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The fin whale *Balaenoptera physalus* (L. 1758) in the Mediterranean Sea

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ABSTRACT

1. The ecology and status of fin whales *Balaenoptera physalus* in the Mediterranean Sea is reviewed. The species' presence, morphology, distribution, movements, population structure, ecology and behaviour in this semi-enclosed marine region are summarized, and the review is complemented with original, previously unpublished data.

2. Although the total size of the fin whale population in the Mediterranean is unknown, an estimate for a portion of the western basin, where most of the whales are known to live, was approximately 3500 individuals. High whale densities, comparable to those found in rich oceanic habitats, were found in well-defined areas of high productivity. Most whales concentrate in the Ligurian-Corsican-Provençal Basin, where their presence is particularly noticeable during summer; however, neither their movement patterns throughout the region nor their seasonal cycle are clear.

3. Based on genetic studies, fin whales from the Mediterranean Sea are distinct from North Atlantic conspecifics, and may constitute a resident population, separate from those of the North Atlantic, despite the species' historical presence in the Strait of Gibraltar. Fin whales are known to calve in the Mediterranean, with births peaking in November but occurring at lower rates throughout the year. They feed primarily on krill *Meganyctiphanes norvegica* which they capture by diving to depths in excess of 470 m. It is suggested that the extensive vertical migratory behaviour of its main prey may have influenced the social ecology of this population.

4. Known causes of mortality and threats, including collisions with vessels, entanglement in fishing gear, deliberate killing, disturbance, pollution and disease, are listed and discussed in view of the implementation of appropriate conservation measures to ensure the species' survival in the region.

Keywords: cetacean, conservation, marine mammal, population size

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INTRODUCTION

Because of the frequently pelagic distribution which characterizes fin whales *Balaenoptera physalus* (L. 1758) in both breeding and feeding habitats, this species is among the least known of all mysticetes. According to common knowledge, fin whales migrate seasonally between localized, high-latitude summer feeding grounds and widely dispersed warm-temperate and tropical winter breeding grounds (e.g. Evans, 1987). However, there are many problems with this simple paradigm as pointed out by several authors in the past (e.g. Ingebrigtsen, 1929; Jonsgård, 1966), and later evidenced through acoustic data (Clark, 1995; Watkins *et al*., 2000).

Fin whales in the Mediterranean, which could constitute a separate resident population on the basis of genetic evidence (Bérubé *et al*., 1998), congregate during summer in highly productive localities to feed, but their winter distribution remains unknown. Unlike in the major oceans, the peculiar Mediterranean environment may provide whales with opportunities for extending their breeding activities in summer and their feeding activities in winter. It is thus not unlikely that fin whales in the Mediterranean have adapted to a more forgiving environment by modifying their ecology, behaviour, and reproductive physiology. The aim of this paper is to review current knowledge concerning the fin whale in the Mediterranean Sea. During the last two decades, considerable attention has been dedicated to this 'population'. These studies have revealed interesting aspects of the fin whale's ecology and biology, but have also raised further questions; the most intriguing of which are the relationship between Mediterranean and North Atlantic fin whales, their movement patterns in the Mediterranean, and their feeding and breeding habits in the region. This review is intended to summarize what is known about Mediterranean fin whales and to highlight major gaps in knowledge. It identifies further research that is needed to better understand and conserve this clearly atypical mysticete population.

Large cetaceans have been known to exist in the Mediterranean since very ancient times, thanks to unambiguous descriptions left to posterity by a number of naturalists and philosophers. In particular, Aristotle's *Φαλλαινα* and Pliny the Elder's *Ballaena* were likely fin whales, as both authors recognized the animal as different from the sperm whale *Φυσητηρ* or *Physeter* (Gervais, 1864; Brusina, 1889). Fin whales may well have always been the most common of the great whales in the Mediterranean Sea. Today, this species still occurs frequently off the coast of western Liguria, which was called in Roman times *Costa Ballaenae*, the 'Coast of whales' (Orsi Relini *et al*., 1992). For obscure reasons such knowledge became lost for centuries, and until very recently the great whales were considered rare and accidental in the Mediterranean even by respected marine zoologists (e.g. Tortonese, 1965).

Very rarely has a *Balaenoptera* been identified in the Mediterranean as belonging to a species other than *B. physalus*. Such rare occurrences primarily involve the small, highly distinctive minke whale *B. acutorostrata*, which occasionally occurs in the region (Notarbartolo di Sciara & Demma, 1997; Van Waerebeek *et al*., 1999). Sei whales *B. borealis* are extremely rare in the Mediterranean, and blue whales *B. musculus* and Bryde's whales *B. edeni* have never been positively identified there.

METHODS

In this paper we have reviewed all fin whale records from the Mediterranean that we could find. While we recognize that our collection may be incomplete, it nevertheless will be sufficient to provide a clear understanding of the present state of knowledge regarding this species in the study region. Data on fin whale sightings and findings were found in a variety of sources, ranging from reports from field campaigns, through single stranding, capture or vessel collision accounts, stranding reports, annotated lists of museum collections (e.g. Cagnolaro, 1996), and occurrences reported in the local news from which species identification could be unambiguously made. Major sources of first-hand information were the stranding reports published yearly by Raymond Duguy for the French coasts from 1972 to 1992, and those published by the Centro Studi Cetacei for the Italian coasts from 1987 to 2001. Among published reports, only those providing sufficient certainty about species identification were used in this summary, and sighting data were considered only when provided by trained observers; uncertain or unconfirmed sightings, deriving from summaries of observations reported by non-specialists or amateurs, were not considered because of the high rate of mistaken species identification deriving from such sources (Zanardelli, Notarbartolo di Sciara & Acquarone, 1992). Although fin whales were once abundant and (after 1921) intensively hunted in the Strait of Gibraltar and in the area immediately to the west, we have excluded these capture records from this review, in the belief that those whales concerned belonged to a non-Mediterranean population (see 'Relationship between Mediterranean and Atlantic fin whales'). To highlight fin whale distributional patterns in the study region through sighting, stranding, vessel collision and capture events reported in the literature or deriving from our original data, the Mediterranean basin was subdivided into seven subregions; whenever possible, national or subnational boundaries were used (Fig. 1). To assemble the data summarized in Table 1 and listed in the Appendix, remarkable difficulties were encountered in wading through accounts in which original data were interspersed with derivative and repetitive summaries. To address these problems, the following criteria were adopted: (i) for each specimen, the earliest certain account was given priority; (ii) if a single specimen was referred to by more than one paper, we listed such papers in chronological order; (iii) when in doubt concerning whether subsequent reports given by the same author referred to different individual whales, or whether reiterate accounts existed for the same individuals, we have retained only the data contained in the latest review work by that author, when available, in the assumption that it contained the previous observations.

To address the question of whether fin whales in the Mediterranean differ dimensionally from their oceanic conspecifics, we selected in the literature all the specimens for which measurements (as opposed to eye estimates) were reportedly taken. However, very rarely was the method of measurement described in such accounts, providing a potentially significant source of error in the data. For example, the large fin whale specimen displayed in the Monaco museum, which at the time of capture was reportedly 20 m long, turned out to be 18.8 m long when mounted as a skeleton (Rode, 1939). Furthermore, the largest specimen on record for the Mediterranean, the 25.6 m-long Saint-Cyprien whale, which was measured in 1828,

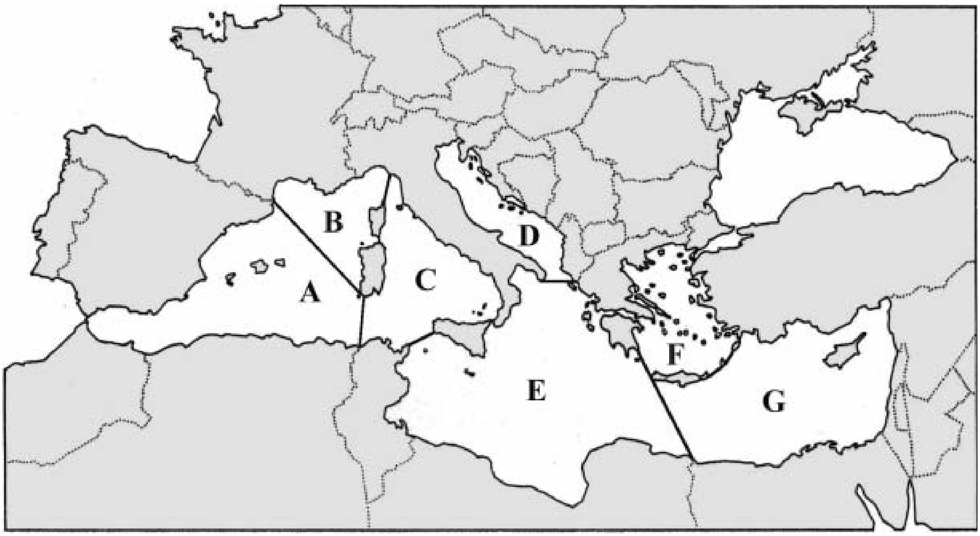

Fig. 1. Subregions of the Mediterranean Sea.

should be critically reassessed. Based on actual, recent measurements made between the perpendiculars to the tip of the snout and the fluke notch, it is very unlikely that Mediterranean fin whales exceed 20 m (L. Cagnolaro, Museo Civico di Storia Naturale, Milano, personal communication).

To elucidate seasonality of births, findings and observations of fin whales ≤8 m were plotted by month. The following criteria were adopted: (i) actual measurements performed on stranded individuals were complemented by eye-estimates at sea performed by experienced observers, under the assumption that such estimates are sufficiently accurate when involving very small (≤ 8 m) whales; (ii) the month of birth was extrapolated from neonate and foetal length assuming a length at birth of 5.2 m and a growth rate of 0.8 m/month in the early months of life; (iii) sighted whales simply labelled as 'very small calves' were placed in the month in which they were observed.

NOMENCLATURAL NOTES

On the basis of vertebral differences (Lönnberg, 1931) and body size (Tomilin, 1946), the fin whale *B. physalus* (L. 1758) was divided into two geographically disjunct subspecies: *B. p. physalus* from the northern hemisphere and *B. p. quoyi* (Fischer, 1829) from the southern hemisphere. Fin whales in the Mediterranean Sea would thus belong to *B. p. physalus*.

In the past, fin whales in the Mediterranean have been the subject of considerable nomenclatural confusion. de Lacépède (1804), based on a specimen stranded on 21 March 1798 on the island of Sainte-Marguerite (Cannes, southern France), created *B. rorqual*, later renamed *B. mediterraneensis* by Lesson (1828), perhaps in accordance with the common name 'Rorqual de la Méditerranée' proposed by Cuvier (1823). Based on the 1798 specimen, Fischer (1829) introduced the name of *Balaena antiquorum*, later renamed *Physalus antiquorum* by Gray (1868) (Giglioli, 1880; Ficalbi, 1907). Another fin whale specimen, the largest on record from the Mediterranean, which stranded near Saint-Cyprien (Perpignan, southern France) on 27 November 1828, was named *Balaenoptera aragous* by Farines & Carcassonne

Table 1. Summary of fin whale sightings, strandings, directed captures, collisions and accidental captures in the Mediterranean (number of specimens), subdivided into seven subregions (see Fig. 1). Numbers followed by '+' are minimum numbers. This summary is derived from the data listed in the Appendix

Subregion	Sighted	Found stranded or dead	Captured or harpooned	Vessel collision	Bycatch	Total	%
A: Western Basin	134	47	2	5	–	188	7.7
B: Ligurian-Corsican-Provençal Basin and Gulf of Lions	1703+	71	8	18	5	1805+	73.8
C: Tyrrhenian Basin	260+	51	2	8	1	322+	13.2
D: Adriatic Basin	23	11	–	–	–	34	1.4
E: Ionian/Central Basin	51+	16	2	1	–	70+	2.7
F: Aegean Basin	10+	3	–	–	–	13+	0.5
G: Levantine Basin	7+	6	–	–	–	15+	0.6
Total	2188+	205	14	32	6	2447+	100
%	89.4	8.4	0.6	1.3	0.2	100	

(1829). One year later, Companyo (1830) erroneously applied to this specimen the Linnaean name *B. musculus*. Subsequently, many authors (including Cornalia, 1872; Richiardi, 1874; Giglioli, 1880; Flower, 1885; Brusina, 1889; Trois, 1893; Parona, 1896; Ficalbi, 1907, 1919; Borri, 1927) used *B. musculus* 'auctorum' (*nec* L. 1758), as well as *Rorqualus musculus* (Cuvier, 1836) for the fin whale from the Mediterranean. It was only at the end of that century that True (1898) managed to restore the correct name for the fin whale, proving that *B. musculus* referred to the blue whale (Tomilin, 1957).

MORPHOLOGY AND SIZE

In the absence of appropriate morphometric comparisons of skeletal and other characters, it is currently impossible to provide any evidence that Mediterranean fin whales differ morphologically from their oceanic conspecifics. Based on the available information, characterizing the body size of Mediterranean fin whales is also difficult, given that the available sample is derived from strandings, which is a biased sampling procedure. A length–frequency distribution of 103 specimens of fin whales found stranded along Mediterranean shores between 1798 and 1997, selected from the literature among those for which actual measurements were reportedly taken, is shown in Fig. 2. The mean length of the sample is 13.8 m (S.E. = 0.52). The maximum measured length, 25.6 m, is that of the 1828 Saint-Cyprien male (see 'Nomenclatural notes' above); however, we don't consider this ancient measurement to be reliable, as the measuring method was not described. Mediterranean fin whales thus appear to grow to a larger size than fin whales from the north-eastern US continental shelf (Hain *et al.*, 1992), but are similar to the north-eastern North Atlantic whales studied by Aguilar & Lockyer (1987). To determine length at birth of Mediterranean fin whales, the lowest size classes of Fig. 2 were considered in greater detail, and are shown in Fig. 3, where the length–frequency distribution of all whales having a total length ≤ 8 m ($n = 20$; mean = 5.9 m, S.E. = 0.2) is represented. The data suggest that the conspicuous peak around 5.2 m, likely caused by an increased mortality at birth, may be assumed, in absence of better evidence, as mean length at birth for Mediterranean fin whales. On this basis, as remarked by Duguy (1990a), Mediterranean fin whales appear to be born substantially smaller than their 6.4 m-long North Pacific conspecifics (Lockyer, 1984), albeit not quite as small as the mean size at birth (4.57 m)

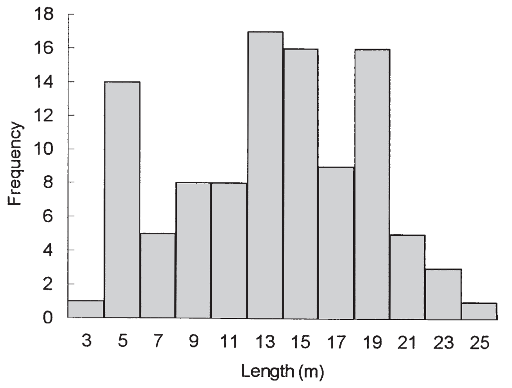

Fig. 2. Length–frequency distribution of 103 specimens of *Balaenoptera physalus*, stranded along Mediterranean Sea coasts between 1798 and 1997, for which an actual measurement was reported.

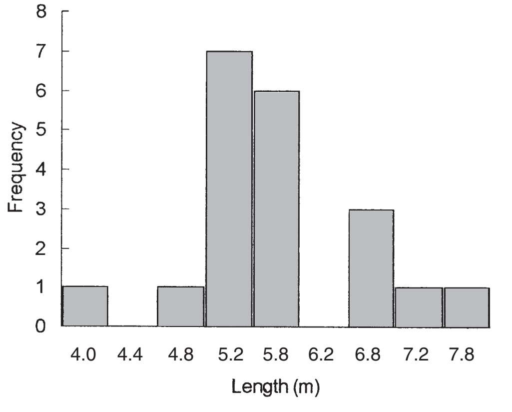

Fig. 3. Length–frequency distribution of the 20 specimens ≤8 m from the sample of Fig. 2.

reported by Duguy & Vallon (1976) and Duguy & Collet (1983). Sex information was available for 75 specimens in our sample (38 males and 37 females), thus allowing a size comparison between sexes. Although, as expected, female mean length (14.66 m) was greater than in males (13.39 m), the difference was insignificant (Mann–Whitney *U*-test), perhaps due to the heterogeneity deriving from a sample composed of stranded animals.

The strikingly asymmetrical pigmentation patterns of Mediterranean fin whales are consistent with those described for north-west Atlantic specimens by Agler *et al.* (1990). These include: (i) white or pale grey lower and upper lips and apical third of baleen on the right side of the head, and dark on the left side; (ii) a whitish patch ('blaze') extending dorsally and caudally from the right side of the head; and (iii) a light V-shaped pattern ('chevron'), with a rostrally orientated apex caudal to the blowholes, curving back down on both sides, and often brighter on the right side. The shape and brightness of these coloration patterns show great variability among individuals, thus allowing photo-identification.

DISTRIBUTION

Fin whales are found throughout the Mediterranean region, where they are the most common mysticete species (Notarbartolo di Sciara & Demma, 1997). By contrast, they are absent from the Black Sea (Tomilin, 1957), nor were they ever reported in the Sea of Marmara (Öztürk, 1995). In spite of their wide distribution throughout the region, however, the published records indicate that their occurrence is conspicuously uneven. Of the various areas concerned, the Ligurian-Corsican-Provençal Basin/Gulf of Lions (Area B) is by far the most important; the Western, Tyrrhenian, Adriatic and Ionian/Central Basins (Areas A, C, D and E) appear to be of intermediate significance. Finally, fin whales seem to occur only rarely in the Aegean and Levantine Basins (Areas F and G). Although such geographical imbalance is partly due to more intense scientific coverage in the north-western portion of the Mediterranean, the marine region between southern France, north-western Italy and northern Sardinia, and surrounding Corsica, is clearly of special importance for Mediterranean fin whales. The relevant information on fin whale presence in the different subregions, ranked into three categories of decreasing importance to fin whales, is summarized below.

Subregion of high importance for fin whales

Area B: Ligurian-Corsican-Provençal Basin and Gulf of Lions (continental France, Liguria, north-western and southern Corsica, northern and western Sardinia) In this subregion, where sighting reports are strikingly abundant (Table 1), *B. physalus* ranks second after *Stenella coeruleoalba* in sighting frequency (Notarbartolo di Sciara *et al*., 1993). The clearest demonstration that this area is particularly important to fin whales is provided by a survey conducted over most of the western Mediterranean in the summer of 1991, in which the species was consistently sighted only in Area B (Forcada *et al*., 1996). Several sighting surveys subsequently conducted in the area (e.g. Notarbartolo di Sciara *et al*., 1993; Orsi Relini *et al*., 1994; Forcada, Notarbartolo di Sciara & Fabbri, 1995; Gannier, 1997a, 1997b) confirmed its importance for fin whales. The abundance of *B. physalus* in the area can be explained by the well-known productivity of the offshore waters in the Ligurian-Corsican-Provençal Basin, where a permanent frontal structure provides the conditions for high primary production (Jacques, 1990). This productivity sustains a large biomass of krill, *Meganyctiphanes norvegica* (Orsi Relini *et al*., 1992, 1994), the fin whales' main prey in the region. This is perhaps the reason why fin whales are found in the area in greatest numbers during summer, which is known to be the species' feeding season. However, sighting cruises (Gannier & Gannier, 1993; Orsi Relini *et al*., 1994) and the deployment of bottom-mounted hydrophones (Clark, Borsani & Notarbartolo di Sciara, 2002) during autumn and winter have demonstrated that the whales' presence in Area B, perhaps in smaller numbers, is continuous throughout the year.

Subregions of intermediate importance for fin whales

Area A: Western Basin (comprised between Spain, Morocco and Algeria) The presence of *B. physalus* in this area is well known from both strandings (Casinos & Vericad, 1976; Casinos & Filella, 1975, 1977; Grau, Aguilar & Filella, 1980; Grau *et al*., 1986; Raga *et al*., 1991; Boutiba, 1994a; Boutiba *et al*., 1996; Borrell *et al*., 2000) and sightings (Viale & Frontier, 1994; Cañadas *et al*., 1999). Overall occurrence is at much lower levels than in Area B. Fin whale presence in the area apparently becomes increasingly scarce from east to west (Franco & Mas, 1994; Viale & Frontier, 1994; Forcada *et al*., 1996; Cañadas *et al*., 1999). Today, fin whales are very rare in the Strait of Gibraltar, after 30 years of whaling activity which ended in the late 1950s and extirpated fin whales from the Strait region and contiguous Atlantic waters (Clapham & Hatch, 2000).

Area C: Tyrrhenian Basin (west coast of continental Italy except Liguria, northern and western Sicily, northern Tunisia, southern and eastern Sardinia, and eastern Corsica) Abundant records of fin whale sightings and strandings in this subregion exist in the literature, probably as a reflection of a relatively high interest in cetaceans by local zoologists of the 19th and 20th century. However, the species' abundance here is clearly lower than in Area B (Notarbartolo di Sciara *et al*., 1993), probably because the offshore waters are not as productive. Marini *et al*. (1996b) reported that fin whales are present in the area throughout the year, with peaks in spring and early autumn; this may reflect migratory movements to and from the Ligurian Sea feeding grounds. This observation is corroborated by results from a fin whale sighting programme conducted in 1995 aboard Italian Navy vessels, which indicated a northward movement of whales from Tyrrhenian to Ligurian waters between May and June (Nascetti & Notarbartolo di Sciara, 1996). However, localized hot spots of fin whale concentrations in Area C may exist. One such site was recently discovered over the 'Cuma' submarine canyon, between the islands of Ischia and Procida and the coast of continental Italy, where waters are known to be locally highly productive and where fin whales have been seen engaging in surface feeding (Mussi *et al*., 1999).

