.</i> (2004)
92	10 Nov. 1983	1	France	Duguay (1984); Oliver (1990)	204	19 Apr. 2001	2	Turkey	A.C. Gucu (pers. comm.)
93	22 Aug. 1984	1*	Italy	Progetto Cetacei 1972-1985 (unpublished data)	205	17 May 2001	1	Italy	Centro Studi Cetacei (2003)
94	2 Oct. 1984	1	France	Duguay (1985)		14 Jun. 2001	1	Italy	Centro Studi Cetacei (2003)

cont.

ID	Date range	No. of animals	Country	References	ID	Date range	No. of animals	Country	References
95	6 Nov. 1984	1	France	Duguy (1985)	206	Jun. 2001	1	Israel	Coffman O. (ECS Newsletter on line, Jun. 2001)
96	21 Nov. 1984	1	France	Duguy (1985)	207	12 Jul. 2001	1	Italy	Centro Studi Cetacei (2003)
97	8 Mar. 1985	1	Italy	Progetto Cetacei 1972-1985 (unpublished data)	208	23 Jul. 2001	2	Algeria	Boutiba <i>et al.</i> (2001)
98	30 Mar. 1985	1	Italy	Progetto Cetacei 1972-1985 (unpublished data)	209	25 Oct. 2001	1	Greece	Drougas and Komnenou (2001)
99	10 Sep. 1985	1	France	Duguy (1986)	210	2001	1	Spain	A. Cañadas (Almitak) (pers. comm.)
100	12 Feb. 1986	1	Italy	Progetto Cetacei 1972-1985 (unpublished data)	211	7 Feb. 2002	1	Croatia	Holcer <i>et al.</i> (2004)
101	22 May 1986	1*	Italy	Centro Studi Cetacei (1987)	212	3 Mar. 2002	1	Greece	Drougas and Komnenou (2001)
102	30 Jun. 1986	1	Spain	Raga <i>et al.</i> (1991)	213	26 Mar. 2002	1	Italy	Centro Studi Cetacei (2004)
103	15 Jan. 1987	1	Italy	Centro Studi Cetacei (1988)	214	12 Apr. 2002	1	Italy	Centro Studi Cetacei (2004)
104	10 Feb. 1987	2	Italy	Centro Studi Cetacei (1988); Podestà and Meotti (1991)	215	16 Apr. 2002	1	Greece	Arion/Delphis (Greece)
105	14 Feb. 1987	1	Italy	Centro Studi Cetacei (1988)	216	27 Apr. 2002	1	Greece	Arion/Delphis (Greece)
106	22 May 1987	1	Italy	Centro Studi Cetacei (1988)	217	17 May 2002	1	Greece	Arion/Delphis (Greece)
107	23 Sep. 1987	1	Algeria	Boutiba (1994); Boutiba <i>et al.</i> (1997)	218	1 Jun. 2002	1	Spain	A. Cañadas (Almitak) (pers. comm.)
108	9 May 1988	1	France	Duguy (1989)	219	3 Oct. 2002	1	Greece	Arion/Delphis (Greece)
109	15 Jul. 1988	1	Italy	Centro Studi Cetacei (1990)	220	14 Apr. 2003	1	France	Van Canneyt <i>et al.</i> (2004)
110	25 Jul. 1988	1*	Italy	Centro Studi Cetacei (1990)	221	24 Apr. 2003	1	France	Van Canneyt <i>et al.</i> (2004)
111	27 Sep. 1988	1*	Italy	Centro Studi Cetacei (1990)	222	24 Jun. 2003	1	Greece	Arion/Delphis (Greece)
112	22 Nov. 1988	1	Italy	Centro Studi Cetacei (1990); Carlini <i>et al.</i> (1992)	223	5 Nov. 2003	1	Greece	Arion/Delphis (Greece)
113	22 Jan. 1989	1	Spain	Borrell <i>et al.</i> (2000)	224	24 Dec. 2003	1	Italy	Centro Studi Cetacei Onlus e Museo Civico di Storia Naturale di Milano (2004)
Total = 307									
Incomplete data:									
	1913	1	Greece	Kinzelbach (1985)					
	1962	1	Greece	Kinzelbach (1985)					
	1963	1	Egypt	Marchessaux (1980)					
	1968	2	Spain	Vinciguerra (1926)					
	2001	1	France	Viale					
		1	Israel	Marchessaux (1980); Kinzelbach (1985)					
		1	France	Viale					
		1	Algeria	Boutiba <i>et al.</i> (2001)					