Area D: Adriatic Basin (eastern Italy, Slovenia, Croatia, Bosnia-Herzegovina, Yugoslavia, Albania) Fin whale occurrence in the Adriatic Sea is scarce, particularly in its shallow northern and central portions where appropriate fin whale habitat is lacking. However, both strandings (Brusina, 1889; Kolombatovic, 1894; Lepri, 1914; Princi & Bussani, 1976; Pilleri & Gihr, 1977; Anonymous, 1987, 1991, 1992) and sightings (Rallo, 1979; Politi *et al*., 1992; Politi, Airoldi & Notarbartolo di Sciara, 1994; Stanzani, Bonomi & Bortolotto, 1997) are known from the subregion, particularly in recent years (D. Holcer, Croatian Natural History Museum, Zagreb, personal communication; Affronte, 2000), perhaps also reflecting an increasing interest in cetaceans by the general public and the media. Occurrence of fin whales in the Adriatic probably stems from the movement of sporadic individuals wandering northwards from the Ionian feeding grounds to the south.

Area E: Ionian/Central Basin (eastern and southern Greece, Libya, Malta, eastern Tunisia, southern and eastern Sicily, south-eastern continental Italy) The scant published record concerning the presence of fin whales in this area, where little research has been conducted, probably does not reflect the real situation and results in an underestimate of the whales' abundance here. Fin whales have been known to strand and have been caught in the Gulf of Taranto (Parona, 1896, 1908), eastern and southern Sicily (Parona, 1908; Anonymous, 1988, 1994b), off the east coast of Tunisia (Heldt, 1949; Postel, 1956; Ktari-Chakroun, 1981), and off the western coast of Greece and adjacent islands (Frantzis *et al*., in press). Sightings of fin whales have been made in the Gulf of Taranto (Cerioni *et al*., 1996), off the Ionian coast of Calabria (Parona, 1908; Tethys original data), and off eastern Sicily (Tethys original data; Giordano *et al*., 1995). Fin whales have also been observed in the waters of Lampedusa Island (Marini, Villetti & Consiglio, 1996d), where the seasonal presence of whales in late winter and spring is apparently well known locally. A sighting of *Balaenoptera* sp., most likely *B. physalus*, is reported by Marini, Carpentieri & Consiglio (1996a) off southern Peloponnese. Politi, Airoldi & Notarbartolo di Sciara (1994) frequently observed fin whales off the western coast of Greece, also reported by Frantzis *et al*. (in press); here oceanographic conditions may sustain substantial zooplankton biomass and thus feeding aggregations of fin whales.

Subregions of low importance for fin whales

Area F: Aegean Basin (eastern and northern continental Greece, western Turkey, and to the south a line from south-eastern Greece to south-western Turkey, connecting the islands of

Crete, Karpathos and Rhodes). Fin whales are extremely rare in this subregion. Öztürk (1995) generically states that 'the Fin Whale is the only baleen whale species present in Aegean Sea', but does not provide further details. Three strandings are known from the Aegean Basin: one in Chalkis, Evoikòs Gulf, on 3 September 1953, a second of a juvenile (13.5 m) female near Kavala, northern Aegean, on 25 December 1997 (Frantzis *et al.*, in press), and a third near Kušadasi, Turkey (B. Öztürk, Istanbul University, pers. comm., no date provided). Fin whale sightings in the Aegean are also scarce. Ozturk (1995) reports sightings but provides no details. An individual of *Balaenoptera* sp., very likely *B. physalus*, is reported by Marini *et al.* (1996a) very close to the southern coast of the Greek island of Karpathos; and sightings of fin whales were repeatedly made in the Saronikos Gulf (Greece) in Spring 1998 (Frantzis *et al.*, in press).

Area G: Levantine Basin (southern Turkey, Cyprus, Syria, Lebanon, Israel, Egypt, and the southern coast of Crete). The situation here is apparently very similar to that in Area F. Strandings of fin whales have been reported in Egypt (Flower, 1932; Paulus, 1966), Israel (Marchessaux, 1980), and southern Turkey (B. Öztürk, Istanbul University, pers. comm.; A. Dede, Istanbul University, pers. comm.). One sighting was reported by Marchessaux (1980) near Gavdos, Crete (Greece), and fin whales were apparently sighted off Antalya and Fethiye, southern Turkey (B. Öztürk, Istanbul University, pers. comm.). Recently, the occurrence of two young fin whales in this subregion were reported: a juvenile female, 10.25 m long, stranded in March 2000 at Yumurtalÿk, Adana, Turkey (A. Dede, posted on 11 March 2002 on the ECS-ALL Discussion List), and a newborn specimen, about 4 m long, observed in very shallow waters in Larnaka Bay, south-east Cyprus, on 21 October 2001 (A. Frantzis and E. Economou, pers. comm.).

HABITAT

Fin whales in the Mediterranean appear to be markedly pelagic. They are primarily observed in deep offshore waters, although their occurrence over the continental shelf is not unusual. Of 62 fin whale groups sighted by Forcada *et al.* (1996) during a dedicated line-transect survey in the western Mediterranean, only two were observed in waters shallower than 1000 m, and overall mean water depth at which sightings were made was 2360 m (S.E. = 46.8). Similarly, 93 sightings made in the western Ligurian Sea between 1990 and 1991 were characterized by a mean water depth of 2248 m (Zanardelli, Notarbartolo di Sciara & Jahoda, 1992). Gannier (1995) estimated that whale density in north-western Mediterranean waters deeper than 2000 m was 65 times higher than in waters shallower than 500 m. Most of the sightings made by Marini *et al.* (1996b) in the central Tyrrhenian Sea also occurred beyond the 2000 m isobath. By contrast, the mean water depth from 20 fin whale sightings made over a wide portion of the central Mediterranean Sea (Notarbartolo di Sciara *et al.*, 1993) yielded a lower value and with a greater variance than the Ligurian Sea values alone (mean = 1775 m, range = 25–2500 m, S.E. = 218). These observations suggest that fin whale habitat is variable across the species' Mediterranean range. This is corroborated by the observations made by Politi, Airoldi & Notarbartolo di Sciara (1994) off the western coast of Greece (Ionian Sea), in which fin whale sightings were associated with a mean water depth of 624 m ($n = 9$, S.E. = 70.8).

In some years, however, fin whales are frequently seen over the narrow shelf waters unusually close to the coast, probably as a result of different oceanographic conditions in those years; this is true even in the Ligurian Sea. Airoldi *et al.* (1999) report dramatic year-to-year differences in mean water depths and in distances from the coast of fin whale sightings from a whale-watching vessel in front of Imperia; these decreased from 2293 m and 31 700 m ($n = 12$) in 1996 to 1301 m and 14 100 m ($n = 20$) in 1997, with whales during the latter year seen as close as 1300 m to the shore. It is noteworthy that during that same period, between June and September 1997, fin whales were unusually abundant in the shallow coastal waters of the Gulf of Lions, occasionally entering small bays and harbours (Beaubrun *et al*., 1999). Sergeant (1977) noted that, unlike ichthyophagous fin whales, which have a very predictable distribution, plankton-feeding fin whales change their distribution annually; this was ascribed to variation in prey distribution, and was reflected in interannual variability in fin whale catches.

Extensive observations in other parts of the world confirm that fin whale habitat appears to be primarily characterized by high densities of the species' principal prey and the physical conditions that facilitate its accumulation, irrespective of water depth (Sergeant, 1977; Woodley & Gaskin, 1996). Such conditions often occur in neritic waters, such as those off the north-eastern coast of the USA and Canada, where fin whales are mostly observed over the continental shelf and even within estuaries such as the St. Lawrence (Sergeant, 1977; Ray *et al*., 1978). In such regions, fin whale distribution is marked by a preference for areas characterized by high topographic variability, where conditions exist for extensive water mixing and enhanced primary production (Hain *et al*., 1992).

In the western Ligurian Sea a close relationship between the presence of fin whales and concentrations of krill *M. norvegica* was noted in early spring (Relini *et al*., 1994) and summer (Orsi Relini *et al*., 1992). This is likely connected to areas of divergence of the Ligurian-Provençal Front (Jacques, 1990; Le Vourch *et al*., 1992). A heterogeneous spatial distribution of fin whales in relation to oceanographic features and zooplankton patchiness was also observed in areas of the western Mediterranean, including the Alboràn Sea and the Algerian Basin (Viale, 1991; Viale & Frontier, 1994). During a summer survey in 1991, Forcada *et al*. (1996) observed that the mean surface water temperature at fin whale sighting locations was significantly lower than in zones without whales, indicating a likely association of whales with productive upwelling waters. However, surface temperatures collected in association with sightings of cetaceans in the Ligurian-Corsican-Provençal Basin, during a line-transect survey conducted in summer 1992, revealed that the surface water in locations of fin whale sightings ($n = 51$, mean = 28.13 °C, S.E. = 0.147) was significantly warmer (unpaired, two tailed t-test, $t = -12.5$, $P < 0.001$) than in locations of striped dolphin sightings ($n = 73$, mean = 25.53°C, S.E. = 0.14); this suggests differential habitat choice by these two species with respect to oceanographic patterns.

No information exists on the relationship between fin whale presence and oceanographic features and zooplankton concentrations in other portions of the Mediterranean, such as the Tyrrhenian Sea, the Sicily Channel and particularly the Ionian Sea, where limited evidence (faeces) exists of whale feeding activity on euphausiids.

RELATIONSHIP BETWEEN MEDITERRANEAN AND ATLANTIC FIN WHALES

Whether fin whales in the Mediterranean belong to an Atlantic population which migrates seasonally through the Strait of Gibraltar, or to a resident population permanently isolated within the Mediterranean, has been the subject of long debate. Zoologists from the early 19th century, such as Cuvier (1823), Lesson (1828), Fischer (1829) and Farines & Carcassonne (1829), considered fin whales found in the Mediterranean as belonging to species endemic to this sea, and named them accordingly. The notion that fin whales regularly enter the Mediterranean from the North Atlantic subsequently gained increasing favour among some observers, including Richiardi (1874), Borri (1927), Paulus (1966), Jonsgård (1966), Cagnolaro (1977) and Viale (1981, 1985). Elaborate but unsubstantiated conjectures were proposed in successive instalments by Viale (1977a, 1977b, 1981, 1985), who envisaged two discrete populations of fin whales in the Mediterranean, both immigrants from the Atlantic: one entering to breed at the beginning of winter from its summer feeding grounds off north-west Scotland, the other arriving in May–June to feed from a supposed Mauritanian winter breeding ground. Such conjectures were also stimulated by the observation, discussed by Jonsgård (1966), that oil extracted from whales captured off the Hebrides in summer had a high iodine content; this led that author to suggest winter feeding by such whales in the Gibraltar area and possibly in the Mediterranean, where iodine content of the whales' prey is known to be higher than the Atlantic average. An intermediate possibility, with at least part of the Mediterranean fin whales remaining during winter in the basin – as hinted by reduced winter observations in the north-western Mediterranean – was proposed by Duguy & Vallon (1976), Duguy *et al*. (1983) and Duguy (1989).

The conviction that fin whales enter the Mediterranean through Gibraltar may have been at least in part influenced by knowledge of the existence of large numbers of fin whales in the Strait area and adjacent Atlantic waters. These were the object of a very successful, albeit short-lived whaling industry (Cabrera, 1925; Tønnessen & Johnsen, 1982; Sanpera & Aguilar, 1992). A first-land station was established in Getares, Spain, on the west side of the Bay of Gibraltar, and began operating with two catchers in April 1921 in the Strait waters and nearby Atlantic (Sanpera & Aguilar, 1992). Captured species included fin, sperm, sei and even (in 1925) blue whales, but 93% of the catch was composed of fin whales (Tønnessen & Johnsen, 1982). These were captured year-round, suggesting that the area represented both feeding and breeding grounds for a likely resident population (Ingebrigtsen, 1929; Jonsgård, 1966). During the initial years the operations were quite successful, with a mean of over 19 000 barrels of oil produced per catcher, among the highest ever recorded for any whaling operation (Tønnessen & Johnsen, 1982). Given the success of the operation, in 1924 two additional companies were granted permission to hunt whales in the Strait area with two floating factories and an uncertain number of whale catchers, in addition to the original Getares land station. Other companies were set up during that period and operated out of the African side of the Strait, however, no catch figures are known from these (Sanpera & Aguilar, 1992). By 1926, with a minimum of 4149 fin whales killed in only 6 years (Sanpera & Aguilar, 1992), the population had collapsed, with catch per unit effort (CPUE) values declining from a maximum of 54 whales per catcher per month in 1922 down to only six at the end of the period (Clapham & Hatch, 2000), and operations were no longer profitable due to lack of whales (Tønnessen & Johnsen, 1982). Operations did continue, albeit at a much slower pace, in the following years, however, catch records were not retained except for a figure of 66 fin whales processed in 1934 by a floating factory in Gibraltar (Anonymous, 1942). After 1936, with the onset of the Spanish civil war followed by World War II, whaling was discontinued. Land stations were again established after the war in the Strait. One was located at Benzou, Spanish Morocco, on the African side of the Strait, and primarily operated in Atlantic waters (Furnestin, 1949); the other was again in Getares. Both operations were short-lived due to the inability of catcher boats to find sufficient whales (Tønnessen & Johnsen, 1982; Sanpera & Aguilar, 1992; Clapham & Hatch, 2000). Although records for this last phase of the Gibraltar operations do not exist for the entire period, between 1948 and 1954 a total of 199 fin whales was caught and processed in Benzou (Anonymous, 1950; Aloncle, 1964), while 102 fin whales were processed in Getares between 1950 and 1953 (Sanpera & Aguilar, 1992). These

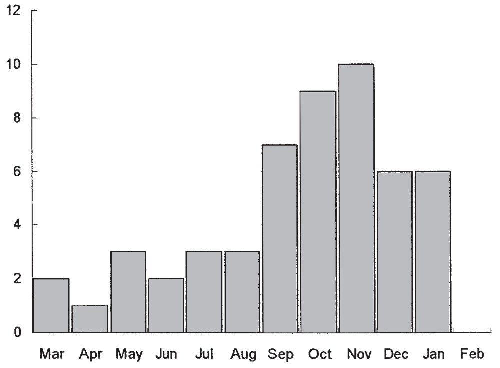

Fig. 4. Seasonal distribution of sightings and strandings of 56 fin whales ≤8 m (listed in the Appendix).

statistics, however, probably greatly underestimate the total number of fin whales killed by whalers in the Strait area since 1921. The remnants of the local fin whale population was exploited until the late 1970s by pirate whaling, which harvested hundreds of animals off the coast of the Iberian Peninsula (Best, 1992), venturing occasionally perhaps as far as the Strait of Gibraltar (Sanpera & Aguilar, 1992).

The existence of large numbers of whales in the Strait during the first half of the 20th century may be taken as evidence of a population continuum between the Atlantic and the Mediterranean. However, this idea is contradicted by the results of Bérubé *et al.* (1998), who conducted genetic studies using samples of fin whales from a number of different locations of the North Atlantic and in the Ligurian Sea. Their study found that fin whales in the Mediterranean are genetically different from those of the Atlantic, and thus likely belong to a resident, reproductively isolated, population. Significant levels of divergence and heterogeneity in both mitochondrial and nuclear DNA were found between Mediterranean and Eastern North Atlantic specimens, and nucleotide diversity among Mediterranean fin whales (estimated to be 0.0057) was significantly lower than that found in North Atlantic whales (0.0113). The hypothesis that fin whales in the Mediterranean are an isolated population is corroborated by clear indications that breeding takes place inside the basin, including numerous findings of stranded neonates (Fig. 4; see also the Appendix). Marini *et al.* (1992, 1996b), based on 4 years of fin whale sightings made year-round from ferries crossing the central Tyrrhenian Sea, also argued in favour of the hypothesis of fin whales permanently residing in the Mediterranean and isolated from the Atlantic. However, Notarbartolo di Sciara (1994) cautioned that the mere decreased abundance of fin whales observed in the northern Mediterranean in the colder seasons could not be considered sufficient evidence for such a hypothesis. That *B. physalus* in the Mediterranean may have been an isolated population was mentioned as early as 1881 by renowned Norwegian zoologist Georg O. Sars; he noted that fin whales had been observed in the Mediterranean and off Norway at the same time, thus leading to the supposition that 'within every greater area there was a whale stock which visited the nearest coast without undertaking longer migrations than necessary for finding food' (Jonsgård, 1966).

Such circumstantial evidence supports the hypothesis that the Gibraltar fin whales which were exploited in the first half of the 20th century formed a population of limited range and size, which barely trespassed into the Mediterranean and thus did not interbreed with whales residing in the central-western Mediterranean. In this context, a comparison of genetic material from Atlantic, Mediterranean and Gibraltar whales, preserved from the former whaling operations, would be highly desirable. Based on such a hypothesis, records of captures and sightings of fin whales in the Strait of Gibraltar and adjacent Atlantic waters were excluded from Table 1. Fin whales were likely extirpated from the Strait area, as demonstrated by the dearth of sightings since the 1960s (Bayed & Beaubrun, 1987; Hashmi & Adloff, 1991; Walmsley, 1996; Cañadas *et al.*, 1999). As proposed by Clapham & Hatch (2000), this probably occurred because the cultural memory of the existence of that habitat was lost within the population. An alternative explanation, that the increase in local shipping activity has discouraged nearby whales from returning, seems less likely.

MOVEMENTS WITHIN THE MEDITERRANEAN

Considerable speculation has been put forward concerning fin whale movements and migrations within the Mediterranean Sea. Most of the information available on this subject relates to the north-western Mediterranean in summer, leaving the situation in the rest of the basin and for the remainder of the year open to considerable conjecture. Extensive observations confirm the presence of large numbers of fin whales in the Ligurian Sea during the summer months (Duguy & Vallon, 1976; Zanardelli, Notarbartolo di Sciara & Jahoda, 1992; Zanardelli *et al.*, 1999). Active feeding in this region has been confirmed by frequently observed defecation episodes. The early summer increase in the Ligurian-Corsican-Provençal Basin coincides with the well-known seasonal migration pattern towards feeding grounds observed in oceanic whales. Likewise, the decline of whale abundance in early autumn is suggestive of a seasonal migration away from the Ligurian Sea feeding ground (Duguy & Vallon, 1976), similar to that observed in other fin whale populations. While in the Ligurian Sea, fin whales show significant site fidelity, as evidenced by the numerous re-sightings of identified individuals made during a 9-year study (1990–98); single individuals have been encountered up to four times in different years, and up to three within-season re-sightings of the same individuals have been recorded at intervals varying from 1 to 90 days (Zanardelli *et al.*, 1999). Similar observations were also reported by Fabbri & Lauriano (1992).

The putative arrival of whales in the Ligurian-Corsican-Provençal Basin in early summer and their later departure, at the outset of autumn, is mirrored by the bimodal sighting frequency of whales observed by Marini *et al.* (1996b) further south in the central Tyrrhenian Sea; peaks were recorded in April–May and September–October, suggesting that, at least in part, access to the northern feeding grounds, as well as departure, occurs through the Tyrrhenian Sea. In a sighting programme conducted in 1995 aboard Italian Navy ships (Nascetti & Notarbartolo di Sciara, 1996), most fin whales sighted before the end of May were scattered in the Tyrrhenian Sea, while after early June they were concentrated in the Ligurian Sea. Predictably, fin whale sightings in the feeding grounds sharply decrease from summer to winter (Duguy & Vallon, 1976); this decrease apparently involves an order of magnitude (Gannier & Gannier, 1997), and contrasts with a less dramatic decline in sightings in the central Tyrrhenian Sea (Marini *et al.*, 1996b). Fin whales, however, never completely leave the Ligurian-Corsican-Provençal Basin. They are found there year-round (Duguy & Vallon, 1976; Poggi, 1982; Palazzoli, 1983; Gannier & Gannier, 1990; Duguy, 1990a; Relini *et al.*, 1994), as further demonstrated in 1999 by extensive winter recordings of fin whale vocalizations off Corsica and western Liguria (Clark, Borsani & Notarbartolo di Sciara, 2002).

A major gap in our knowledge of Mediterranean fin whale ecology concerns whale movement patterns in the remainder of the region and throughout the seasonal cycle. Marini *et al.* (1996d) speculated that fin whales migrate to the southern part of the Mediterranean during winter, when resources diminish and climatic conditions worsen. From here, in spring, they would move back to the Ligurian Sea but also to other areas such as the Ionian Sea and the Levantine Basin. Such a notion is supported by Marsili & Focardi (1996), who observed a drop of DDT levels in the blubber of Mediterranean fin whales after 1990 and suggested a connection between a possible whales' winter presence in north African waters and the decreased use of DDT in Africa. However, given the well-known ability of these persistent organic compounds to disperse over wide geographical ranges and to enter the marine food web at the global level (Loganathan & Kannan, 1991), this hypothesis must be considered speculative.

We suggest an alternative interpretation of the pattern of fin whale movements in the Mediterranean. It is possible that whales aggregate in specific productivity hot spots during their peak feeding season, and disperse over wider areas throughout the Mediterranean basin at times of the year in which feeding ceases to be their predominant occupation. If such times were to coincide with the mating season, the remarkable range over which fin whale vocalizations can be heard (Payne & Webb, 1971; Watkins *et al.*, 1987) might mean that dispersal over a relatively limited area such as that of the Mediterranean would not preclude the finding of mates. Unlike humpback and grey whales, which congregate for mating in well-defined breeding grounds, oceanic fin whales are thought to disperse widely during their mating season (Payne & Webb, 1971; Tyack, 2000). The challenges of mate location that this presumably creates should be reduced in the more confined area of the Mediterranean (Notarbartolo di Sciara *et al.*, 1999). At this stage of knowledge, however, speculating about movement patterns of fin whales within the Mediterranean is unwarranted without a rigorous observation scheme and long-time tracking of a sufficiently large number of individuals.

POPULATION DATA

No inference can be made concerning the population structure of *B. physalus* in the Mediterranean, nor about whether fin whales found in the region belong to a single, panmictic population or to a metapopulation comprised of a number of subunits. Evidence deriving from sex ratios and sightings of groups having different age composition, limited to the Ligurian-Corsican-Provençal summer feeding grounds, argues against sex or size segregation in this area (Zanardelli *et al.*, 1999), unlike fin whales off Iceland studied by Rørvik *et al.* (1976). The genetically determined sex ratio in a sample of 100 biopsied whales (51 females and 49 males) from the Ligurian Sea did not significantly differ from parity (χ^2 $P < 0.01$)(Zanardelli *et al.*, 1999).

The total number of fin whales present in the Mediterranean Sea is unknown. Various attempts have been made in the past at guessing numbers of fin whales in portions of the western Mediterranean. A population size of 400 individuals during summer between the French and Italian coasts north of the Rome parallel was proposed by Duguy & Vallon (1976). However, details of the reasoning for obtaining such a number were not presented. Viale (1981, 1985) tried to extrapolate population size in the area north of 42°N from data collected during a number of different cruises, which resulted in a crude estimate of between 500 and 2000 individuals. Marini *et al.* (1992) remarked that, in their opinion, '… the number of fin whales [in the Mediterranean] up until now has been over-estimated, due to the morphological similarity of this species with *B. edeni* and *B. borealis*'. However, this conclusion seems unjustified: Bryde's whales have never been reported in the Mediterranean, and the entire record for sei whales in the region comprises only two certain strandings and two sightings (Bompar, 2000). Data to estimate population size were first collected in the region through dedicated line-transect surveys conducted over most of the western Mediterranean in 1991 (Forcada *et al.*, 1996), and over a more limited area centred on the Ligurian-Corsican-

Provençal Basin in 1992 (Forcada, Notarbartolo di Sciara & Fabbri, 1995). During the first of these cruises, in which most whale sightings were concentrated in a narrower area comprising the continental coast of France, Italy, western Corsica, north-western Sardinia, and Minorca, mean fin whale density was found to be 0.02408 individuals/km^2 (S.E. = 0.0065, %CV 27.0, 95% C.I. 0.0143–0.0405). The overall abundance estimate was given as 3583 whales (S.E. = 967, 95% C.I. 2130–6027). In the 1992 cruise, whale density was lower, with 0.0155 individuals/km^2 (S.E. = 0.0033, %CV 21.77, 95% C.I. 0.0101–0.0235), giving an overall abundance in that area of 901 whales (S.E. = 196.1, %CV 21.77, 95% C.I. 591–1374). Further line-transect survey effort conducted in the same area yielded a strikingly consistent whale density estimate of 0.015 individuals/km^2 (Gannier, 1997a, 1997b). Fin whale densities were surprisingly high in the Mediterranean, a marine region which was not known to be able to sustain large whale populations; indeed, densities were higher than those estimated for North Atlantic feeding grounds, suggesting a very high availability of prey in the region (Forcada *et al.*, 1996).

REPRODUCTION

Figure 4 summarizes the available data (listed in the Appendix) on records of neonate fin whales in the Mediterranean, by month. Although the frequency of occurrence of neonates appears to be greatest between September and January, with a peak in November, as also reported by Viale (1985), the available data indicate that fin whale births may occur throughout the year in the Mediterranean. These data do not support the assertion by Di Natale & Mangano (1983), who suggested a calving period between May and September based on reports from amateurs. A birth peak in late autumn–winter in Mediterranean fin whales would be consistent with the known breeding patterns for the species elsewhere (Gambell, 1985). The apparent extension of the calving season beyond this period suggests that the peculiar Mediterranean environmental conditions (including perhaps availability of prey extending beyond a single season, and mild climate) may put less pressure on a narrow birth season than the oceanic environment, thus offering energetic advantages, ultimately resulting in increased reproductive success (Clapham, 2001). A similar reproductive trait was apparently adopted by inshore-form Bryde's whales off South Africa (Best, 1977), in sharp contrast with non-migratory humpback whales from the Arabian Sea that have retained markedly seasonal reproductive habits (Mikhalev, 1997). A rare case of multiparity was observed in August 1980, when a 19.2 m-long female stranded near Toulon (France) bearing three foetuses: two 1.4 m-long males and a 1.3 m-long female (Besson, Duguy & Tardy, 1982); a possible link between such abnormal gestation and the death of the mother was not suggested by the authors.

Information is lacking to suggest localized calving grounds in the Mediterranean. Marini *et al.* (1992) suggested that fin whales during winter migrate to the southern part of the Mediterranean to give birth and to mate, and reported 'sightings of females with calves' during winter in the waters around the Sicilian island of Lampedusa (Marini *et al.*, 1996d). However, the wide geographical distribution of the overall record of neonate fin whales in the Mediterranean argues against any precise calving location for fin whales in the Mediterranean Sea. Of the 56 newborn individuals in our record, 19% were found in Area A, 40% in Area B, 35% in Area C, and 2%, respectively, in Area D, E and F. Considering the uneven geographical distribution of records (Table 1), this pattern supports the alternative hypothesis that fin whales in the Mediterranean may be dispersed throughout a wider portion of the basin during breeding (Notarbartolo di Sciara *et al.*, 1999). Such a notion is in agreement with Ingebrigtsen (1929), who suggested that fin whales do not set out on definite breeding migrations like blue, humpback and sei whales, but rather give birth in any part of the sea as soon as their foetus is fully grown.

FEEDING

It is now known that the Mediterranean Sea encompasses pelagic areas of remarkable primary productivity (Jacques, 1990). These areas can sustain a large zooplanktonic (notably euphausiid) biomass (Casanova, 1970; Goy & Thiriot, 1976), and thus a viable population of feeding fin whales. This recent view contrasts with the ancient belief, summarized by 19th century zoologist Charles Dessalines d'Orbigny (quoted by Brusina, 1889), that fin whales would enter the Mediterranean from the Atlantic in pursuit of their prey, either fish or plankton (Paulus, 1966), and then starve to death because the allegedly low-productive Mediterranean waters could not sustain them (Tortonese, 1965; Di Natale & Giuffré, 1976).

Balaenoptera physalus is a known predator of a wide spectrum of marine organisms. These range from copepods to euphausiids to small schooling fish such as capelin *Mallotus villosus* and herring *Clupea harengus* (Jonsgård, 1966; Sergeant, 1977; Gambell, 1985), as well as anchovy *Engraulis encrasicolus* (Jonsgård, 1966), sand lance *Ammodytes* spp. (Overholtz & Nicolas, 1979), and probably sardine *Sardina pilchardus* (Sergeant, 1977). Several authors (reviewed in Jonsgård, 1966) proposed that in the North Atlantic crustaceans (mostly krill) constitute the preferred food of fin whales, which exploit fish only when crustaceans are unavailable. Knowledge of the species' feeding habits in the Mediterranean is partial, being based primarily on the inspection of a small sample of stranded whales' stomachs (Viale, 1985; Besson, Duguy & Tardy, 1982; Orsi Relini & Giordano, 1992) and on limited scat analyses, all from the Ligurian-Corsican-Provençal area. Such information indicates *M. norvegica* as the only known prey in this portion of the Mediterranean. Fin whale faeces, appearing as bright orange, football-sized floating masses, are frequently observed during summer in the Ligurian Sea feeding grounds (Richard, 1936; Orsi Relini & Cappello, 1992). Faeces are also seen in localized regions of the southern Tyrrhenian Sea (Mussi *et al*., 1999) and of the eastern Ionian Sea off Greece (Tethys Research Institute, unpublished data). On 32 occasions from 1990 to 1999, defecating whales were observed by the Tethys Research Institute in the Ligurian Sea, and faecal samples were collected in 31 cases. Orsi Relini & Giordano (1992) analysed 15 of these and found the exclusive presence of *M. norvegica* in various developmental stages, thus indicating a monospecific predatory habit by the observed whales.

Fin whales have long been thought to concentrate in summer in the Ligurian Sea for feeding reasons (Duguy & Vallon, 1976; Viale, 1985; Duguy, 1990a). Relini *et al*. (1992, 1994) and Orsi Relini *et al*. (1992) demonstrated the strong correlation between whales and krill, which they found to be present in the Ligurian Sea throughout the year, although in greater concentrations during summer. They found the greatest densities of both whales and krill in association with areas of divergence of the Ligurian-Provencal front.

Observations of fin whales engaging in feeding, frequent on many feeding grounds in the world (e.g. Watkins & Schevill, 1979), are strikingly absent in the Ligurian-Corsican-Provençal Basin, in spite of the wealth of direct observation time collectively spent by many investigators on these feeding grounds. This is likely related to the vertical distribution and movement pattern of the whales' main prey in the area. *Meganyctiphanes norvegica* in the Mediterranean is known to spend the daylight hours at depths often below 1000 m, and to migrate to about 30–50 m from the surface only during the night (Casanova, 1970; Franqueville, 1971). Accordingly, fin whales in the Ligurian Sea perform the deepest dives known for the species, exceeding 470 m (Panigada *et al*., 1999), and their feeding behaviour was thus never seen at the surface. For the same reason, foraging associations between whales and marine birds are extremely scarce in the Ligurian-Corsican-Provençal Basin. Rare instances have been reported of Cory's shearwaters *Calonectris diomedea* and black terns *Clidonias niger* flying over fin whales, perhaps attracted by swarms of euphausiids driven to the surface by the feeding cetaceans (Forcada *et al*., 1996). Forcada *et al*. (1996) noted that fin whales in the north-western Mediterranean feeding grounds were found in groups (mean = 1.44) smaller than in most known feeding grounds in the North Atlantic (typically composed of 1.4–2.5 individuals), or in the Southern Ocean (mean = 2–3). Since whale group size is related to the pattern of prey distribution, which in the Mediterranean is likely to be very patchily dispersed over a wide area, a loose schooling behaviour would reduce intraspecific competition and maximize foraging efficiency (Forcada *et al*., 1996).

Very little is known about the availability of krill to whales in seasons other than summer, and whether Mediterranean fin whales feed at other times of the year. Orsi Relini *et al*. (1994) found krill in the Ligurian Sea in all seasons covered by their sampling (spring, summer and autumn). In winter an indirect indication of abundance is provided by the well-known mass stranding events of euphausiid swarms along the coast of western Liguria, southern France and Monaco (Franqueville, 1971; Orsi Relini *et al*., 1994). In the absence of better knowledge throughout the region, it can be suggested that krill is available as a prey over a wide temporal span, perhaps even year-round, and the hypothesis should be tested that fin whales in the Mediterranean may not be limited by their environment to a strict summer feeding season.

Whether fin whales in the Mediterranean feed solely on krill is also unknown. Stomachs were inspected and faeces were analysed only in the Ligurian-Corsican-Provençal Basin during summer, and in different seasons and different areas whales may resort to other prey types, such as small schooling fish. Jonsgård (1966) observed that in the North Atlantic fin whales are planktophagous during summer and ichthyophagous in winter; this may also be the case in the Mediterranean, where the potential importance of micronectonic fish should not be neglected (Viale, 1985). The possibility that fin whales seen in unusually high numbers near the coast in the Gulf of Lions in summer 1997 may have been engaging in feeding on abundant sardines and anchovies was proposed by Beaubrun *et al*. (1999). This event may have been related to a possible temporal scarcity of the *M. norvegica* biomass, caused by a supposed delay of the spring phytoplankton bloom. That fin whales in the wider Mediterranean may not be as closely linked to *M. norvegica* is also indicated by reports of *B. physalus* chasing fish from other portions of the region, such as the Alboràn Sea (Cañadas *et al*., 1999) and off Ischia in the southern Tyrrhenian Sea (Mussi *et al*., 1999). More research is needed in other Mediterranean areas where the existence of fin whale feeding grounds is suspected in order to ascertain whether feeding occurs on fish as well as on crustaceans in such places. Such areas would include the western Ionian Sea off the Greek coast, and the waters surrounding the Sicilian island of Lampedusa (Marini *et al.*, 1996d).

BEHAVIOUR

Fin whales, like most mysticetes, are social mammals which are presumed to be capable of communicating over large distances (Payne & Webb, 1971). Because of the range of their vocalizations, it is quite likely that they can maintain social cohesion even when perceived by human observers to be alone. While we recognize the difficulty of reliably defining the concept of a 'group' in mysticetes (see Clapham, 2000), the term 'group' used here means '… affiliations in which two or more individuals swim side by side within 1–2 body lengths and generally coordinate at least their surfacing and diving, as well as their speed and direction of movement' (Clapham, 2000).

Table 2. Group sizes of fin whales observed in the Mediterranean Sea

n	Mean	S.E.	Range	Location	Reference
478	2.15		1–30	Ligurian-Corsican-Provençal Basin	Duguy & Vallon (1976)
107	1.48			Ligurian Sea	Zanardelli, Notarbartolo di Sciara & Jahoda (1992)
20	1.5	0.19	1–4	Central Mediterranean	Notarbartolo di Sciara *et al.* (1993)
53	1.5	0.1	1–3	Ligurian-Corsican-Provençal Basin	Forcada, Notarbartolo di Sciara & Fabbri (1995)
62	1.44	0.08		Ligurian-Corsican-Provençal Basin	Forcada *et al.* (1996)
123	1.44	1.18	1–11	Central Tyrrhenian Sea	Marini *et al.* (1996b)
	1.44			Off north-western Sardinia	Lauriano (1997)
	1.25			Gulf of Lions, Ligurian-Corsican-Provençal Basin	Beaubrun *et al.* (1997)
	1.64			Ligurian-Corsican-Provençal Basin	Gannier (1997b)
75	1.71	0.11	1–5	Ligurian Sea	Airoldi *et al.* (1999)

Mean fin whale group size in the Mediterranean was often recorded, and is summarized in Table 2. Most authors agree in reporting mean group sizes ranging between 1.3 and 1.7 whales. A notable exception is given by Duguy & Vallon (1976), who reported a much higher mean group size of 2.15 with as many as 30 individuals seen together; these, however, might have been feeding aggregations quite different from the close, coordinated associations defined above. Group size values from the Mediterranean are lower than most of those reported elsewhere, but intermediate between the values from the north-eastern US continental shelf given by Seipt *et al.* (1990) and those reported by Hain *et al.* (1992) from the same area. This suggests that, aside from a problem of definition, the question of what makes fin whales associate is a complex one that needs further investigation. Most Mediterranean values refer to whales sighted on their summer feeding grounds, where a possible adaptive explanation for smaller group sizes, related to the patchiness of prey, was proposed by Forcada *et al.* (1996). It is noteworthy that in fin whale groups sighted year-round in the central Tyrrhenian Sea, outside known feeding grounds, variance was higher and the maximum observed group size reached the unusually high value of 11 (Marini *et al.*, 1996b). Based on re-sightings within seasons of photo-identified whales in the Ligurian Sea, group composition changed always, indicating a large variability in social aggregation (Zanardelli, Notarbartolo di Sciara & Jahoda, 1992). Furthermore, in 14 cases in which both individuals in pairs could be sexed, no sex predominance was apparent, while male–female pairs were significantly more frequent (χ^2 $P < 0.05$) than couples of the same sex (Zanardelli, Notarbartolo di Sciara & Jahoda, 1992). Panigada *et al.* (in press) reported significant variation in group size across years between 1990 and 1999, ranging between 1.4 and 2.1, perhaps influenced by the reported great year-to-year variability of krill abundance (Franqueville, 1971).

Fin whale swimming and diving patterns in the Ligurian Sea have recently been the subject of considerable research effort. Panigada *et al.* (1999) applied velocity-time-depth-recorders (v-TDR) with suction cups to six fin whales, revealing diving abilities hitherto unsuspected in this species. Depths exceeding 470 m were attained twice, while dives of at least 150 m were routinely performed around sunset. This suggests that Mediterranean fin whales have achieved deep diving capabilities to match diel vertical migrations of their prey, and to prolong feeding time in spite of the protracted residency of krill at depths greater than 750 m.

Jahoda *et al*. (2003), by means of a passive tracking technique based on laser range-finding coupled with global positioning system (GPS) technology, detected two major horizontal swimming modes in fin whales, linear and convoluted. They suggested that the first may be associated with travelling and the second with feeding. In one instance in which surface horizontal movements could be associated with dive profiles through the use of v-TDRs (Jahoda *et al*., 1999), linear swimming coincided with shallow dives (mean depth = 9.82 m ± 5.35 S.D., max = 20 m), whereas convoluted swimming, confined to a much more restricted area, coincided with very deep dives (mean 181.29 m ± 195.45 S.D., max = 474 m). Ventilation intervals were distinguished from dives by a cut-off point placed at 26 s, on the basis of log-survivorship analysis (Jahoda *et al*., 2003); this is in remarkable agreement with the cut-off value of 25 s calculated for North Atlantic fin whales by Stone *et al*. (1992). Dive/ventilation data were recorded on 18 fin whales, and yielded a mean dive time (defined as an interval between consecutive blows ≥26 s) of 227.5 s (± 133.3 S.D.), a mean blow interval (time between two consecutive blows ≤26 s) of 17.1 s (± 1.5 S.D.), a mean surface time (sum of all consecutive blow intervals ≤26 s) of 90 s (± 34.6 S.D.), and a mean of 5.2 blows (± 2.4 S.D.) per surface time (Jahoda *et al*., 2003). Both mean dive time and mean surface time in the Mediterranean were higher than in other regions (Jahoda & Notarbartolo di Sciara, 1993), probably as a consequence of different ecological conditions. Mean horizontal swimming velocity was 1.3 m/s (± 0.5 S.D.), lower than the mean 3–4 knots (= 1.5–2 m/s) described by Duguy & Vallon (1976), but much higher than the mean value of 0.4 m/s (1.5 km/hour) computed over long periods through radiotelemetry on Atlantic whales (Watkins *et al*., 1984, 1996). This likely reflects the inclusion in the latter of resting time that was precluded in the former studies by disturbance from human observers. Duguy & Vallon (1976) reported a fin whale which was seen following a ferry for 10 min at 19 knots (9.8 m/s).

Although aerial displays are generally considered rather rare in fin whales (Whitehead, 1985; Pryor, 1986), Marini *et al*. (1996c) described the occurrence of breaching in the central Tyrrhenian Sea as relatively frequent (4% of all their sightings). We recorded breaching in 6.9% of our fin whale sightings in the Ligurian-Corsican-Provençal Basin (1990–99). The mean number of consecutive breaches we observed was 2.45 ($n = 34$, S.E. = 0.39, mode = 1, range 1–6). The mean size of groups with breaching animals was 2.24 ($n = 34$, S.E. = 0.23, range 1–7, mode = 1), significantly greater than non-breaching groups ($n = 459$, mean = 1.75, S.E. = 0.05, range = 1–6, mode = 1) (unpaired, two-tailed, Student's *t*-test, $t = 2.48$, $P < 0.05$).

Fin whales are known to produce a variety of sounds, most typically high-intensity 20-Hz pulses. These are likely used for local and long-distance communication (Watkins, 1981). Until recently, there were no published reports of fin whale sounds from the Mediterranean region, and extensive near-surface underwater listening and sound recordings in the Ligurian-Corsican-Provençal Basin (Notarbartolo di Sciara & Gordon, 1997) had failed to detect acoustic signals from *B. physalus*. This was probably due to the masking effect of the loud low-frequency background noise, produced continuously by the region's intense vessel traffic. Fin whales were first recorded in the Ligurian Sea in 1999 using autonomous seafloor recorders ('pop-ups'), deployed south of the Italian coast and north-west of Corsica. Recordings revealed that whales produce long, patterned sequences of infrasonic pulses of two types: the typical fin whale '20-Hz' pulse (1 s, 25–19 Hz), and a narrow-band pulse type (1 s, 22–19 Hz), referred to as a 'backbeat'. These basic acoustic features are different from those reported for fin whales elsewhere in the North Atlantic, raising the possibility that genetic differences at the population level are reflected in this stereotyped acoustic behaviour (Clark, Borsani & Notarbartolo di Sciara, 2002).

Cetaceans regularly found in the Ligurian-Corsican-Provençal Basin include sperm whales *Physeter macrocephalus*, Cuvier's beaked whales *Ziphius cavirostris*, long-finned pilot whales *Globicephala melas*, Risso's dolphins *Grampus griseus*, common bottlenose dolphins *Tursiops truncatus*, striped dolphins *Stenella coeruleoalba* and short-beaked common dolphins *Delphinus delphis* (Notarbartolo di Sciara, 1994). Of these species, only striped dolphins were found to associate with fin whales. Of 493 fin whale sightings made by the Tethys Research Institute during summer between 1990 and 1999, in 91 (18.5%) whales and striped dolphins were sighted in close association; in 12 of these, dolphins were observed 'bowriding' the whales.