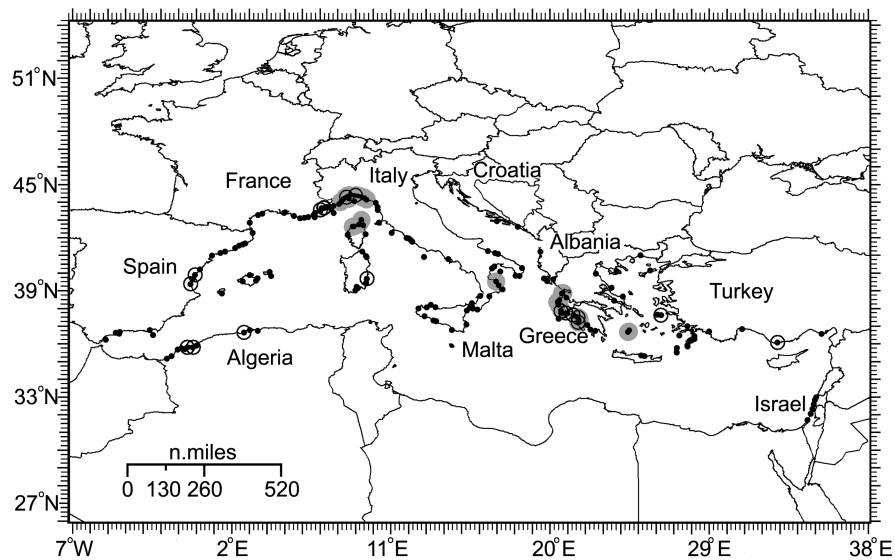


Fig. 1. Strandings recorded in the Mediterranean Sea (1803-2003). Open circles show strandings of two animals, grey circles show strandings of three or more animals.

Table 2

Number of animals and number of stranding events by Country. Numbers marked with (x) include bycatch. For stranding events with three or more animals, total animals are given in brackets. Other than those reported here, nine more animals have been found with incomplete data and were not included in the table.

Country	Total animals	Strandings (1 animal)	% of total	Strandings (2 animals)	% of total	Strandings (≥ 3 animals)	% of total
Italy	118	73 x	61.9	2	3.4	5 (41)	34.7
Greece	86	37 x	43	7 x	16.3	6 (35)	40.7
Spain	38	36 x	94.7	1	5.3		
France	34	26 x	76.5	2	11.8	1 (4)	11.8
Algeria	13	9 x	69.2	2	30.8		
Turkey	7	5	71.4	1	28.6		
Israel	6	6	100				
Croatia	3	3	100				
Albania	1	1	100				
Malta	1	1	100				
	307	197	64.2	15 (30)	9.8	12 (80)	26.1

available at the Pisa Museum. Physical verification of the skeleton confirmed that it belongs to an 1823 stranding reported by Richiardi in 1875 (Table 1, # 2). Paulus (1962) also reported a stranding in Beaulieu, Villafranca (France) on 23 June 1878. This stranding actually occurred on 4 September 1878 (Table 1, #8), as first published by Giglioli (1880) and Vinciguerra (1926).

In another example, Mezzana (1900) reported a specimen stranded in Varazze (Genova, Italy) (Table 1, # 11) as a '*Hyperoodon bidens*', and this report was subsequently repeated in Vinciguerra (1926) and Paulus (1962). However, both the description given, and examination of the skull preserved at the Museum of Natural History of Calci (Pisa) (Cagnolaro, 1996) confirm that this was a Cuvier's beaked whale.

A short report concerning historical strandings of Cuvier's beaked whales in the Ligurian Sea was presented to the International Commission for the Study of the Mediterranean Sea (ICSM-CIESM) by Littardi *et al.* (2004). In this paper, few original source references for these strandings were cited, with a significant amount of information derived from unlisted newspaper accounts. When possible, original source references were obtained to validate the events presented. This comparison of the data presented in Table 1 and in Littardi *et al.* (2004) highlights some reporting inconsistencies. Two strandings reported in 1956 over two subsequent days (28 and 29 December) at two different locations very close to each other, were actually the same animal (Table 1, # 33). Tortonese (1957) described the mistake made by a newspaper journalist at the time (dated 29 December) that reported the stranding at the incorrect location. Two strandings were listed for 1964, one of which was reported in Cagnolaro (1965) (Table 1, # 52), while the other was from a newspaper with no date. The

Table 3

Mass strandings of three or more animals. ID numbers refer to Table 1. Bycatch is not included.