CAUSES OF MORTALITY AND THREATS

Known causes of past or current mortality for fin whales in the Mediterranean include deliberate killing by humans, collisions with vessels, and entanglement in fishing gear. Other factors that may have negative effects on the conservation status of Mediterranean fin whales include: (i) disturbance by anthropogenic noise, vessel traffic, intrusive whale watching and research; (ii) pollution; (iii) parasite load and disease; and (iv) predation.

Deliberate killing

Commercial whaling, other than in the Gibraltar area, never took place in the Mediterranean proper, probably because whales had always been presumed to be too rare to warrant the effort (Toschi, 1965). However, fin whales were occasionally killed during the 19th and first half of the 20th century. These kills took place for several reasons: for museum collections and research (Richard, 1936), as target practice by the military (Minà Palumbo, 1868; Cornalia, 1872; Parona, 1896, 1908; Anonymous, 1903; Cagnolaro, 1977), and by fishermen who often undertook to chase and kill large cetaceans. These latter hunts took both sperm whales (Bolognari, 1949) and fin whales (e.g. Lepri, 1914; Borri, 1927; Tamino, 1953a; Cyrus, 1969). The intent was presumably to extract oil or other valuable products, although the rendering of the carcasses was not always performed successfully, and the bodies were often discarded or left adrift at sea (Damiani, 1911; Borri, 1927). Today, with Mediterranean cetaceans protected by international law (under the Barcelona Convention and by ACCOBAMS) and by the national laws of most coastal countries, and because of a radical change of the public attitude towards cetaceans and wildlife in general, it is very unlikely that directed catches still occur.

Collisions with vessels

The Mediterranean Sea is one of the most heavily navigated of all marine regions, with 30% of the world's merchant shipping (Anonymous, 1999) concentrated within only 0.8% of the global ocean surface. A recent review of collisions between ships and whales by Laist *et al*. (2001) revealed that *B. physalus* is the cetacean most frequently reported as a victim of ship strikes. Ramming of fin whales by vessels has been known for a long time in the Mediterranean (Table 1, Appendix), and the frequency of these events is further corroborated by skeletal material (in museum collections) bearing distinctive signs of ship strikes (Richard, 1936). Past instances of fin whales rammed by ships have been reported off France (Duguy, 1974, 1976a, 1977; Duguy *et al*., 1983) and Italy (Parenzan, 1958; Di Natale & Giuffré, 1976; Cagnolaro & Notarbartolo di Sciara, 1992). In more recent times, records from the Italian stranding network from 1986 to 1998 revealed that 11 specimens (26.2% of the total fin whale record of 42) had been killed in vessel collisions (Anonymous, 1987, 1988, 1991, 1992, 1994a, 1996a, 1996b, 1997a, 2000). Similarly, among the cetacean stranding records from the Med-

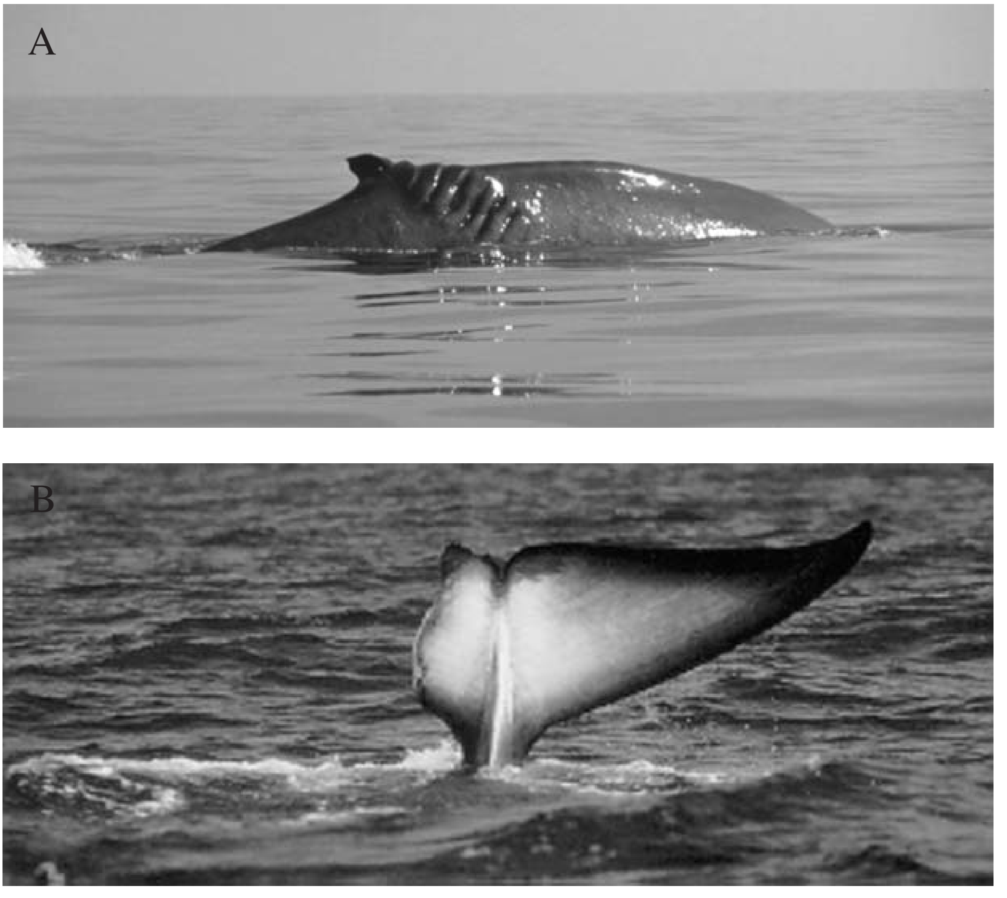

Fig. 5. Wounded fin whales in the Ligurian-Corsican-Provençal Basin. (A) Propeller scars (21 September 1998, in position 43°36.88′N, 008°07.80′E. Photograph by Tethys Research Institute.). (B) Left caudal lobe excision, possibly as a consequence of a collision with a ship (14 August 1996, in position 43°35.91′N, 008°08.49′E. Photograph by IFAW – Song of the Whale).

iterranean coasts of France (1972–98), 16 fin whales were killed by vessels or had marks of ship strikes on their bodies (Laist *et al*., 2001). Pesante *et al*. (2000) analysed a sample of 380 fin whales photo-identified in the Ligurian Sea between 1990 and 1999, 15 of which (3.9%) bore on their bodies, flukes or dorsal fins scars obviously caused by collisions with large vessels (Fig. 5). Given that this percentage represents only those individuals which survived the event, the overall impact of vessel strikes on the Mediterranean fin whale population may be far from negligible.

Disturbance

In addition to causing direct damage through collisions, and to being a major source of pollution, maritime traffic is a cause of disturbance and noise which may affect cetaceans and have long-term impacts on their populations. Whales are known to alter their behaviour as a response to disturbance deriving from the production of loud noise by industrial, extractive, prospective or military activities, or even from approaching vessels, such as during whale watching or research (Richardson *et al.*, 1995). Contrary to common belief, that cetaceans bear no economical interest for the region's human population (Tortonese, 1965), commercial whale watching is today an expanding industry in the Mediterranean. This is particularly true off the coasts of western Liguria and southern France, where whale watching has been stimulated by the recent awareness of an abundant cetacean fauna within easy reach of land. As an example, revenues of a single-vessel operation in Imperia, western Liguria, grew by a factor of 3.3 in 4 years, from €31 000 in 1996 to €103 300 in 1999 (A. Sturlese, personal communication). An anticipated substantial growth of whale watching in the Ligurian-Corsican-Provençal Basin (a very popular tourist destination) should ideally be controlled through a strict, science-based regulatory regime.

Jahoda *et al.* (2003) investigated reactions of fin whales to an approaching small inflatable using laser range-finding binoculars in association with the determination of azimuth of the target animal and position of the main observation vessel. Two different avoidance strategies were simultaneously performed by the whales: escape at increased velocity and reduction of the time spent at the surface. In comparison to the control (undisturbed) phase, disturbed fin whales significantly increased swimming speed by 23%, and decreased surface time (37%), percent of surfacing (27%), blow rate (18%), and number of blows per surfacing (29%). Soon after the disturbance ceased, the surfacing activity reverted to predisturbance conditions; however, feeding behaviour appeared to be indefinitely suspended throughout the observation time.

Despite the above, however, the long-term impacts on fin whales of disturbance from anthropogenic sources remain unknown. In particular, it is not clear whether the reproductive success of individuals, and the growth rate of the population as a whole, is negatively affected.

Entanglement in fishing gear

Although fin whales seem to be less vulnerable than most Mediterranean cetaceans to fishery entanglements, even by pelagic drift nets (Notarbartolo di Sciara, 1990), several cases of gear entrapments have been reported (Podestà & Magnaghi, 1989). The 14-year-long Italian stranding network (1986–99) recorded two fin whales entangled in drift nets (Anonymous, 1992, 1998), 4.8% of a total of 42 fin whales found during the study period, considerably less than the 57 sperm whales (59% of a total of 96) lost to drift nets during the same period. Accidental captures of Mediterranean fin whales in other fishing gear are extremely rare. Known cases include the entanglement of a juvenile in a drifting longline off eastern Sicily (Di Natale & Mangano, 1983; Duguy *et al.*, 1983), and of another 12-m-long juvenile in a tuna gill net off Sète, southern France (Anthony & Calvet, 1905). Fin whales have also been known to become entrapped occasionally in 'tonnare' (traditional tuna traps set in coastal areas in late spring); one such entanglement was recorded around 1840 near St. Tropez, southern France (Diorio, 1866), and another in 1894 near Gallipoli, Puglia (Parona, 1896). More recently, entanglements were recorded in June 1997 in the Gulf of Asinara near Stintino, northern Sardinia (G. Lauriano, personal communication), and in July 2000 near Camogli, eastern Liguria. Unlike in the other three cases, this latter individual was released at sea in apparently good condition and probably survived the incident.

Pollution

One of the first suggestions that fin whales in the Mediterranean might be affected by marine pollution was presented by Viale (1974, 1978). This author reported an apparent increase in the frequency of whale mortality in the northern Tyrrhenian Sea, suggesting a causal link between such deaths and the discharge at sea of by-products of the production of titanium dioxide, largely consisting of iron sulphate, from an industrial plant of Scarlino, southern Tuscany. Duguy & Collet (1983), examining cetaceans stranded on the French coasts, considered Mediterranean fin whale neonatal mortality to be abnormally high, and speculated that the observed small mean neonatal size of 5 m, compared to >6 m in oceanic whales, might have been caused by premature births induced by pollution; however, their speculation was based on very limited data (three neonates out of a total of 13 *B. physalus* specimens found in the Mediterranean in 10 years). Systematic studies of the contamination by xenobiotic compounds of free-ranging Mediterranean fin whales were first started in 1990 in the Ligurian Sea through the remote collection of small skin and subcutaneous blubber biopsies (Focardi *et al*., 1991; Marsili, 2000). A total of 68 samples collected between 1990 and 1993 from animals of both sexes, ranging in length from 8 to 20 m, yielded PCBs values of 5.5–7.1 ppm dry weight (dw) and DDTs values of 4.2–9.5 ppm dw (Marsili & Focardi, 1996). Such values are, for both compounds, higher than those obtained from fin whales in the Atlantic and Pacific Oceans (Marsili, 2000). Significant differences in levels of organochlorine residues in blubber were found between males and females; this is due to the ability of females to transfer their toxic load to their offspring during pregnancy and lactation (Aguilar & Borrell, 1988). As expected, the greatest differences were found among adults (Marsili, 2000). Organochlorine values in *B. physalus* were significantly ($P < 0.001$) lower than those found in *S. coeruleoalba*, sampled in the same area and time, this difference probably being caused by the different trophic levels at which the two species feed (Marsili & Focardi, 1996). Much higher levels of organochlorine compounds (up to 47.29 and 61.9 mg/kg lipid weight, respectively, for PCBs and DDTs) were found in the tissues of three stranded immature fin whales by Alzieu & Duguy (1979), two from the Mediterranean and one from the Atlantic, suggesting a causal link between the whales' contamination state and the stranding events.

The poor detoxifying potential possessed by marine mammals (relative to that of terrestrial mammals) is evident in studies of both Mediterranean fin whales and striped dolphins. Analysis of mixed-function oxidase using skin biopsies (Fossi *et al*., 1992) revealed a significant correlation between organochlorine contamination and biomarker response (Marsili *et al*., 1998). An analysis of 14 polycyclic aromatic hydrocarbons (PAHs) was performed on skin biopsies collected from 23 fin whales in the Ligurian Sea in 1993 and 1996. The median value of total PAHs was 1970 ppb fresh weight (fw), while median carcinogenic PAH values were 89.8 ppb fw (Marsili *et al*., 2001). Interestingly, both total and carcinogenic PAHs in 1993 were significantly higher than in 1996; this was probably a consequence of major oil spills which occurred in the Ligurian Sea in April 1991, when two oil tankers named *Agip Abruzzi* and *Haven* exploded off Livorno and Genova, respectively, within a 12-hour span. The latter released into the sea 144 000 t of 'Iranian heavy 090' oil (Marsili *et al*., 2001). Conversely, DDT concentrations in the blubber of whales sampled in the early 1990s significantly decreased between 1990 and 1991, levelling off afterwards, perhaps reflecting a decrease in DDT use in North Africa (Marsili, 2000). Skin biopsies from 35 fin whales sampled in the Ligurian Sea were also analysed for hexachlorobenzene (HCB) and trace elements. The study revealed low levels of contamination from these substances relative to those observed in striped dolphins sampled in the same area and time (Focardi *et al*., 1992). Observed levels for fin whales were HCB 0.11 ppm fw, S.D. = 0.06; Pb 2.32 ppm fw, S.D. = 1.5; Cd 0.25 ppm fw, S.D. = 0.2; Hg 0.65 ppm fw, S.D. = 0.3. Data on total mercury collected from a young specimen of fin whale found in the harbour of Trieste in 1976 were given by Princi & Bussani (1976), and ranged from a minimum of 0.10 ppm in the blood to a maximum of 0.28 ppm in the faeces.

Parasites

The presence on Mediterranean fin whales of ectoparasitic copepods *Pennella* sp. has been known for a long time (Richiardi, 1874; Anthony & Calvet, 1905). Such parasites are commonly observed on fin whales in the Ligurian-Corsican-Provençal Basin, and are occasionally quite abundant and uniformly distributed over the visible part of the surfacing whales' body. Cases of particularly severe infestations by *Pennella* are known in weakened specimens, such as the whale which stranded alive near Livorno in October 1990 (Benvenuti *et al*., 1991). In addition, marine lampreys *Petromyzon marinus* were occasionally observed by us in the Ligurian Sea clinging to the whales' side, and many identified individuals in the Tethys' fin whale photographic catalogue show the winding whitish, ribbon-like marks that are typically left on whales by lampreys (Pike, 1951). Accounts of endoparasites in Mediterranean fin whales are quite rare. They include the mention of a few unidentified nematodes found in the stomach of a young whale stranded near Salerno in 1953 (Tamino, 1953b), a report of large numbers of digenean trematodes *Ogmogaster antarcticus* from the caecum and colon of a young male stranded along the east coast of the northern Tyrrhenian Sea (Malatesta *et al*., 1998), and the finding of a massive infestation by nematodes *Crassicauda* sp. in a juvenile stranded in Turkey (A. Dede, posted on the ECS-ALL Discussion List on 11 March 2002).

Disease

After the Mediterranean striped dolphin morbillivirus epizootic of 1990–92 (Aguilar & Raga, 1993), and following the report of an infected *B. physalus* in the North Sea (Jauniaux *et al*., 1998), it was feared that the disease might spread to fin whales in the Mediterranean. Such apprehension perhaps induced unwarranted diagnoses of exanthematic infection of fin whales in this region, following the stranding of two specimens in a 2-month period (Sept–November 1995), and the sighting of a free-swimming individual bearing reddish marks on its back, interpreted as skin eruptions (Guibourgé *et al*., 1996). In reality, as is evident from the published photograph, the latter were the typically coloured abdominal portions of *Pennella* sp., protruding from the host's skin. No further information was given about viral analyses on the specimens, reportedly under way at the time of publication (Guibourgé *et al*., 1996); apparently morbillivirus did not spread to Mediterranean fin whales, and luckily epizootics were never observed.

Predation

Few extant predators are known or suspected to pose threats to large whales world-wide. Potential cetacean predators include killer whales *Orcinus orca* (Vidal & Pechter, 1989), and false killer whales *Pseudorca crassidens*. It is also possible that fin whales are occasionally preyed upon by large sharks, such as the white shark *Carcharodon carcharias* (Connor, 2000). All three species are present in the Mediterranean; however, killer whales and false killer whales are very rare and occur only accidentally in the region (Notarbartolo di Sciara, 1987; Notarbartolo di Sciara & Demma, 1997). By contrast, the Mediterranean Sea is known as a centre of reproduction and abundance of white sharks (Fergusson, 1996), and thus the possibility of predation at least on juvenile or weakened fin whales cannot be dismissed. Although no such events have been documented in the Mediterranean, an old report exists of sharks (possibly white sharks, *Carcharodon rondeletii* = *C. carcharias*) showing interest in a towed fin whale carcass off the Ligurian coast (Parona, 1896). Another report concerns a shark supposedly attacking and killing a small balaenopterid whale, possibly a juvenile *B. physalus* or a minke whale *B. acutorostrata* near Elba Island in November 1910 (Damiani, 1911). A fin whale carcass stranded on the northern coast of Sicily in 1976 also bore shark bite marks on one of the tail flukes (Di Natale & Giuffré, 1976).

CONCLUSIONS AND CONSERVATION RECOMMENDATIONS

Based on genetic evidence, Mediterranean fin whales are likely a resident population, reproductively isolated from those inhabiting the Atlantic Ocean. This possibility bears substantial conservation implications: given its likely small size and confinement in a partially degraded marine environment, this population should be considered vulnerable. A crucial element of a Mediterranean fin whale conservation strategy thus involves setting priorities for research. Essential fin whale habitat in the Mediterranean needs to be precisely identified, by linking whale presence to oceanographic features of the Mediterranean, and potentially to predict where they should occur in other portions of the region. Although localized breeding sites may not exist, hot spots of marine productivity linked with the presence of feeding whales should be recognized and protected. These may include areas in the Ionian Sea and off the African coast south of Sicily. In addition, connecting movements of migrating whales between such areas and the well-known Ligurian-Corsican-Provençal Basin feeding grounds, possibly involving crossing through narrow straits (e.g. the Strait of Messina), requires elucidation through appropriate satellite tagging programmes. Genetic analyses should be undertaken on specimen material (baleen, bone or cartilage) remaining from the whaling operations formerly occurring in the Strait of Gibraltar, to reconstruct the population identity of those specimens and determine their relationship to both Atlantic and Mediterranean whales. To detect possible trends, total population size of fin whales in the Mediterranean should be assessed by replicating line-transect surveys performed a decade ago in the western Mediterranean (Forcada, Notarbartolo di Sciara & Fabbri, 1995; Forcada *et al.*, 1996) and by extending survey effort to the whole basin. An effort should also be made to gain insight into the question of whale food requirements, consumption and availability, particularly to estimate the standing crop of krill. Finally, the ability of Mediterranean fin whales to switch to other prey types should be investigated, and an assessment made of the potential risk of krill depletion due to environmental degradation or climate change.

Contamination of the food chain by toxic man-made compounds and negative interactions with fisheries are commonly considered among the main factors threatening cetacean survival on a global scale. Indeed, such factors are particularly evident in the semi-enclosed, overexploited Mediterranean Sea (Anonymous, 1999). Fisheries and pollution, however, do not seem to be affecting fin whales as much as other cetacean species in the region. Although the negative effects of persistent organic pollutants and trace elements may not be irrelevant for fin whales (Fossi *et al.*, 1992), contamination levels in *B. physalus* are the lowest known among studied Mediterranean cetaceans. Accidental captures of fin whales in fishing gear are also quite uncommon in the region, and the impact on the population is therefore considered minimal (Anonymous, 1994b). By contrast, ship strikes are a significant source of fin whale mortality in the Mediterranean, potentially on the increase. This is reflected by the growth of vessel traffic and the rapid development of high-speed maritime transportation taking place throughout the Mediterranean, particularly in its north-western portion. In addition, other human activities may generate potentially high levels of disturbance which is known to induce short-term avoidance reactions in whales. These include intense maritime traffic, a burgeoning and currently unregulated whale-watching industry (Airoldi *et al.*, 1999), loud noise production by oil and gas prospecting and military activities, and even scientific research on the whales themselves. Disturbance from intrusive human presence at sea can cause disruption of fin whale feeding activities (Jahoda *et al.*, 2003). In light of the fact that the whales' preferred prey *M. norvegica* is likely unavailable to predation throughout the 24 hour daily cycle due to its deep vertical migration habits, it is possible that fin whales may be more energetically stressed and therefore more susceptible to disturbance than mysticetes which do not need to dive deeply to forage. Ultimately, the question becomes whether human disturbance of the types listed above affect the reproductive success and growth of the population. It may be that the amount of time that an individual whale is exposed to disturbance is inconsequential when viewed as a fraction of the time it spends engaged in key behaviours like foraging; but this remains to be studied. Until this issue is better understood, we suggest that unlimited and unregulated approaches to fin whales and other cetaceans by an array of seafarers, whale watchers and amateurs (e.g. de la Poype & Riddell, 1997) is inadvisable and should be strongly discouraged.

We are hopeful that the fin whale in the Mediterranean can be protected and conserved in the future. Particularly encouraging in this regard was the entry into force in Febraury 2002 of the *Agreement on the Creation of a Mediterranean Sanctuary for Marine Mammals* between France, Italy and Monaco. This agreement encompassed essential fin whale habitat in portions of the Ligurian-Corsican-Provençal Basin, northern Tyrrhenian and northern Sardinian Seas, an area also known as the 'Ligurian Sea Sanctuary'. The agreement provides the appropriate legislative framework for specific, effective cetacean protection, and should ensure, among other things, the sustainable and sensible development of the whale-watching industry in this region. Conservation tools such as the Ligurian Sea Sanctuary represent part of a broader attempt to promote a region-wide cetacean conservation strategy. In particular, such conservation efforts is becoming possible through two other agreements, the *Protocol Concerning Specially Protected Areas and Biological Diversity in the Mediterranean* of the Barcelona Convention, and the *Agreement on the Conservation of Cetaceans of the Black Sea, Mediterranean Sea and Contiguous Atlantic Area* (ACCOBAMS). Both of these important agreements were recently adopted by signatory governments. It is to be hoped that their passage reflects the beginning of a more enlightened attitude towards the future conservation of fin whales and other marine species in the Mediterranean Sea.

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REFERENCES

Affronte, M. (2000) Balenottere a frotte in Alto Adriatico. *Cetacea Informa*, **9**, 9–12.

Agler, B.A., Beard, J.A., Bowman, R.S., Corbett, H.D., Frohock, S.E., Hawermale, M.P., Katona, S.K., Sadove, S.S. & Seipt, I.E. (1990) Fin whale (*Balaenoptera physalus*) photographic identification: methodology and preliminary results from the Western North Atlantic. In: *Individual Recognition of Cetaceans: Use of Photo-Identification and Other Techniques to Estimate Population Parameters* (Ed. by P.S. Hammond, S.A. Mizroch & G.P. Donovan), pp. 349–356. Reports of the International Whaling Commission, Special Issue 12, Cambridge.

Aguilar, A. & Borrell, A. (1988) Age- and sex-related changes in organochlorine compound levels in fin whales (*Balaenoptera physalus*) from the Eastern North Atlantic. *Marine Environmental Research*, **25**, 195–211.

Aguilar, A. & Lockyer, C.H. (1987) Growth, physical maturity, and mortality of fin whales (*Balaenoptera physalus*) inhabiting the temperate waters of the northeast Atlantic. *Canadian Journal of Zoology*, **65**, 253–264.

Aguilar, A. & Raga, J.A. (1993) The striped dolphin epizootic in the Mediterranean Sea. *Ambio*, **22**, 524–528.

Airoldi, S., Azzellino, A., Nani, B., Ballardini, M., Bastoni, C., Notarbartolo di Sciara, G. & Sturlese, A. (1999) Whale-watching in Italy: results of the first three years of activity. *European Research on Cetaceans*, **13**, 153–156.

Aloncle, H. (1964) Premières observations sur les petits cétacés des côtes marocaines. *Bulletin de l'Institut des Pêches Maritimes du Maroc*, **12**, 21–42.

Alzieu, C. & Duguy, R. (1979) Teneurs en composés organochlorés chez les cetacés et pinnipèdes fréquentant les côtes françaises. *Oceanologica Acta*, **2**, 107–120.

Anonymous (1903) Una balenottera presa a Savona. *L'Acquicoltura lombarda*, **5**, 133.

Anonymous (1932) Un balenottero distratto. *La Domenica del Corriere*, **34**, 47.

Anonymous (1942) *International Whaling Statistics. XVI.* Committee for Whaling Statistics, Oslo.

Anonymous (1950) *International Whaling Statistics. XXIII.* Committee for Whaling Statistics, Oslo.

Anonymous (1987) Cetacei spiaggiati lungo le coste italiane. I. Rendiconto 1986. *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **128**, 305–313.

Anonymous (1988) Cetacei spiaggiati lungo le coste italiane. II. Rendiconto 1987 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **129**, 411–432.

Anonymous (1990) Report of the Workshop. In: *Individual Recognition of Cetaceans: Use of Photo-Identification and Other Techniques to Estimate Population Parameters* (Ed. by P.S. Hammond, S.A. Mizroch & G.P. Donovan), pp. 3–17. Reports of the International Whaling Commission, Special Issue 12, Cambridge.

Anonymous (1991) Cetacei spiaggiati lungo le coste italiane. IV. Rendiconto 1989 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **131**, 413–432.

Anonymous (1992) Cetacei spiaggiati lungo le coste italiane. V. Rendiconto 1990 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **132**, 337–355.

Anonymous (1994a) Cetacei spiaggiati lungo le coste italiane. VI. Rendiconto 1991 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **133**, 261–291.

Anonymous (1994b) Report of the workshop on mortality of cetaceans in passive fishing nets and traps. In: *Gillnets and Cetaceans.* (Ed. by W.F. Perrin, G.P. Donovan & J. Barlow), pp. 1–72. Reports of the International Whaling Commission, Special Issue 15, Cambridge.

Anonymous (1995) Cetacei spiaggiati lungo le coste italiane. VII. Rendiconto 1992 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **134**, 285–298.

Anonymous (1996a) Cetacei spiaggiati lungo le coste italiane. VIII. Rendiconto 1993 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **135**, 437–450.

Anonymous (1996b) Cetacei spiaggiati lungo le coste italiane. IX. Rendiconto 1994 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **135**, 451–462.

Anonymous (1997a) Cetacei spiaggiati lungo le coste italiane. X. Rendiconto 1995 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **136**, 205–216.

Anonymous (1997b) Cetacei spiaggiati lungo le coste italiane. XI. Rendiconto 1996 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **137**, 135–147.

Anonymous (1998) Cetacei spiaggiati lungo le coste italiane. XII. Rendiconto 1997 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **139**, 213–226.

Anonymous (1999) *State and Pressures of the Marine and Coastal Mediterranean Environment.* European Environment Agency, Environmental Issues Series no. 5.

Anonymous (2000) Cetacei spiaggiati lungo le coste italiane. XIII. Rendiconto 1998 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **141**, 129–143.

Anonymous (2001) Cetacei spiaggiati lungo le coste italiane. XIV. Rendiconto 1999 (Mammalia). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **141**, 353–365.

Anthony, R. & Calvet, J. (1905) *Recherches faites sur le cétacé capturé a Cètte, le 6 octobre 1904 – Balaenoptera Physalus (Linné).* Bulletin de la Société Philomatique.

Barberis, S., Davico, A., Davico, L., Massajoli, M. & Trucchi, R. (1997) The third WWF research campaign in the Ligurian Sea. *European Research on Cetaceans*, **11**, 99.

Bayed, A. & Beaubrun, P.-C. (1987) Les mammifères marins du Maroc: inventaire préliminaire. *Mammalia*, **51**, 437–446.

Beaubrun, P.-C., David, L., Di Meglio, N., Gannier, A. & Gannier, O. (1997) First aerial survey in the north-west Mediterranean: preliminary results. *European Research on Cetaceans*, **11**, 100–103.

Beaubrun, P.-C., David, L., Fabre, J.L. & Muller, M. (1999) Exceptional appearance of fin whales during the summer 1997, in the Gulf of Lion (French Mediterranean coast). *European Research on Cetaceans*, **13**, 162–164.

Bello, G. (1990) I cetacei dei mari di Puglia. *Umanesimo della Pietra Verde, Martina Franca*, **5**, 5–16.

Ben Mustapha, K. (1986) Echouage d'un rorqual commun *Balaenoptera physalus* (Linné 1758) à Carthage Dermech dans le Golfe de Tunis. *Bulletin de l'Institut National Scientifique et Technique d'Océanographie et de Peche de Salammbô*, **13**, 19–24.

Benvenuti, A., Bortolotto, A., Gonnella, S., Odierna, A. & Stanzani, A.L. (1991) Report on rescue treatment of two whales in the Mediterranean. *European Research on Cetaceans*, **5**, 118–123.

Bérubé, M., Aguilar, A., Dendanto, D., Larsen, F., Notarbartolo di Sciara, G., Sears, R., Sigurjonsson, J., Urbàn, R. & Palsbøll, P. (1998) Population genetic structure of North Atlantic, Mediterranean Sea and Sea of Cortez fin whales, *Balaenoptera physalus* (Linnaeus, 1758); analysis of mitochondrial and nuclear loci. *Molecular Ecology*, **7**, 585–599.

Besson, J., Duguy, R. & Tardy, G. (1982) Note sur un cas de multiparité chez un rorqual commun (*Balaenoptera physalus*). *Mammalia*, **46**, 408.

Best, P.B. (1977) Two allopatric forms of Bryde's whale off South Africa. *Reports of the International Whaling Commission*, **Special issue 1**, 10–35.

Best, P.B. (1992) Catches of fin whales in the North Atlantic by the M.V. Sierra (and associated vessels). *Report of the International Whaling Commission*, **42**, 697–700.

Bolognari, A. (1949) A proposito della recente cattura di alcuni esemplari di capodoglio (*Physeter macrocephalus* L.) nel Mediterraneo. *Bulletin de l'Institut Océanographique (Fondation Albert 1^er^. Prince de Monaco)*, **949**, 1–43.

Bompar, J.-M. (2000) *Les cétacés de Méditerranée*. Édisud, La Calade, Aix-en-Provence.

Borrell, A., Aguilar, A., Forcada, J., Fernàndez, M., Aznar, F.J. & Raga, J.A. (2000) Varamiento de cetàceos en las costas espanolas del Mediterràneo durante el periodo 1989–2000. *Miscellània Zoologica*, **23**, 1–17.

Borri, C. (1927) Una notabile comparsa di grandi cetacei nell'Arcipelago Toscano. *Monitore Zoologico Italiano*, **38**, 18–23.

Boutiba, Z. (1994a) Bilan de nos connaissances sur la présence des cétacés le long des côtes algériennes. *Mammalia*, **58**, 613–622.

Boutiba, Z. (1994b) Cetaceans in Algerian coastal waters. *European Research on Cetaceans*, **8**, 104–106.

Boutiba, Z., Hamoutene, D., Merzoug, D., Bouderbala, M., Taleb, M.Z. & Abdelghani, F. (1996) *Le rorqual commun (Balaenoptera physalus) dans le bassin sud de la Méditerranée occidentale: état actuel des observations*, pp. 30–32. Proceedings of the 5th International Conference RIMMO, 15–17 November 1996. Antibes, France.

Bradai, N.M. & Ghorbel, M. (1999) Les cétacés dans les eaux tunisiennes: nouvelles mentions d'éspèces rares en Méditerranée. In: *Actes de la 8ème Conference Intérnationale RIMMO* (Ed. by M. Riddell & M. Aubert), pp. 51–53. Sophia Antipolis, 19–21 November 1999.

Brusina, S. (1889) Sisavci Jadranskoga mora: Gradja za faunu hrvatsku uz obzir na ostale sisavce Sredozemnoga mora. *Rad Jazu, Zagreb*, **95**, 79–177.

Cabrera, A. (1925) Los grandes cetàceos del Estrecho de Gibraltar, su pesca y explotaciòn. *Trabajos Museo Nacional de Ciencias Natuales, Madrid, Serie Zoologica*, **52**, 5–48.

Cagnolaro, L. (1977) Lo scheletro di *Balaenoptera physalus* (L.) esposto al Museo Civico di Storia Naturale di Milano. Studio osteometrico. *Natura, Società Italiana di Scienze Naturali, Museo Civico di Storia Naturale, Acquario Civico, Milano*, **68**, 33–64.

Cagnolaro, L. (1996) Profilo sistematico e tipologico delle raccolte di cetacei attuali dei musei italiani. *Museologia Scientifica*, **13**, 193–212.

Cagnolaro, L., Cozzi, B., Magnaghi, L., Podestà, M., Poggi, R. & Tangerini, P. (1986) Su 18 cetacei spiaggiati sulle coste italiane dal 1981 al 1985: rilevamento biometrico ed osservazioni necroscopiche (Mammalia: Cetacea). *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **127**, 79–106.

Cagnolaro, L. & Notarbartolo di Sciara, G. (1992) Research activities and conservation status of cetaceans in Italy. *Bollettino dei Musei e degli Istituti Biologici dell'Università di Genova*, **56**, 57, 53–85.

Cañadas, A., Sagarminaga, R., Hernàndez-Falcòn, L., Fernàndez, E. & Fernàndez, M. (1999) Fin whales (*Balaenoptera physalus*) in the northern part of the Alboran Sea and Strait of Gibraltar. *European Research on Cetaceans*, **13**, 300–304.

Capellini, G. (1877) Sulla balenottera di Mondini: *Rorqual de la Mer Adriatique* di G. *Cuvier. Memorie della Reale Accademia delle Scienze dell'Istituto di Bologna*, **7**, 413–448.
Carpentieri, P., Corsini, M. & L.Marini (1999) Contribute to the knowledge of the presence and distribution of cetaceans in the Aegean Sea. *Atti della Società Italiana di Scienze Naturali, Museo Civico di Storia Naturale, Milano*, **140**, 65–75.
Carruccio, A. (1913) Sulla *Balaenoptera acuto-rostrata* catturata per la prima volta nel Mare Laziale (Castel Fusano). E notizie su altri giganteschi cetacei arenati e catturati lungo le coste dello stesso mare dai tempi più remoti agli attuali. *Bollettino della Società Zoologica Italiana, Serie III*, **2**, 157–169.
Casanova, B. (1970) Répartition bathymétrique des euphausiacés dans le bassin occidental de la Méditerranée. *Revue de Travaux de L'Institut des Pêches Maritimes*, **34**, 205–219.
Casinos, A. & Filella, S. (1975) Primer recull anual (1973) de la Comissiò de cetologia de la Instituciò Catalana d'Històri a Natural. *Bulletin Instituciò Catalana d'Història Natural*, **39** (Seciò Zoologia 1), 5–26.
Casinos, A. & Filella, S. (1977) Les cétacés de la Méditerranée espagnole: état actuel de nos connaissances. *Rapport de la Commission Intérnationale pour l'Exploration Scientifique de la Mer Méditerranée*, **24**, 31–33.
Casinos, A. & Vericad, J.S. (1976) The cetaceans of the Spanish coasts: a survey. *Mammalia*, **40**, 267–289.
Cerioni, S., Forni, L., Lo Tenero, A., Nannarelli, S. & Pulcini, M. (1996) A cetacean survey in the Taranto Gulf: work in progress. *European Research on Cetaceans*, **9**, 102–103.
Chakroun, F. (1966) Captures d'animaux rares en Tunisie. *Bulletin de l'Institut National Scientifique et Technique d'Océanographie et de Pêche de Salammbô*, **1**, 75–79.
Clapham, P.J. (2000) The humpback whale: seasonal feeling and breeding in a baleen whale, In: *Cetacean Societies: Field Studies of Dolphins and Whales* (Ed. by J. Mann, R.C. Connor, P.L. Tyack & H. Whitehead), pp. 173–196. University of Chicago Press, Chicago and London.
Clapham, P.J. (2001) Why do baleen whales migrate? A response to Corkeron and Connor. *Marine Mammal Science*, **17**, 432–436.
Clapham, P.J. & Hatch, L.T. (2000) *Determining Spatial and Temporal Scales for Population Management Units: Lessons from Whaling*. International Whaling Commission document SC/52/ID2, Adelaide, Australia.
Clark, C.W. (1995) Application of U.S. Navy underwater hydrophone arrays for scientific research on whales. *Report of the International Whaling Commission*, **45**, 210–212.
Clark, C.W., Borsani, J.F. & Notarbartolo di Sciara, G. (2002) Vocal activity of fin whales, *Balaenoptera physalus*, in the Ligurian Sea. *Marine Mammal Science*, **18**, 286–295.
Companyo, L. (1830) *Mémoirs descriptifs et ostéographie de la baleine échouée sur le côtes de la mer, près de Saint Cyprien, Département des Pyrénées–Orientales, le 27 novembre 1828*. Perpignan.
Connor, R.C. (2000) Group living in whales and dolphins, In: *Cetacean Societies: Field Studies of Dolphins and Whales* (Ed. by J. Mann, R.C. Connor, P.L. Tyack & H. Whitehead), pp. 199–218. University of Chicago Press, Chicago and London.
Cornalia, E. (1872) *Fauna d'Italia. Parte prima. Catalogo descrittivo dei mammiferi osservati fino ad ora in Italia*. F. Vallardi, Milano.
Cuvier, G. (1823) *Recherches sur les ossements fossiles ou l'on rétablit les caractères de plusieurs animaux dont les révolutions du globe ont détruit les espèces*. Vol. 5, p. 370. Dufour et d'Ocagne, Paris.
Cuvier, F. (1836) *De l'histoire naturelle des cétacés*. De Roret, Paris.
Cyrus, J.L. (1969) A propos du *Balaenoptera physalus* (L.) du Museum de Marseille et de sa présentation. *Bulletin du Museum d'Histoire Naturelle de Marseille*, **29**, 65–72.
Damiani, G. (1911) Sovra una *Balaenoptera* del novembre 1910 a Marciana Marina (Elba). *Bollettino della Società Zoologica Itiana, Roma*, **1911**, 50–57
Di Natale, A. & Giuffré, G. (1976) Su di un esemplare di *Balaenoptera physalus* L. (Cetacea, Misticeti) arenato lungo il litorale tirrenico della Sicilia. *Memorie di Biologia Marina e Oceanografia*, **6**, 37–43.
Di Natale, A. & Mangano, A. (1983) Presence and distribution of *Balaenoptera physalus* (L.) and *Balaenoptera spp*. in the Central Mediterranean Sea. *Rapport de la Commission Intérnationale pour l'Exploration Scientifique de la Mer Méditerranee*, **28**, 185–187.
Diorio, V. (1866) Il cetaceo di S. Marinella. *Atti dell'Accademia Pontificia de' Nuovi Lincei*, **19**, 189–199.
Duguy, R. (1973) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. II – Année 1972. *Mammalia*, **37**, 669–677.
Duguy, R. (1974) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. III – Année 1973. *Mammalia*, **38**, 545–555.
Duguy, R. (1975) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. IV – Année 1974. *Mammalia*, **39**, 689–701.
Duguy, R. (1976a) Nouvelles données sur les cétacés de la Méditerranée occidentale. *Rapport des Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranee*, **23**, 83–84.

Duguy, R. (1976b) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. V – Année 1975. *Mammalia.*, **40**, 671–681.
Duguy, R. (1977) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. VI – Année 1976. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **6**, 308–317.
Duguy, R. (1978) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. VII – Année 1977. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **6**, 333–344.
Duguy, R. (1979) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. VIII – Année 1978. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **6**, 463–474.
Duguy, R. (1980) *Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. IX – Année. 1979.* Conseil International pour l'Exploration de la Mer, 68ème réunion statutaire, Copenhague 1980, C.M. 1980/N: 3, Comité des Mammifères Marins.
Duguy, R. (1981) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. X – Année 1980. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **6**, 803–818.
Duguy, R. (1982) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. XI – Année 1981. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **6**, 969–984.
Duguy, R. (1983) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. XII – Année 1982). *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **7**, 121–135.
Duguy, R. (1985) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. XIV – Année 1984. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **7**, 349–364.
Duguy, R. (1986) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. XV – Année 1985. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **7**, 507–522.
Duguy, R. (1987) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. XVI – Année 1986. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **7**, 617–639.
Duguy, R. (1988) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. XVII – Année 1987. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **7**, 753–769.
Duguy, R. (1989) Rapport annuel sur les cétacés et pinnipèdes trouvés sur les côtes de France. XVIII – Année 1988. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **7**, 781–808.
Duguy, R. (1990a) Les mammifères marins de la Méditerranée occidentale. *Bulletin de la Société Zoologique de France*, **114**, 89–96.
Duguy, R. (1990b) Rapport annuel sur le cétacés et pinnipèdes trouvés sur le côtes de France. XX – Année 1990. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **7**, 1017–1048.
Duguy, R. (1992) Rapport annuel sur le cétacés et pinnipèdes trouvés sur le côtes de France. XXI – Année 1991. *Annales de la Société des Sciences Naturelles de la Charente-Maritime*, **8**, 9–34.
Duguy, R., Besson, J., Casinos, A., Di Natale, A., Filella, S., Raduan, A., Raga, J. & Viale, D. (1983) L'impact des activités humaines sur les cétacés de la Méditerranée occidentale. *Rapport de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée*, **28**, 5.
Duguy, R. & Budker, P. (1972) Rapport annuel sur le cétacés et pinnipèdes trouvés sur le côtes de France. I – Année 1971. *Mammalia*, **36**, 517–520.
Duguy, R. & Collet, A. (1983) *Note sur quelques facteurs pathologiques affectant la géstation chez les cétacés*. Conseil International pour l'Exploration de la Mer, 71ème réunion statutaire, Goteborg, 1983, C.M. 1983/N: 8, Comité des Mammifères Marins.
Duguy, R. & Vallon, D. (1976) *Rorqual commun (Balaenoptera physalus) en Méditerranée. occidentale: état actuel des observations.* CIESM XXV^e Congrès-Assemblée Plen., Split, 22–30 October 1976, Comité Vertébrés Marins et Céphalopodes.
El Bouali, M. (1987) Les cétacés du littoral ouest algérien. Mémoire de Thèse, Département de Biologie Animale, Option Biologie Marine.
Evans, P.G.H. (1987) *The Natural History of Whales and Dolphins*. Christopher Helm, London.
Fabbri, F. & Lauriano, G. (1992) Greenpeace report on two year research in the Ligurian Sea. *European Research on Cetaceans*, **6**, 69–74.
Farines, J. & Carcassonne, C. (1829) *Mémoire sur un cétacé échoué le 27 novembre 1928 [sic=1828] sur la côte de Saint-Cyprien*, pp. 1–27. Perpignan.
Fergusson, I.K. (1996) Distribution and autecology of the white shark in the Eastern North Atlantic Ocean and the Mediterranean Sea. In: *Great white sharks. The biology of Carcharodon Carcharias* (Ed. by A.P. Klimley & D.G. Anley), pp. 321–345. Academic Press, London.
Fernàndez-Casado, M., Fernàndez, E.J., Garcìa, E. & Mons, J.L. (1999) Record of stranded cetaceans on the Andalusian coast (southern Iberian peninsula), Ceuta and Melilla (northern Africa) during the period 1996–1998. *European Research on Cetaceans*, **13**, 201–205.
Ficalbi, E. (1907) Una balenottera arenata sul litorale toscano. *Monitore Zoologico Italiano*, **18**, 192.
Ficalbi, E. (1919) Tre grandi cetacei dati in secco sul litorale toscano. *Monitore Zoologico Italiano*, **30**, 199–200.
Fischer, J.B. (1829) *Synopsis Mammalium*. J.G. Cottae, Stuttgart.