ID	Map	Year	Date	Location	Country	Animals
46	A	1963	Jan.-Feb.	Ligurian Sea (Liguria)	Italy	5
47	B	1963	11 May	Ligurian Sea (Liguria)	Italy	15
48	C	1963	9 Nov.	Ligurian Sea (Liguria)	Italy	15
59	D	1966	15 Nov.	Ligurian Sea (Liguria)	Italy	3
71	E	1974	16-22 Dec.	Ligurian Sea (N. Corsica)	France	4
123	F	1992	24 Jan.	Ionian Sea (Calabria)	Italy	3
130	G	1993	20 Apr.	Ionian Sea (Kephalonia and Zakynthos Islands)	Greece	3
154	H	1996	12-13 May	Ionian Sea (Kyparissiakos Gulf)	Greece	14
171	I	1997	26 Aug.	Ionian Sea (Assos Island)	Greece	3
174	J	1997	2-5 Oct.	Ionian Sea (Kephalonia Island)	Greece	8
175	K	1997	3 Oct.	Ionian Sea (Lefkas Island)	Greece	4
186	L	1999	14-16 Jan.	Aegean Sea (Mylos Island)	Greece	3

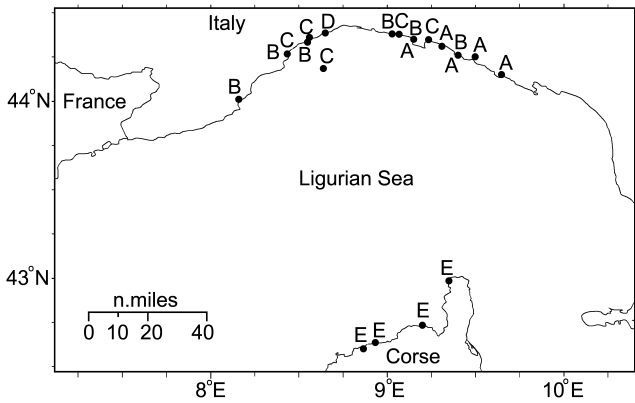


Fig. 2. Strandings occurred in the Ligurian Sea in years 1963-74. See Table 3 for details.

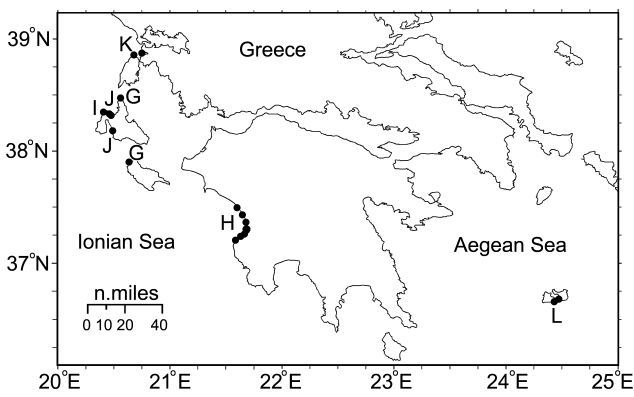


Fig. 3. Strandings occurred in Greek waters in years 1996-99. See Table 3 for details.

second reference source was rejected since it was felt that this was a duplicate report. Three live animals that stranded in Cogoleto (Genova) in 1966 were described as ‘disoriented’ (Table 1, # 59). Two were able to swim back toward the open sea, while the third was caught by fishermen, but eventually escaped after being wounded. This particular animal might have died and stranded later, but this cannot be confirmed (M. Rosso, pers. comm.). Furthermore, the authors postulate that five strandings could

be correlated with the presence of military ships in the area. Two of these five events involved a single specimen (5 and 13 January 1963: Table 1, #44, #45). For the mass stranding events listed in Littardi *et al.* (2004), some specimens were described as disoriented and others showed evidence of firearms wounds, although this cannot be confirmed as the cause of death (Anon., 1963).

Of the three Italian mass stranding events in 1963 (Table 1, #46, #47, #48), only two have been documented in the scientific literature (Tortonese, 1963). In addition, Tortonese provided some details of another mass stranding event that occurred in the same area earlier that year during ‘the end of January, the beginning of February’ (Table 1, #46). While searching newspaper accounts for reports about the 1963 stranding events, an additional mass stranding event was discovered in this same region on 9 November 1963 (Anon., 1963; Littardi *et al.*, 2004; Table 1, #48), probably after Tortonese’s paper was published. The newspaper account (Anon., 1963) describing this event contained pictures of the animals, which confirm these as Cuvier’s beaked whales.

DISCUSSION AND CONCLUSION

This review of Cuvier’s beaked whale strandings in the Mediterranean Sea has facilitated the creation of a comprehensive, geo-referenced database.