Flower, W.H. (1885) *List of Specimens of Cetacea in the Zoological Department of the British Museum*. British Museum, London.

Flower, S.S. (1932) Notes on recent mammals of Egypt, with a list of the species recorded from that kingdom. *Proceedings of the Zoological Society of London*. **1932**, 369–450.

Focardi, S., Marsili, L., Leonzio, C., Zanardelli, M. & Notarbartolo di Sciara, G. (1992) Organochlorines and trace elements in skin biopsies of fin whale *Balaenoptera physalus* and striped dolphin *Stenella coeruleoalba*. *European Research on Cetaceans*, **6**, 230–233.

Focardi, S., Notarbartolo di Sciara, G., Venturino, C., Zanardelli, M. & Marsili, L. (1991) Subcutaneous organochlorine levels in fin whales (*Balaenoptera physalus*) from the Ligurian Sea. *European Research on Cetaceans*, **5**, 93–96.

Forcada, J., Aguilar, A., Hammond, P., Pastor, X. & Aguilar, R. (1996) Distribution and abundance of fin whales (*Balaenoptera physalus*) in the western Mediterranean sea during the summer. *Journal of Zoology, London*, **238**, 23–34.

Forcada, J., Notarbartolo di Sciara, G. & Fabbri, F. (1995) Abundance of fin whales and striped dolphins summering in the Corso-Ligurian Basin. *Mammalia*, **59**, 127–140.

Fossi, M.C., Marsili, L., Leonzio, C., Notarbartolo di Sciara, G., Zanardelli, M. & Focardi, S. (1992) The use of non-destructive biomarker in Mediterranean cetaceans: preliminary data on MFO activity in skin biopsy. *Marine Pollution Bulletin*, **24**, 459–461.

Franco, I. & Mas, J. (1994) Distribution and evaluation of cetaceans in the Alboran Sea (S.E. Mediterranean). *European Research on Cetaceans*, **8**, 103.

Franqueville, C. (1971) Macroplancton profond (invértebrés) de la Méditerranée Nord-Occidentale. *Tethys*, **3**, 11–56.

Frantzis, A., Alexiadou, P., Politi, E., Gannier, A. & Corsini-Foca, M. (in press) Cetacean fauna of the Greek seas: unexpectedly high species diversity. *European Research on Cetaceans*, **15**.

Furnestin, J. (1949) Les baleines: leur pêche est-elle possible sur les côtes du Maroc? *Revue de la Conserve Marocaine*, **5**, 17–21.

Gambell, R. (1985) Fin whale, *Balaenoptera physalus* (Linnaeus, 1758), In: *Handbook of Marine Mammals*, **Vol. 3**. *'the Sirenians and Baleen Whales'* (Ed. by S.H. Ridgway & R. Harrison), pp. 171–192. Academic Press, London.

Gannier, A. (1995) Les Cétacés de Méditerranée nord-occidentale: estimation de leur abondance et mise en relation de la variation saisonnière de leur distribution avec l'écologie du milieu. Thèse de Doctorat, Ecole Pratique des Hautes Etudes.

Gannier, A. (1997a) Summer abundance estimates of striped dolphins and fin whales in the area of the future International Marine Sanctuary. *European Research on Cetaceans*, **11**, 95–98.

Gannier, A. (1997b) Estimation de l'abondance estivale du rorqual commun *Balaenoptera physalus* (Linné, 1758) dans le Bassin liguro-provençal (Méditerranée occidentale). *Revue d'Ecologie la Terre et la Vie*, **52**, 69–86.

Gannier, A. & Bourreau, S. (1999) Comparison of cetacean populations from simultaneous surveys in the Gulf of Lion and Ligurian areas. *European Research on Cetaceans*, **13**, 222–225.

Gannier, A. & Gannier, O. (1989) Some sightings of cetaceans in the Western Mediterranean Sea. *European Research on Cetaceans*, **3**, 62–64.

Gannier, A. & Gannier, O. (1990) Cetacean sightings in the Mediterranean Sea: second report. *European Research on Cetaceans*, **4**, 39.

Gannier, A. & Gannier, O. (1992) Northwestern Mediterranean survey: 4th annual report. *European Research on Cetaceans*, **6**, 56–60.

Gannier, A. & Gannier, O. (1993) The winter presence of the fin whale in the liguro provençal basin: preliminary study. *European Research on Cetaceans*, **7**, 131–134.

Gannier, A. & Gannier, O. (1997) New results on the seasonal variation of cetaceans in the Liguro-Provençal Basin. *European Research on Cetaceans*, **11**, 91–94.

Gervais, P. (1864) Cétacés des côtes françaises de la Méditerranée. *Comptes-rendus de l'Académie des Sciences, Paris*, **2**, 876–881.

Giglioli, E.H. (1880) *Elenco dei mammiferi, degli uccelli e dei rettili ittiofagi appartenenti alla fauna italiana*. Firenze.

Giordano, A. (1986) Nouvelles données sur *Balaenoptera physalus* en Méditerranée occidentale. *Rapport des Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée*, **30**, 244.

Giordano, A., Arena, R., Cane, A., Guerrieri, G., Petralia, R., Trincali, L.M. & Bazzana, L. (1995) *Risultati della ricerca cetofauna siciliana*. Museo del Mare di Cefalù.

Goy, J. & Thiriot, A. (1976) Conditions estivales dans la divergence de Méditerranée nord-occidentale. II. Macroplancton et micronecton: étude qualitative et estimation quantitative des cnidaires et des euphausiacés. *Annales de l'Institut Océanographique, N.S.*, **52**, 33–44.

Grau, E., Aguilar, A. & Filella, S. (1980) Cetaceans stranded, captured or sighted in the Spanish coasts during 1976–79. *Bulletin Instituciò Catalana d'Historia Natural*, **45** (Seciò de Zoologia 3), 167–179.

Grau, E., Filella, S., Raga, J.A. & Raduàn, A. (1986) Cetàceos varados en las costas del Mediterraneo ibérico, durante los años 1980–1981. *Miscelanìa Zoologica*, **10**, 353–358.

Gray, J.E. (1868) *Synopsis of the Species of Whales and Dolphins in the British Museum*. Bernard Quaritch, London.

Guibourgé, E., Frodello, J.-P., Terris, N., D'Oriano, F. & Viale, D. (1996) Le baleines ont-elles la rougeole? *La Rechêrche*, **283**, 34–35.

Hain, J.H.W., Ratnaswamy, M.J., Kenney, R.D. & Winn, H.E. (1992) The fin whale, *Balaenoptera physalus*, in waters of the northeastern United States continental shelf. *Report of the International Whaling Commission*, **42**, 653–669.

Hashmi, D.D.K. & Adloff, B. (1991) Surface frequency of cetaceans in the Strait of Gibraltar. *European Research on Cetaceans*, **5**, 16–17.

Heldt, H. (1949) Incursions de baleinoptères sur les côtes tunisiennes. *Annales Biologiques, Copenhague*, **6**, 80.

Ingebrigtsen, A. (1929) Whales caught in the North Atlantic and other seas. *Conseil Permanent International pour l'Exploration de la Mer, Rapports et Procès-verbaux des Réunions, Copenhague*, **56**, 3–26.

Jacques, G. (1990) L'oligotrophie du milieu pélagique en Méditerranée occidentale: un paradigme qui s'éstompe? *Bulletin de la Société Zoologique de France*, **114**, 17–30.

Jahoda, M., Almirante, C., Azzellino, A., Panigada, S., Zanardelli, M. & Canese, S. (1999) *3D-tracking as a tool for studying behavior in Mediterranean fin whales (Balaenoptera physalus)*, p. 89, 13th Biennial Conference on the Biology of Marine Mammals. The Society of Marine Mammalogy, Hawaii.

Jahoda, M., Lafortuna, C.L., Biassoni, N., Almirante, C., Azzellino, A., Panigada, S., Zanardelli, M. & Notarbartolo di Sciara, G. (2003) Mediterranean fin whale's (*Balaenoptera physalus*) response to small vessel and biopsy sampling assessed through passive tracking and timing of respiration. *Marine Mammal Science*, **19**, 96–110.

Jahoda, M. & Notarbartolo di Sciara, G. (1993) Respiration patterns of fin whales summering in the Ligurian Sea. *European Research on Cetaceans*, **7**, 237–240.

Jauniaux, T., Charlier, G., Desmecht, M. & Coignoul, F. (1998) Lesions of morbillivirus infection in a fin whale (*Balaenoptera physalus*) stranded along the Belgian coast. *The Veterinary Record*, **143**, 423–424.

Jonsgård, Å. (1966) Biology of the North Atlantic fin whale *Balaenoptera physalus* (L.): taxonomy, distribution, migration and food. *Hvalradets Skrifter*, **49**, 1–62.

Kolombatovic, G. (1894) *O navodima vrsti Meœi (Cephalopoda) i Kraljeŝnjaka (Vertebrata) Jadranskoga Mora*. Brzot. A. Zannoni (St. Bulat), Split.

Ktari-Chakroun, F. (1981) Nouvelles mentions de cétacés en Tunisie. *Bull. Inst. Oceanogr. Pêche Salammbô*, **8**, 119–121.

de Lacépède, B.G.E., (1804) Histoire naturelle des cétacés. In: *Buffon.* Histoire naturelle, Paris. Vol. 37.

Laist, D.W., Knowlton, A.R., Mead, J.G., Collet, A.S. & Podestà, M. (2001) Collisions between ships and whales. *Marine Mammal Science*, **17**, 35–75.

Lauriano, G. (1997) Preliminary observations of fin whales (*Balaenoptera physalus*) off north-western Sardinia. *European Research on Cetaceans*, **11**, 122–124.

Lauriano, G. & Notarbartolo di Sciara, G. (1996) The distribution of cetaceans off north-western Sardinia. *European Research on Cetaceans*, **9**, 104–106.

Lauriano, G., Tunesi, L., Notarbartolo di Sciara, G., Salvati, E. & Cardinali, A. (1999) The role of cetaceans in the zoning proposal of marine protected areas: the case of the Asinara Island MPA. *European Research on Cetaceans*, **13**, 114–117.

Le Vourch, J., Millot, C., Castagne, N., Le Borgne, P. & Olry, J.-P. (1992) Atlas des fronts thermiques en Méditerranée d'après l'imagerie satellitaire. *Mémoires de l'Institut Océanographique Monaco*, **16**, 1–160.

Lepri, G. (1914) Su di una balenottera arenatasi presso Ostia. *Bollettino della Società Zoologica Italiana*, **3**, 32–38.

Lesson, R. (1828) *Cétacés*. **Vol. 1** *Compléments des œuvres de Buffon ou Histoire Naturelle des animaux rares découverts par les naturalistes et les voyageurs depuis la mort de Buffon*. Paris.

Lockyer, C. (1984) Review of baleen whale (Mysticeti) reproduction and implications for management. In: *Reproduction in Whales, Dolphins and Porpoises* (Ed. by W.F. Perrin, R.L. Brownell, Jr & D.P. DeMaster), pp. 27–50. Reports of the International Whaling Commission, Special Issue 6, Cambridge.

Loganathan, B.G. & Kannan, K. (1991) Time perspectives of organochlorine contamination in the global environment. *Marine Pollution Bulletin*, **22**, 582–584.

Lönnberg, E. (1931) The skeleton of *Balaenoptera brydei* Ö. Olsen. *Arkiv for Zoologi*, **23A**, 1–23.

Maio, N., Picariello, O. & Cagnolaro, L. (2001) I cetacei del Museo Zoologico dell'Università di Napoli Federico II (Mammalia, Cetacea): catalogo della collezione con note osteometriche. *Natura (Milano)*, **90**, 71–83.

Malatesta, T., Frati, R., Cerioni, S., Agrimi, U. & DiGuardo, G. (1998) *Ogmogaster antarcticus* Johnston, 1931 (Digenea, Notocotylidae) in *Balaenoptera physalus* (L): first record in the Mediterranean Sea. *Systematic Parasitology*, **40**, 63–66.

Manni di S. Cesario, P. (1827) *Memoria sul genere e sulla specie di cetaceo approdato nel litorale dell'Adriatico, luogo detto Botte*. Presso la Società Tipografica, Napoli.

Marchessaux, D. (1980) A review of the current knowledge of the cetaceans in the Eastern Mediterranean Sea. *Vie Marine*, **2**, 59–66.

Marini, L., Carpentieri, P. & Consiglio, C. (1996a) Presence and distribution of the cetological fauna of the Aegean Sea: preliminary results. *European Research on Cetaceans*, **9**, 99–101.

Marini, L., Consiglio, C., Angradi, A.M., Catalano, B., Sanna, A., Valentini, T., Finoia, M.G. & Villetti, G. (1996b) Distribution, abundance and seasonality of cetaceans sighted during scheduled ferry crossings in the central Tyrrhenian Sea: 1989–1992. *Italian Journal of Zoology*, **63**, 381–388.

Marini, L., Consiglio, C., Catalano, B., Valentini, T. & Villetti, G. (1996c) Aerial behavior of fin whales in the Mediterranean Sea. *Marine Mammal Science*, **12**, 489–495.

Marini, L., Consiglio, C., Sanna, A. & Angradi, A.M. (1992) *Some notes on the fin whale (Balaenoptera physalus) in the Western Mediterranean Sea*, pp. 63–71. Proceedings of the Symposium 'Whales: Biology – Threats – Conservation', Brussels.

Marini, L., Villetti, G. & Consiglio, C. (1996d) Wintering areas of fin whales (*Balaenoptera physalus*) in the Mediterranean Sea: a preliminary survey. *European Research on Cetaceans*, **9**, 126–128.

Marsili, L. (2000) Lipophilic contaminants in marine mammals: review of the results of ten years' work at the Department of environmental biology, Siena University (Italy). *International Journal of Environmental Pollution*, **13**, 416–452.

Marsili, L., Caruso, A., Fossi, M.C., Zanardelli, M., Politi, E. & Focardi, S. (2001) Polycyclic aromatic hydrocarbons (PAHs) in subcutaneous biopsies of Mediterranean cetaceans. *Chemosphere*, **44**, 147–154.

Marsili, L. & Focardi, S. (1996) Organochlorine levels in subcutaneous blubber biopsies of fin whales (*Balaenoptera physalus*) and striped dolphins (*Stenella coeruleoalba*) from the Mediterranean Sea. *Environmental Pollution*, **91**, 1–9.

Marsili, L., Fossi, M.C., Notarbartolo di Sciara, G., Zanardelli, M., Nani, B., Panigada, S. & Focardi, S. (1998) Relationship between organochlorine contaminants and mixed function oxidase activity in skin biopsy specimens of Mediterranean fin whales (*Balaenoptera physalus*). *Chemosphere*, **37**, 1501–1510.

Mikhalev, Y.A. (1997) Humpback whales *Megaptera novaeangliae* in the Arabian Sea. *Marine Ecology Progress Series*, **149**, 13–21.

Minà Palumbo, F. (1868) Catalogo dei mammiferi della Sicilia. Ordine VIII. Cetacci [Sic]. *Biblioteca del Naturalista Siciliano*, **12**, 111–123.

Mussi, B., Miragliuolo, A., Monzini, E., Diaz Lopez, B. & Battaglia, M. (1999) Fin whale (*Balaenoptera physalus*) feeding ground in the coastal waters of Ischia (Archipelago Campano). *European Research on Cetaceans*, **13**, 330–335.

Nascetti, D. & Notarbartolo di Sciara, G. (1996) A fin whale and sperm whale sighting programme undertaken by the Italian Navy in the Central Mediterranean Sea. *European Research on Cetaceans*, **10**, 150–153.

Notarbartolo di Sciara, G. (1987) Killer whale, *Orcinus orca*, in the Mediterranean Sea. *Marine Mammal Science*, **3**, 356–360.

Notarbartolo di Sciara, G. (1990) A note on the cetacean incidental catch in the Italian driftnet swordfish fishery, 1986–1988. *Report of the International Whaling Commission*, **40**, 459–460.

Notarbartolo di Sciara, G. (1994) La cetofauna del Bacino corso-liguro-provenzale: rassegna delle attuali conoscenze. *Biologia Marina Mediterranea*, **1**, 95–98.

Notarbartolo di Sciara, G., Clark, C.W., Zanardelli, M. & Panigada, S. (1999) Migration patterns of fin whales, *Balaenoptera physalus*: shaky old paradigms and local anomalies. *European Research on Cetaceans*, **12**, 118.

Notarbartolo di Sciara, G. & Demma, M. (1997) *Guida dei mammiferi marini del Mediterraneo*, 2nd edn. Franco Muzzio Editore, Padova.

Notarbartolo di Sciara, G. & Gordon, J. (1997) Bioacoustics: a tool for the conservation of cetaceans in the Mediterranean Sea. *Marine and Freshwater Behaviour and Physiology*, **30**, 125–146.

Notarbartolo di Sciara, G., Venturino, M.C., Zanardelli, M., Bearzi, G., Borsani, J.F. & Cavalloni, B. (1993) Cetaceans in the Central Mediterranean Sea: distribution and sighting frequencies. *Italian Journal of Zoology*, **60**, 131–138.

Orsi Relini, L. & Cappello, M. (1992) The fin whale and other large pelagic filters as samplers of *Meganyctiphanes norvegica*. *Rapport des Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée*, **33**, 263.

Orsi Relini, L. & Giordano, A. (1992) Summer feeding of the fin whale, *Balaenoptera physalus*, in the Liguro-Provençal Basin. *European Research on Cetaceans*, **6**, 138–141.

Orsi Relini, L., Relini, G., Cima, C., Fiorentino, F., Palandri, G., Relini, M. & Torchia, G. (1992) Una zona di tutela biologica ed un parco pelagico per i cetacei del Mar Ligure. *Bollettino dei Musei e degli Istituti Biologici dell'Università di Genova*, **56**, 57, 247–281.

Orsi Relini, L., Relini, G., Cima, C., Palandri, G., Relini, M. & Torchia, G. (1994) *Meganyctiphanes norvegica* and fin whales in the Ligurian Sea: new seasonal patterns. *European Research on Cetaceans*, **8**, 179–182.

Overholtz, W.J. & Nicolas, J.R. (1979) Apparent feeding by the fin whale, *Balaenoptera physalus*, and the humpback whale, *Megaptera novaeangliae*, on the American sandlance, *Ammodytes americanus*, in the Northwest Atlantic. *Fishery Bulletin*, **77**, 285–287.

Öztürk, B. (1995) Marine mammals inventory of Turkey. *European Research on Cetaceans*, **9**, 96–98.

Palazzoli, I. (1983) Note préliminaire: étude des cétacés dans le bassin liguro-provençal par observation directe à la mer. *Rapport de la Commission Internationale pour l'Exploration. Scientifique de la Mer Méditerranée*, **28**, 217–218.

Panigada, S., Notarbartolo di Sciara, G., Zanardelli, M., Airoldi, S., Borsani, J.F., Jahoda, M., Pesante, G. & Revelli, E. (in press) Distribution and occurrence of fin whales in the Ligurian Sea between 1990–99. *European Research on Cetaceans*, **15**.

Panigada, S., Zanardelli, M., Canese, S. & Jahoda, M. (1999) How deep can baleen whales dive? *Marine Ecology Progress Series*, **187**, 309–311.

Parenzan, P. (1958) A proposito di una balenottera arenata nel gennaio 1957 nell'isola di Ponza. *Thalassia Jonica*, **1**, 127–134.

Parona, C. (1896) Notizie storiche sopra i grandi cetacei nei mari italiani ed in particolare sulle quattro balenottere catturate in Liguria nell'autunno 1896. *Atti della Società Italiana di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **36**, 297.