The geographic distribution of the data may suggest an abundance of this species in particular areas, such as the Ligurian and the Ionian Seas. However, the study effort along the Mediterranean coast is extremely variable by area and this must be taken into account in any analysis. While national networks have been operating in France and Italy for many decades, other countries also have historical reports, even if not organised at a national level (e.g. Spain). Many southern Mediterranean nations have only sporadic reports of strandings, with no methodical monitoring of their coasts. Stranding records date back to the beginning of the 19th century in Italy and France, while the first record in Spain is nearly a hundred years later. For other countries, records started within the first half of the 20th century.

Geo-referencing of the data shows that most strandings of Cuvier’s beaked whales occur near regions with steep bathymetry. This is consistent with sightings data for the same areas (Ballardini *et al.*, 2005; Azzellino *et al.*, 2003) for the Ligurian Sea. Despite the obvious limitations, the use

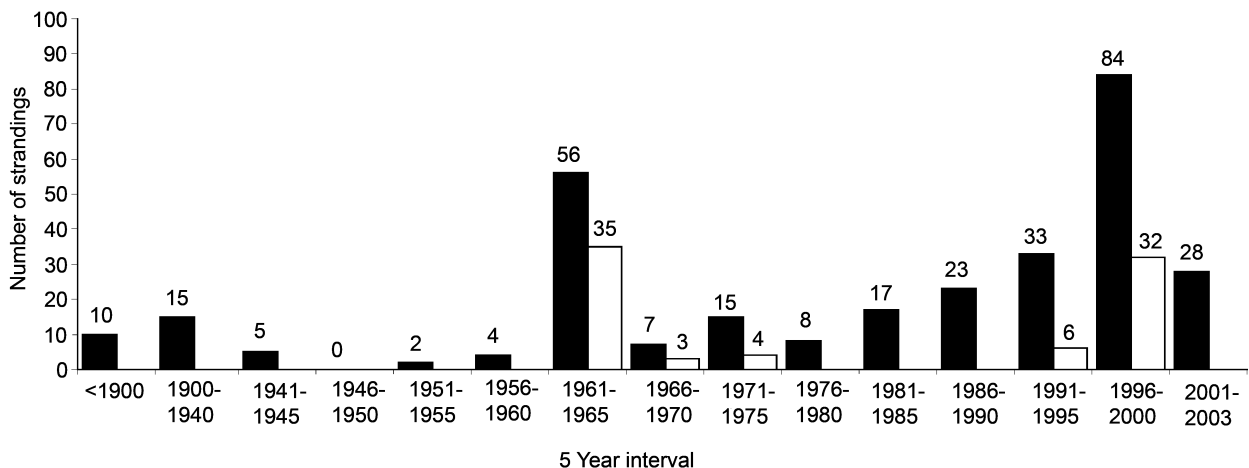


Fig. 4. Cuvier’s beaked whale strandings in the Mediterranean in five-year intervals, earliest year – 2003. Shaded columns show the total number of animals; white columns show the number of animals stranded in groups of 3 or more.

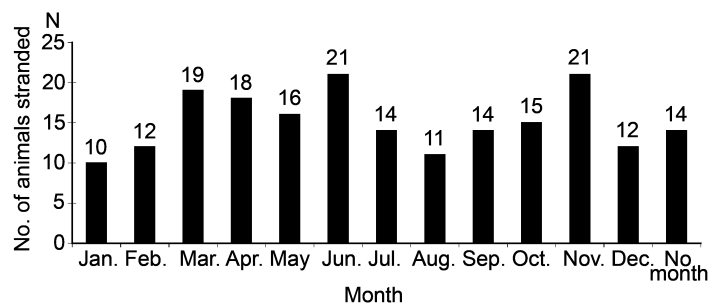


Fig. 5. Distribution of individual strandings by month.

and reliability of stranding records as a source of information on the occurrence of certain species in certain areas has been shown in a paper on the Hawaiian Islands *Odontocetes* (Maldini *et al.*, 2005).

The absence of strandings along the Italian Adriatic Sea coastline, despite relatively consistent effort along the Italian coast, may indicate that this is an area which these whales do not frequent; its shallow water depth is typically not considered a beaked whale habitat. However, the pronounced lack of strandings along the North African coast may be more likely connected to scarce effort than the steep bathymetry here, which suggests that it may be a suitable Cuvier's beaked whale habitat.

The first reported mass stranding in the Mediterranean area was in 1963 near Genova, Italy. We are confident that this event is the first mass stranding event for the Ligurian Sea, since single stranding events have been recorded in this region since 1823.

From the analysis of the percentages reported in Table 2, it can be shown that for Greece, strandings of three or more animals are nearly as likely as individual strandings. However, for Spain single strandings make up the majority (94.7%) and mass strandings of three or more have never been reported.

All mass strandings of three or more animals (Table 3) have occurred in the Ligurian Sea (Italy and France, Fig. 2), the Ionian Sea and the Aegean Sea (Greece, Fig. 3), accounting for 80 animals and representing 26% of the total number of the animals recorded for the whole Mediterranean area. Note that the May 1963 stranding in Italy (#B, Table 3) extends over more than 50 n.miles of coastline; however, this stranding was described as a single event in the first report by Tortonese (1963). Furthermore, since these strandings occurred on the same day along a coastline that forms a wide gulf on which carcasses can be spread out by counterclockwise currents documented for the Ligurian Sea, they have been maintained as a single mass stranding event.

The majority of the mass stranding events of three or more animals have occurred in the Ligurian Sea (Italy 4 events, France 1 event) and in the Ionian Sea (Greece 5 events). The mass stranding in the Ligurian Sea in 1963 is one of the first events reported worldwide. Notably, events in the Ligurian Sea occurred in the period 1963-74, while events in Ionian Sea occurred in years 1993-97.

The Greek mass stranding event in Kyparissiakos Gulf (#H, Table 3) of May 1996, consisting of 14 animals, was the first case reported in the Mediterranean Sea that was identified as being correlated in both space and time with sonar activities (D'Amico and Verboom, 1998; Frantzis, 1998 and Frantzis, 2004). Two more specimens found on 15 May were not included in the total for this mass stranding event because although the location of these animals was

close to Kyparissiakos Gulf, the stranding report documents that they were entangled alive in a fishing net and subsequently released.

The two Greek mass strandings in October 1997, listed as #J and #K in Table 3, totalled 12 animals, and could be considered a single event given that they took place in the same area (approximately 34 n.miles apart) and in the same time frame (within four days), with the majority of carcasses slightly decomposed. The data were directly collected by two of the authors of this paper (Drougas and Komnenou, 2001). Frantzis (2004) reported nine animals stranded in ten days for this event.

The analysis of the number of animals stranded in five-year intervals (Fig. 4) indicates an increase in the number of stranded animals during the last two decades. Given the increased worldwide interest in marine mammal stranding events, it cannot be determined whether this apparent trend is the result of improved reporting and record keeping, or an actual increase in stranding occurrence. The inclusion of infrequent mass stranding events that contain a large number of animals can influence the overall stranding trend suggested in Fig. 4. For instance, the anomalous peak in 1963 is due to three mass stranding events on the Ligurian coast (Tortonese, 1963; Anon., 1963), while another peak in 1996 and 1997 is due to two mass stranding events in Greece (D'Amico and Verboom, 1998; Frantzis, 1998 and Frantzis, 2004; Drougas and Komnenou, 2001).

The monthly distribution of individual strandings (Fig. 5) shows peaks in spring/early summer and in November. Unfortunately, these strandings data cannot be compared with sightings data because studies at sea of this species are primarily conducted in summer.

In recent years there has been increasing concern, in both the scientific and military communities, about the potential impacts of anthropogenic acoustic activities on beaked whales (Simmonds and Lopez-Jurado, 1991; Frantzis, 1998 and Frantzis, 2004; Anon., 2001; Martín, 2002; Freitas, 2004; Brownell *et al.*, 2004; Evans and Miller, 2004; Fernández *et al.*, 2004; Cox *et al.*, 2006). In the Mediterranean Sea, only one mass stranding out of a total of 12 can be unequivocally associated with naval activity, as the sonar activity and corresponding ship's tracks have been well documented (D'Amico and Verboom, 1998; Frantzis, 1998 and Frantzis, 2004). For other 'atypical' (*sensu* Frantzis and Cebrian, 1998) mass stranding events there is only anecdotal information about the presence of military ships in the same region (Anon., 1963; Littardi *et al.*, 2004). Better information would be valuable, if it could be provided by appropriate military authorities.

Further study is required to investigate the context of the mass strandings described here and to possibly link them to specific human activities. Nevertheless, the analyses presented here and the validated geo-referenced database

may be useful for predicting areas of Cuvier's beaked whale habitat in the Mediterranean Sea, in order to mitigate potential impacts of man-made noise, as recommended by ACCOBAMS Resolution 2.16 (ACCOBAMS, 2004).

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