Parona, C. (1908) Catture recenti di grandi cetacei nei mari italiani. *Atti della Società Ligustica di Scienze Naturali e Geografiche, Genova*, **19**, 173–205.

Paulus, M. (1966) Les baleinoptères de la Méditerranée. *Bulletin du Muséum d'Histoire Naturelle du Marseille*, **26**, 27, 117–139.

Pavletič, J., Čanadjija, S. & Magerle, A. (1962) Skelet kita perajara – *Balaenoptera physalus* (L.). *Biološki Glasnik*, **15**, 115–126.

Payne, R.S. & Webb, D. (1971) Orientation by means of long-range acoustic signalling in baleen whales. *Annals of the New York Academy of Science*, **188**, 110–141.

Pelegrì, J. (1980) Recull de la comisiò de cetologia de la instituciò catalana d'història natural. II: Anys 1974 i 1975. *Bulletin de la Instituciò Catalana d'Història Natural*, **45** (Seciò Zoologia 3), 155–165.

Pesante, G., Zanardelli, M. & Panigada, S. (2000) Evidence of man-made injuries on Mediterranean fin whales. *European Research on Cetaceans*, **14**, 192–193.

Pezzo, F., Cancelli, F. & Baccetti, N. (1995) Catalogo della collezione teriologica (Museo zoologico, Accademia dei Fisiocritici). *Atti dell'Accademia dei Fisiocritici di Siena*, **15** (Suppl. 14), 1–73.

Pierantoni, N. (1930) La *Balaenoptera physalus* (L.) arenatasi sulla spiaggia di S. Giovanni a Teduccio. *Bollettino della Società dei Naturalisti di Napoli*, **41**, 152–155.

Pike, G.C. (1951) Lamprey marks on whales. *Journal of the Fisheries Research Board of Canada*, **8**, 275–280.

Pilleri, G. & Gihr, M. (1977) Some records of cetaceans in the Northern Adriatic Sea. *Investigations on Cetacea*, **8**, 85–88.

Podestà, M. & Magnaghi, L. (1989) Unusual number of cetacean bycatches in the Ligurian Sea. *European Research on Cetaceans*, **3**, 67–70.

Poggi, R. (1982) Recenti incrementi alla collezione cetologica del Museo Civico di Storia Naturale di Genova (Mammalia, Cetacea). *Annali del Museo Civico di Storia Naturale di Genova*, **84**, 1–8.

Politi, E., Airoldi, S. & Notarbartolo di Sciara, G. (1994) A preliminary study of the ecology of cetaceans in the waters adjacent to Greek Ionian islands. *European Research on Cetaceans*, **8**, 111–115.

Politi, E., Bearzi, M., Notarbartolo di Sciara, G., Cussino, E. & Gnone, G. (1992) Distribution and frequency of cetaceans in the waters adjacent to the Greek Ionian Islands. *European Research on Cetaceans*, **6**, 75–78.

Postel, E. (1956) Echouage d'une baleinoptère aux Iles Kerkennah. *Bulletin de la Station Océanographique de Salammbô*, **53**, 75–76.

Pouchet, G. (1893) Anciens échouages de cétacés du IX au XVII Siècle. *Comptes rendus hebdomadaires des séances et mémoires de la Société de Biologie*, **5**, 97–104.

de la Poype, R. & Riddell, M. (1997) Pourquoi *Delphis*? In: *Actes de la 6ème Conférence Internationale RIMMO, Cannes 29–30 Novembre 1997*. (Ed. by M. Riddell & M. Aubert), p. 31. Cannes, France.

Princi, M. & Bussani, M. (1976) Determinazione di Hg in un esemplare di *Balaenoptera physalus* L. catturato nel porto di Trieste. *Bollettino di Pesca, Piscicoltura e Idrobiologia*, **31**, 93–95.

Pryor, K. (1986) Non-acoustic communicative behavior of the great whales: origins, comparisons and implications for management. *Reports of the International Whaling Commission*, **Special issue 8**, 89–95.

Pulcini, M., Angradi, A.M. & Sanna, A. (1993) Distribution and frequency of cetaceans in the Ligurian-Provençal Basin and in the North Tyrrhenian Sea (Mediterranean Sea). *European Research on Cetaceans*, **7**, 144–147.

Raga, J.A., Raduàn, A., Balbuena, J.A., Aguilar, A., Grau, E. & Borrell, A. (1991) Varamientos de cetàceos en las costas españolas del Mediterràneo durante el perìodo 1982–1988. *Miscelanìa Zoologica*, **15**, 215–226.

Raga, J.A., Raduàn, A. & Blanco, C. (1985) Contribuciòn al estudio de la distribuciòn de cetàceos en el Mediterràneo y Atlantico Ibérico. *Miscelanìa Zooogica.*, **9**, 361–366.

Rallo, G. (1979) I cetacei dell'Adriatico. *WWF Veneto*, **4**, 3–4.

Ray, G.C., Mitchell, E.D., Wartzok, D., Kozicki, V.M. & Maiefski, R. (1978) Radio tracking of a fin whale (*Balaenoptera physalus*). *Science*, **202**, 521–524.

Relini, G., Orsi Relini, L., Cima, C., Fasciana, C., Fiorentino, F., Palandri, G., Relini, M., Tartaglia, M.P., Torchia, G. & Zamboni, A. (1992) Macroplancton, *Meganyctiphanes norvegica*, and fin whales, *Balaenoptera physalus*, along some transects in the Ligurian Sea. *European Research on Cetaceans*, **6**, 134–137.

Relini, G., Orsi Relini, L., Siccardi, A., Fiorentino, F., Palandri, G., Torchia, G., Relini, M., Cima, C. & Cappello, M. (1994) Distribuzione di *Meganyctiphanes norvegica* e *Balaenoptera physalus* in Mar Ligure all'inizio della primavera. *Biologia Marina Mediterranea*, **1**, 89–94.

Richard, J. (1936) Notes sur les cétacés et les pinnipèdes. In: *Documents sur les cétacés et pinnipèdes des croisières du Prince Albert I de Monaco* (Ed. by J. Richard), pp. 34–61. Résultats des campagnes scientifiques accomplies sur son yacht par Albert I Prince Souverain de Monaco, 94.

Richardson, W.J., Greene,C.R., Jr, Malme, C.I. & Thomson, D.H. (1995) *Marine Mammals and Noise*. Academic Press, London.

Richiardi, S. (1874) Sulle variazioni individuali della *Balaenoptera musculus*. *Atti della Società Toscana di Scienze Naturali*, **1**, 246–259.

Rode, P. (1939) La collection de cétacés du Musée Océanographique de Monaco. Notes ostéometriques. *Bulletin de l'Institut Oceanographique (Fondation Albert I^er^, Prince de Monaco)*, **780**, 1–20.

Rørvik, C.J., Jonsson, J., Mathisen, O. & Jonsgård, A. (1976) Fin whales, *Balaenoptera physalus* L. off the west coast of Iceland: distribution, segregation by length and exploitation. *Rit Fiskideildar*, **5**, 1–30.

Salle, E. & Becherucci, G. (1902) *Cenni intorno alla balenottera arenata nelle vicinanze del Marzocco – Livorno, 7 settembre 1901*. Livorno, Officina Tipografica di B, Ortalli.

Sanpera, C. & Aguilar, A. (1992) Modern whaling off the Iberian Peninsula during the 20th Century. *Report of the International Whaling Commission*, **42**, 723–730.

Sanna, A., Blasi. B., Corain, D., Falasconi, R. & Castañeda Moreno, J.A. (1999) Cetaceans sighting in the North-Western Mediterranena Sea. *European Research on Cetaceans*, **13**, 259.

Seipt, I., Clapham, P.J., Mayo, C.A. & Hawvermale, M.P. (1990) Population characteristics of fin whales, *Balaenoptera physalus*, in Massachusetts Bay. *Fishery Bulletin*, **88**, 271–278.

Sergeant, D.E. (1977) Stocks of fin whales, *Balaenoptera physalus* L. in the North Atlantic Ocean. *Report of the International Whaling Commission*, **27**, 460–473.

Stanzani, L.A., Bonomi, L. & Bortolotto, A. (1997) 'Onde dal Mare': an update on the Italian network for cetacean and turtle sightings. *European Research on Cetaceans*, **11**, 87–89.

Stone, G.S., Katona, S.K., Mainwaring, A., Allen, J.M. & Corbett, H.D. (1992) Respiration and surfacing rates of fin whales (*Balaenoptera physalus*) observed from a lighthouse tower. *Report of the International Whaling Commission*, **42**, 739–745.

Tamino, G. (1953a) Note sui cetacei. VIII. Rinvenimento di una giovane balenottera arenata sulla spiaggia dei Maronti (Isola d'Ischia), il 16 Novembre 1953. *Atti della Società di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **92**, 123–126.

Tamino, G. (1953b) Ricupero di una balenottera arenata sul lido di Salerno il 10 febbraio 1953. *Bollettino di Zoologia*, **20**, 51–54.

Tamino, G. (1956) Note sui cetacei italiani: rinvenimento di una balenottera nel Golfo di La Spezia (9 Giugno 1955). *Atti della Società di Scienze Naturali e del Museo Civico di Storia Naturale di Milano*, **95**, 45–51.

Tomilin, A.G. (1946) Thermoregulation and the geographical races of cetaceans. *Doklady Akademii Nauk S.S.S.R.*, **54**, 465–472.

Tomilin, A.G. (1957) *Mammals of the U.S.S.R. and Adjacent Countries*. **Vol. IX**. *Cetacea*. Nauk S.S.S.R., Moscow. English translation, 1967, Israel Program for Scientific Translations, Jerusalem.

Tønnessen, J.N. & Johnsen, A.O. (1982) *The History of Modern Whaling*. University of California Press, Berkeley and Los Angeles.

Tortonese, E. (1965) *Pesci e cetacei del Mar Ligure*. Libreria Editrice Mario Bozzi, Genova.

Toschi, A. (1965) *Mammalia: Lagomorpha, Rodentia, Carnivora, Artiodactyla, Cetacea. Fauna D'italia*, **Vol. 7**. Edizioni Calderini, Bologna.

Trois, E.F. (1893) Elenco dei cetacei dell'Adriatico. *Atti del Regio Istituto Veneto di Scienze, Lettere e Arti*, **7**, 1315–1320.

Trucchi, R., dell'Acqua, A., De Novellis, F., Massajoli, M., Ottonello, C., Fossa, F., Gallo, M., Virzi, D. & Zoratti, A. (1999) A comparison between the fourth and the fifth WWF's research campaign in the Ligurian Sea. *European Research on Cetaceans*, **13**, 271–273.

Trucchi, R., Ottonello, C. & Tribocco, F. (1999) The first experience of a daily whalewatching activity to collect data and to inform people about cetacean biology and ecology carried out by WWF – Liguria. *European Research on Cetaceans*, **13**, 137.

True, F.W. (1899) On the nomenclature of the whalebone whales of the tenth edition of Linnaeus's Systema Naturae. *Proceedings of the United States National Museum*, 21, 617–635.

Tyack, P.L. (2000) Functional aspects of cetacean communication. In: *Cetacean Societies: Field Studies of Dolphins and Whales* (Ed. by J. Mann, R.C. Connor, P.L. Tyack & H. Whitehead), pp. 270–307. University of Chicago Press, Chicago and London.

Van Waerebeek, K., André, M., Sequeira, M., Martìn, V., Robineau, D., Collet, A., Papastavrou, V. & Ndiyaye, E. (1999) Spatial and temporal distribution of the minke whale, *Balaenoptera acutorostrata* (Lacépède, 1804), in the southern northeast Atlantic and the Mediterranean Sea, with reference to stock identity. *Journal of Cetacean Research and Management*, **1**, 223–237.

Viale, D. (1974) Fréquence des accidents survenus à des cétacés sur les côtes tyrrhéniennes. *Bulletin de la Société Zoologique de France*, **99**, 146–147.

Viale, D. (1977a) Big whale populations on the Atlantic coasts of Spain and the western Mediterranean. *Report of the International Whaling Commission*, **27**, 235.

Viale, D. (1977b) Contribution à l'étude des grands cétacés en Méditerranée et sur la côte atlantique d'Espagne. *Mammalia*, **41**, 197–206.

Viale, D. (1978) Evidence of metal pollution in Cetacea of the western Mediterranean. *Annales de l'Institut Océanographique de Paris*, **54**, 5–16.

Viale, D. (1981) Ecologie des cétacés de la Méditerranée Occidentale. FAO Fish. Ser. 5. *Mammals in the Seas*, **3**, 287–300.

Viale, D. (1985) Cetaceans in the northwestern Mediterranean: their place in the ecosystem. *Oceanography and Marine Biology an Annual Review*, **23**, 491–571.

Viale, D. (1991) Une méthode synoptique de recherche des zones productives en mer: détection simultanée des cétacés, des fronts thermiques et des biomasses sous-jacentes. *Annales de l'Institut Océanographique, N.S.*, **67**, 49–62.

Viale, D., De Crescenzo, J.N., Erlich, I. & Isetti, A.M. (1988) Cétacés en Méditerranée orientale: campagnes CETORIENT sur N/O Le Surlot IFREMER, 1896. *Rapport de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée*, **31**, 289.

Viale, D. & Frontier, S. (1994) Surface megafauna related to western Mediterranean circulation. *Aquatic Living Resources*, **7**, 105–126.

Viale, D., Moriaz, C., Palazzoli, I., Viale, A. & Viale, C. (1986) Repérage aérien de cétacés en Mer Ligure. *Rapport de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée*, **30**, 245.

Viale, D. & Terris, N. (1990) Indice d'abondance de la megafaune en Méditerranée. Campagne Transmedicet du <<Jean Charcot>> (IFREMER) de 20.10.89 au 26.10.89. *Rapport de la Commission Internationale pour l'Exploration Scientifique de la Mer Méditerranée*, **32**, 239.

Vidal, O. & Pechter, G. (1989) Behavioral observations on fin whale, *Balaenoptera physalus*, in the presence of killer whale, *Orcinus orca*. *Fishery Bulletin*, **87**, 370–373.

Walmsley, T. (1996) Cetacea survey around Gibraltar. *European Research on Cetaceans*, **10**, 130.

Watkins, W.A. (1981) Activities and underwater sounds of fin whales. *Scientific Reports of the Whales Research Institute*, **33**, 83–117.

Watkins, W.A., Daher, M.A., George, J.E. & Haga, S. (2000) *Distribution of calling blue, fin, and humpback whales in the North Pacific*. Wood Hole Oceanographic Institution Technical Report WHOI-00–12.

Watkins, W.A., Moore, K.E., Sigurjònsson, J., Wartzok, D. & Notarbartolo di Sciara, G. (1984) Fin whale (*Balaenoptera physalus*) tracked by radio in the Irminger Sea. *Rit Fiskideildar*, **8**, 1–14.

Watkins, W.A. & Schevill, W.E. (1979) Aerial observations of the feeding behavior in four baleen whales: *Eubalaena glacialis, Balaenoptera borealis, Megaptera novaeangliae, Balaenoptera physalus*. *Journal of Mammalogy*, **60**, 155–163.

Watkins, W.A., Sigurjònsson, J., Wartzok, D., Maiefski, R.R., Howey, P.W. & Daher, M.A. (1996) Fin whale tracked by satellite off Iceland. *Marine Mammal Science*, **12**, 564–568.

Watkins, W.A., Tyack, P.L., Moore, K.E. & Bird, J.E. (1987) The 20-Hz signals of finback whales (*Balaenoptera physalus*). *Journal of the Acoustic Society of America*, **82**, 1901–1912.

Whitehead, H. (1985) Why whales leap. *Scientific American*, **252**, 84–93.

Woodley, T.H. & Gaskin, D.E. (1996) Environmental characteristics of North Atlantic right and fin whale habitat in the lower Bay of Fundy. *Canada. Canadian Journal of Zoology*, **74**, 75–84.

Zanardelli, M., Notarbartolo di Sciara, G. & Acquarone, M. (1992) Cetacean sightings by amateurs: a two-sided coin. *European Research on Cetaceans*, **6**, 79–82.
Zanardelli, M., Notarbartolo di Sciara, G. & Jahoda, M. (1992) Photo-identification and behavioural observations of fin whales summering in the Ligurian Sea. *European Research on Cetaceans*, **6**, 86–89.
Zanardelli, M., Panigada, S., Airoldi, S., Borsani, J.F., Jahoda, M. & Notarbartolo di Sciara, G. (1999) Site fidelity, seasonal residence and sex ratio of fin whales (*Balaenoptera physalus*) in the Ligurian Sea feeding grounds. *European Research on Cetaceans*, **12**, 124.

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APPENDIX

Fin whale sightings, strandings, directed captures, collisions and accidental captures in the Mediterranean Sea, based on the published record and original data

Event	No. of species	Date	Locality	Source	Notes
Subregion A					
Stranding	1	August 1829	Escala, Girona, Spain	Paulus (1966)	Total length 15.5 m (included in Fig. 2)
Stranding	1	28/06/1832	Escala, Girona, Spain	Paulus (1966)	Total length 21 m (included in Fig. 2)
Stranding	1	July 1835	Barceloneta, Barcelona, Spain	Paulus (1966)	
Stranding	1	19/02/1861	Borriana, Castellón de la Plana, Spain	Paulus (1966)	
Stranding	1	1862	Alger, Algeria	Paulus (1966)	
Killed	2	17/06/1863	Cape Creus, Girona, Spain	Paulus (1966)	Mother and calf
Stranding	1	March 1892	Cape of Palos, Murcia, Spain	Casinos & Vericad (1976)	Total length 9.1 m (included in Fig. 2)
Sighting	1	17/06/1897	Near Gibraltar	Richard (1936)	
Stranding	1	September 1912	Sant Feliu de Guixols, Girona, Spain	Casinos & Vericad (1976)	
Stranding	1	14/10/1921	Llancà, Girona, Spain	Casinos & Vericad (1976)	Total length 14 m (included in Fig. 2)
Stranding	1	13/11/1923	Cagnaret, Oran, Algeria	Boutiba (1994a)	
Stranding	1	02/11/1950	Buda Island, Tarragona, Spain	Casinos & Vericad (1976)	Total length 16 m (included in Fig. 2)
Stranding	1	1953	Playa de Pals, Girona, Spain	Grau *et al.* (1986)	
Stranding	1	25/12/1954	Alcudia, Majorca, Spain	Casinos & Vericad (1976)	Total length 6.51 m (included in Figs 2, 3 and 4)
Stranding	1	26/08/1955	Llancà, Girona, Spain	Casinos & Vericad (1976)	
Stranding	1	1956	Port d'Oran, Algeria	El Bouali (1987)	
Stranding	1	1959	Port d'Oran, Algeria	El Bouali (1987)	
Stranding	1	07/08/1966	West Temouchent, Algeria	El Bouali (1987)	
Stranding	1	1969	Arzew, Algeria	El Bouali (1987)	
Stranding	1	03/07/1971	Sant Carles de la Ràpita, Tarragona, Spain	Casinos & Vericad (1976)	
Stranding	1	1972	El Saler, Valencia, Spain	Casinos & Vericad (1976)	
Stranding	1	30/04/1973	Segur de Calafell, Tarragona, Spain	Casinos & Filella (1975)	
Stranding	1	January 1974	Calò des Mort, Formentera, Spain	Pelegrì (1980)	
Stranding	11	1974–1993	Algerian coasts	Boutiba (1994a, 1994b); Boutiba *et al.* (1996)	
Sighting	10	1974–1993	Algerian coasts	Boutiba (1994a, 1994b); Boutiba *et al.* (1996)	Five neonates, included in Fig. 4
Stranding	1	15/01/1976	La Colonia de San Pedro, Majorca, Spain	Grau, Aguilar & Filella (1980)	
Stranding	1	03/03/1977	Matarò, Barcelona, Spain	Grau, Aguilar & Filella (1980)	
Sighting	3	13/10/1977	Off Majorca Island, Spain	Grau, Aguilar & Filella (1980)	
Stranding	1	04/06/1979	S'Arenal d'en Moro, Favatrix, Minorca, Spain	Grau, Aguilar & Filella (1980)	
Dead	1	25/08/1980	Off Playa de Torreblanca, Castellón de la Plana, Spain	Grau *et al.* (1986)	
Collision	1	27/05/1982	Puerto Valencia, Spain	Raga *et al.* (1991)	
Stranding	1	01/01/1986	Delta del Ebro, Tarragona, Spain	Raga *et al.* (1991)	Newborn, included in Fig. 4
Collision	1	23/01/1986	Barcelona, Spain	Raga *et al.* (1991)	
Sighting	6	01/04/1986	North of Balearic Islands	Viale (1991)	
Sighting	7	23/04/1986	West of Balearic Islands	Viale (1991)	
Sighting	5	10/05/1986	North-east of Balearic Islands	Viale (1991)	
Sighting	15	23/05–12/06/1986	Alboran Sea and Algerian Basin	Viale & Frontier (1994)	
Stranding	1	27/06/1986	Salou, Tarragona, Spain	Raga *et al.* (1991)	Newborn, included in Fig. 4
Collision	1	10/08/1986	Puerto Barcelona, Spain	Raga *et al.* (1991)	
Collision	1	21/05/1987	Puerto Valencia, Spain	Raga *et al.* (1991)	

Stranding	1	30/05/1987	Kristel, Algeria	El Bouali (1987)	
Sighting	5	September–November 1987	Strait of Gibraltar	Hashmi & Adloff (1991)	
Collision	1	29/09/1988	Puerto Valencia, Spain	Raga *et al.* (1991)	
Stranding	1	23/06/1989	Montroig del Camp, Tarragona, Spain	Borrell *et al.* (2000)	
Stranding	1	11/09/1990	St. Antoni de Calonge, Girona, Spain	Borrell *et al.* (2000)	
Stranding	1	11/02/1991	Fuengirola, Malaga, Spain	Borrell *et al.* (2000)	
Sighting	82	1992–98	Gulf of Vera, Alboran Sea, Spain	Cañadas *et al.* (1999)	Two neonates, included in Fig. 4
Stranding	4	1996–98	Andalusian Coast and Melilla, Spain	Fernàndez-Casado *et al.* (1999)	
Stranding	1	April 1998	Ceuta, Spain	Cañadas *et al.* (1999)	
Subregion B or C					
Stranding	1	1620	Corsica, France	Pouchet (1893)	Pregnant with near-term foetus
Stranding	1	21/11/1830	Corsica, France	Paulus (1966)	Total length 15.3 m (included in Fig. 2)
Collision	1	05/07/1972	37 km off Cape Corse, Corsica, France	Duguy (1973)	
Sighting	19	1988–1989	Ligurian, Corsica and Tyrrhenian Seas	Gannier & Gannier (1990)	
Subregion B					
Stranding	1	05/10/1682	Ile Sainte-Anne, Alpes Maritimes, France	Paulus (1966)	
Stranding	1	20/03/1798	Ile Sainte-Marguerite, Alpes Maritimes, France	Paulus (1966)	Total length 20 m (included in Fig. 2)
Stranding	1	12/11/1817	Sagone, Corsica, France	Paulus (1966)	
Stranding	1	27/11/1828	Saint-Cyprien, Pyrénées Orientales, France	Paulus (1966)	Total length 25.6 m (included in Fig. 2)
Stranding	1	1833	Saint-Tropez, Var, France	Paulus (1966)	
Bycatch	1	1840	Saint-Tropez, Var, France	Diorio (1866)	Caught in traditional tuna trap
Dead	1	1842	Marseille, Bouches du Rhone, France	Paulus (1966)	Only skull
Stranding	1	1844	Saint-Tropez, Var, France	Paulus (1966)	
Stranding	1	10/11/1845	Bordighera, Imperia, Italy	Parona (1896)	Total length 24 m (included in Fig. 2)
Stranding	1	1852	Bordighera, Imperia, Italy	Paulus (1966)	
Stranding	1	1855	Alghero, Sardinia, Italy	Cagnolaro (1977)	Total length 19.3 m (included in Fig. 2)
Killed	2	1859	Port-Vendre, Pyrénées Orientales, France	Paulus (1966)	Mother and calf; total length 20 m (included in Fig. 2); newborn included in Fig. 4
Stranding	1	1860	Saint-Mandrier, Var, France	Paulus (1966)	
Stranding	1	February 1862	Hérault, Aude, France	Paulus (1966)	Total length 19.8 m (included in Fig. 2)
Sighting	2	1862	Hérault, Aude, France	Gervais (1864)	Mother and calf
Stranding	1	October 1863	Sestri Levante, Genova, Italy	Parona (1908)	
Stranding	1	1863	Saint-Tropez, Var, France	Paulus (1966)	
Stranding	1	1864	Ile Sainte-Marguerite, Alpes Maritimes, France	Paulus (1966)	
Stranding	1	20/05/1870	Marseille, Bouches du Rhone, France	Paulus (1966)	Total length 13 m (included in Fig. 2)
Killed	1	23/09/1870	Thons à Palavas, Hérault, France	Paulus (1966)	Pregnant; total length 19.4 m (included in Fig. 2)
Killed	1	1871	La Ciotat, Var, France	Paulus (1966)	Total length 15 m (included in Fig. 2)
Stranding	1	08/11/1872	Diano Marina, Imperia, Italy	Parona (1908)	
Stranding	1	03/12/1877	Piana, Corsica, France	Paulus (1966)	Total length 18.5 m (included in Fig. 2)
Dead	1	September 1878	Off La Spezia, Italy	Giglioli (1880)	Pregnant with near-term foetus
Dead	1	01/10/1878	Monterosso, La Spezia, Italy	Parona (1896)	Pregnant with near-term foetus; total length 23 m (included in Fig. 2); foetus included in Fig. 4
Stranding	1	1878	Saintes-Maries-de-la-Mer, Bouches du Rhone, France	Paulus (1966)	
Killed	1	28/11/1884	Cavalaire, Var, France	Paulus (1966)	Total length 5.3 m (included in Figs 2, 3 and 4)
Stranding	1	October 1891	Saint-Raphael, Var, France	Paulus (1966)	
Harpooned	1	05/05/1896	7 km off Cap Cerbére, Pyrénées Orientales, France	Paulus (1966)	

APPENDIX. *Continued*

Event	No. of species	Date	Locality	Source	Notes
Harpooned	1	26/05/1896	In the waters in front of Monaco	Richard (1936)	Presumed by the author to be the same individual stranded in Pietra Ligure on 6 September 1896 (see below)
Dead	1	06/09/1896	Pietra Ligure, Savona, Italy	Parona (1896)	Total length 23 m (included in Fig. 2)
Dead	1	14/09/1896	Off Capo Vado, Savona, Italy	Parona (1896)	Total length 18 m (included in Fig. 2)
Dead	1	19/10/1896	28 km off Genova, Italy	Parona (1896)	Total length 21 m (included in Fig. 2)
Stranding	1	23/10/1896	Framura, La Spezia, Italy	Parona (1896)	Total length 14 m (included in Fig. 2)
Stranding	1	December 1896	Gruissant, Aude, France	Paulus (1966)	
Stranding	1	08/12/1898	Porto Torres, Sardinia, Italy	Parona (1908)	Total length 9 m (included in Fig. 2)
Stranding	1	28/03/1900	Carloforte, Sardinia, Italy	Parona (1908)	
Stranding	1	01/01/1902	Levanto, La Spezia, Italy	Parona (1908)	Total length 14 m (included in Fig. 2)
Stranding	1	10/05/1903	Cabras, Sardinia, Italy	Parona (1908)	Total length 16.7 m (included in Fig. 2)
Killed	1	06/08/1903	74 km off Capo Mele, Imperia, Italy	Anonymous (1903), Parona (1908)	Total length 19.3 m (included in Fig. 2)
Sighting	3	13/04/1904	Ligurian Sea	Richard (1936)	
Sighting	1	21/04/1904	Ligurian Sea	Richard (1936)	
Bycatch	1	06/10/1904	Off Sète, Hérault, France	Anthony & Calvet (1905)	Total length 12.3 m (included in Fig. 2)
Sighting	1	22/04/1905	Ligurian Sea	Richard (1936)	
Stranding	1	January 1908	Ajaccio, Corsica, France	Paulus (1966)	
Sighting	1	09/05/1908	Ligurian Sea	Richard (1936)	
Sighting	1	05/10/1908	Off Sturla, Genova, Italy	Parona (1908)	Total length 20 m (included in Fig. 2)
Stranding	1	23/09/1909	Var, France	Richard (1936)	Total length 5.5 m (included in Figs 2, 3 and 4)
Stranding	1	28/09/1909	Théoule, Alpes-Maritimes, France	Richard (1936)	
Sighting	1	20/04/1912	Off Perpignan, Pyrénées Orientales, France	Richard (1936)	
Sighting	1+	02/05/1915	Ligurian Sea	Richard (1936)	
Sighting	1	March 1939	Cap d'Agde, Hérault, France	Paulus (1966)	
Stranding	1	30/06/1940	Sausset-les-Pins, Bouches du Rhone, France	Paulus (1966)	Total length 19.8 m (included in Fig. 2)
Stranding	1	10/11/1950	Saintes-Maries-de-la-Mer, Bouches du Rhone, France	Paulus (1966)	Total length 12 m (included in Fig. 2)
Stranding	1	09/06/1955	La Spezia, Italy	Tamino (1956)	Total length 10.6 m (included in Fig. 2)
Stranding	1	23/04/1960	Port-Saint-Louis-du-Rhone, France	Paulus (1966)	Total length 9 m (included in Fig. 2)
Dead	1	31/08/1961	Off Cap Cépet, Var, France	Paulus (1966)	Total length 20 m approximately
Dead	1	09/08/1962	Off Saintes-Maries-de-la-Mer, Bouches du Rhone, France	Paulus (1966)	Total length 20 m approximately
Stranding	1	05/11/1963	Saintes-Maries-de-la-Mer, Bouches du Rhone, France	Paulus (1966)	Total length 20 m approximately
Stranding	1	13/11/1971	Sainte-Maxime, Var, France	Duguy & Budker (1972)	Newborn, included in Fig. 4
Collision	1	03/09/1972	Between Nice and Bastia	Duguy (1973)	
Collision	1	06/04/1973	Gulf of Lions	Casinos & Filella (1975)	
Sighting	9	August 1973	Ligurian Sea	Viale (1985)	
Collision	1	30/08/1973	Between Nice and Calvi	Duguy (1974)	
Collision	1	1973	Off Genova, Italy	L. Cagnolaro (personal communication)	Salvaged in 1977 from a soap factory, conserved at the Verona Natural History Museum
Collision	1	10/09/1974	28 km off Antibes, France	Duguy (1975)	Noted as collision by Laist *et al.* (2001)
Sighting	78	July 1975	Ligurian Sea	Viale (1985)	
Dead	1	24/09/1975	46 km off Ile de Porquerolles, Var, France	Duguy (1976b)	

Dead	1	24/09/1975	4 km off Ile du Levant, Var, France	Duguy (1976b)	
Stranding	1	10/10/1975	Ile Sainte Marguerite, Alpes-Maritimes, France	Duguy (1976b)	Total length 5.35 m (included in Figs 2, 3 and 4)
Sighting	1	01/11/1975	Gruissan, Aude, France	Duguy (1976b)	Newborn, included in Fig. 4
Collision	1	03/04/1976	Toulon, Var, France	Duguy (1977)	Total length 14.3 m (included in Fig. 2)
Collision	1	01/01/1977	Gulf of Genova, Italy	Poggi (1982)	
Stranding	1	23/10/1977	Off Le Grau du Roi, Bouches-du-Rhone, France	Duguy (1978)	Total length 4 m (included in Figs 2.3 and 4)
Dead	1	03/02/1978	Off Cannes, France	Duguy (1979)	Total length 15 m approximately
Sighting	7	July 1979	Ligurian Sea	Viale (1985)	
Sighting	15	July 1980	Ligurian Sea	Viale (1985)	
Stranding	1	08/08/1980	Cap Camarat, Var, France	Duguy (1981); Besson, Duguy & Tardy (1982)	Pregnant with three embryos; total length 19.2 m (included in Fig. 2)
Dead	1	12/09/1980	Off Calvi, Corsica, France	Duguy (1981)	
Stranding	1	17/01/1981	Port-Camargue, Hérault, France	Duguy (1982)	Newborn, included in Fig. 4; stranded alive, returned to the sea
Sighting	15	September 1981	Ligurian Sea	Viale (1985)	
Sighting	3	1981	46 km off Cape d'Antibes, Alpes-Maritimes, France	Palazzoli (1983)	
Sighting	4	1981	Ligurian Sea	Giordano (1986)	
Sighting	1	15/08/1982	Ligurian Sea	Raga, Raduàn, & Blanco (1985)	
Sighting	27	Summer 1982	Ligurian Sea	Viale (1985)	
Collision	1	19/09/1982	Villeneuve-les-Maguelonne, Hérault, France	Duguy (1983)	Noted as collision by Laist *et al.* (2001)
Dead	1	05/11/1982	Off Menton, Alpes-Maritimes, France	Duguy (1983)	
Sighting	1	1982	Within 46 km off Cape d'Antibes, Alpes-Maritimes, France	Palazzoli (1983)	
Sighting	44	Summer 1983	Ligurian Sea	Viale (1985)	
Sighting	3	1983	Ligurian Sea	Giordano (1986)	
Stranding	1	07/01/1984	Girolata, Corsica, France	Duguy (1985)	Total length 17 m (included in Fig. 2)
Stranding	1	24/09/1984	Saint-Florent, Corsica, France	Duguy (1985)	Total length 4.75 m (included in Figs 2, 3 and 4)
Stranding	1	07/11/1984	Sausset-les-Pins, Bouches-du-Rhone, France	Duguy (1985)	Total length 5.5 m (included in Figs 2, 3 and 4)
Stranding	1	11/11/1984	Grimaud, Var, France	Duguy (1985)	Total length 11 m approximately
Sighting	2	1984	Ligurian Sea	Giordano (1986)	
Collision	1	15/01/1985	La Palme, Aude, France	Duguy (1986)	Noted as collision by Laist *et al.* (2001); total length 18 m (included in Fig. 2)
Stranding	1	14/02/1985	Marseille, France	Duguy (1986)	Total length 6 m approximately; newborn, included in Fig. 4
Sighting	7	July 1985	Ligurian Sea	Viale *et al.* (1986)	Sighted from airplane
Sighting	1	1985	Ligurian Sea	Giordano (1986)	
Sighting	1	11/03/1986	Ligurian Sea	Viale (1991)	
Sighting	1	March–April 1986	Ligurian Sea	Viale *et al.* (1988)	
Dead	1	20/09/1986	Off Ile du Levant, Var, France	Duguy (1987)	Total length 6 m (included in Figs 2,3 and 4)
Collision	1	10/11/1986	Fos-sur-Mer, Bouches-du-Rhone, France	Duguy (1987)	Noted as collision by Laist *et al.* (2001); total length 16 m (included in Fig. 2)
Stranding	1	30/04/1987	Ajaccio, Corsica, France	Duguy (1988)	Total length 15 m approximately
Stranding	1	04/02/1988	Sausset-les-Pins, Bouches-du-Rhone, France	Duguy (1989)	Total length 20 m approximately
Sighting	2	26/08/1988	Ligurian Sea	Gannier & Gannier (1989)	
Sighting	1	27/08/1988	Ligurian Sea	Gannier & Gannier (1989)	Newborn, included in Fig. 4
Sighting	3	30/10/1988	Ligurian Sea	Gannier & Gannier (1989)	Newborn, included in Fig. 4
Sighting	1+	October–November 1988	Ligurian Sea	Gannier & Gannier (1993)	
Dead	1	October 1989	26 km off San Remo, Imperia, Italy	Anonymous (1990)	

APPENDIX. *Continued*

Event	No. of species	Date	Locality	Source	Notes
Sighting	1+	20–26/10/1989	Gulf of Lions	Viale & Terris (1990)	
Sighting	2+	October–November 1989	Ligurian Sea	Gannier & Gannier (1993)	
Sighting	4+	February 1990	Ligurian Sea	Gannier & Gannier (1993)	
Dead	1	10/03/1990	Gulf of La Spezia, Italy	Anonymous (1991)	Total length 12 m approximately
Collision	1	28/04/1990	Porto Torres, Sardinia, Italy	Anonymous (1991)	Total length 16 m approximately
Stranding	1	09/05/1990	Palavas-les-Flots, Hérault, France	Duguy (1990b)	Total length 13 m approximately
Sighting	6	1990–91	Ligurian Sea	Fabbri & Lauriano (1992)	
Sighting	127	Summer 1990–91	Ligurian Sea	Zanardelli, Notarbartolo di Sciara & Jahoda (1992)	
Sighting	328	1990–97	Ligurian Sea	Zanardelli *et al*. (1999)	Three neonates, included in Fig. 4
Stranding	1	16/01/1991	Grimaud, Var, France	Duguy (1992)	Total length 15 m approximately
Collision	1	30/04/1991	Genova, Italy	Anonymous (1992)	Total length 16 m (included in Fig. 2)
Stranding	1	21/07/1991	Barcaggio, Corsica, France	Duguy (1992)	Total length 10 m (included in Fig. 2)
Sighting	83	August 1991	Liguro-Provencal basin	Forcada *et al*. (1996)	
Sighting	52	August 1991	Ligurian Sea	Relini *et al*. (1992)	
Sighting	54	1991	Ligurian Sea	Gannier & Gannier (1992)	
Sighting	224	Summer 1991–94	Corso-Ligurian Basin	Gannier (1997b)	
Sighting	2+	March 1992	Ligurian Sea	Gannier & Gannier (1993)	
Sighting	5+	April 1992	Ligurian Sea	Gannier & Gannier (1993)	
Sighting	84	August 1992	Corso-Ligurian Basin	Forcada, Notarbartolo di Sciara & Fabbri (1995)	
Sighting	3	Summer 1992	Ligurian Sea	Relini *et al*. (1994)	
Sighting	28	Summer 1992	Ligurian Sea	Pulcini, Angradi & Sanna (1993)	
Collision	1	30/03/1993	Porto Torres, Sardinia, Italy	Anonymous (1994a)	Total length 15 m (included in Fig. 2)
Sighting	1+	August 1993	Ligurian Sea	Relini *et al*. (1994)	
Collision	1	09/09/1993	Saint-Tropez, Var, France	Laist *et al*. (2001)	
Collision	1	09/09/1993	Toulon, Var, France	Laist *et al*. (2001)	
Sighting	2	1993–96	Ligurian Sea	Stanzani, Bonomi & Bortolotto (1997)	
Sighting	9+	Summer 1994	North-western Sardinia	Lauriano & Notarbartolo di Sciara (1996)	
Sighting	62	Summer 1994–96	North-western Sardinia, Corsica Sea	Lauriano (1997)	
Sighting	2	July–August 1995	Ligurian Sea	Barberis *et al*. (1997)	
Sighting	8	25/09/1995	Off Ajaccio, Corsica, France	Guibourgé *et al*. (1996)	
Collision	1	26/09/1995	Fos-sur-Mer, Bouches-du-Rhone, France	Laist *et al*. (2001)	
Stranding	1	29/09/1995	Gulf of Sagone, Corsica, France	Guibourgé *et al*. (1996)	
Sighting	7	01–02/11/1995	West Corsica	Guibourgé *et al*. (1996)	
Sighting	1	15/11/1995	Off Ajaccio, Corsica, France	Guibourgé *et al*. (1996)	
Stranding	1	27/11/1995	Corsica, France	Guibourgé *et al*. (1996)	Newborn, included in Fig. 4
Stranding	1	12/12/1995	Cabras, Sardinia, Italy	Anonymous (1995)	Total length 6 m (included in Figs 2, 3 and 4)
Sighting	28+	12–17 July 1996	Ligurian Sea, Corsica Sea and Gulf of Lions	Beaubrun *et al*. (1997)	
Collision	1	26/07/1996	Ligurian Sea	Laist *et al*. (2001)	
Sighting	20	Summer 1996	Ligurian Sea	Airoldi *et al*. (1999)	
Sighting	49+	Summer 1996	Ligurian Sea	Gannier (1997a)	
Sighting	11+	Summer 1996	Ligurian Sea	Airoldi *et al*. (1999)	
Collision	1	24/02/1997	Marseille, Bouches-du-Rhone, France	Laist *et al*. (2001)	
Bycatch	1	20/06/1997	Stintino, Sardinia, Italy	Lauriano (personal communication)	Caught in traditional tuna trap ('tonnara')
Sighting	1	25/06/1997	Espiguette, Gulf of Lions, France	Beaubrun *et al*. (1999)	
Sighting	58+	Summer 1997	Coastal part of the Gulf of Lions, France	Beaubrun *et al*. (1999)	
Sighting	34	Summer 1997	Ligurian Sea	Airoldi *et al*. (1999)	

Sighting	3	Summer 1997	Ligurian Sea	Trucchi *et al*. (1999)	
Bycatch	1	25/09/1997	Stintino, Sardinia, Italy	Anonymous (1998)	Total length 15 m approximately
Dead	1	12/10/1997	Off Genova, Italy	Anonymous (1998)	Total length 12.7 m (included in Fig. 2)
Stranding	1	14/10/1997	Is Arenas, Narbolia, Sardinia, Italy	Anonymous (1998)	Total length 15 m approximately
Stranding	1	27/01/1998	Oristano, Sardinia, Italy	Anonymous (2000)	Total length 17 m approximately
Sighting	17+	August 1998	Gulf of Lions and Ligurian Sea	Gannier & Bourreau (1999)	
Sighting	79	Summer 1998	Ligurian Sea	Airoldi *et al*. (1999)	
Sighting	19	Summer 1998	Ligurian Sea	Sanna *et al*. (1999)	
Sighting	38+	1998	Around Asinara Island, Sardinia, Italy	Lauriano *et al*. (1999)	
Sighting	2	1998	Ligurian Sea	Trucchi, Ottonello & Tribocco (1999)	
Stranding	1	15/08/1999	Off Savona, Italy	Anonymous (2001)	Total length 12 m approximately
Bycatch	1	16/07/2000	Camogli, Genova, Italy	Lauriano (personal communication)	Caught in traditional tuna trap ('tonnara'); released alive
Subregion C					
Stranding	1	28/01/1624	Santa Marinella, Roma, Italy	Paulus (1966)	
Stranding	1	February 1624	Santa Severa, Roma, Italy	Paulus (1966)	
Stranding	1	1714	Populonia, Livorno, Italy	Borri (1927)	
Stranding	1	December 1827	Solenzara, Corsica, France	Paulus (1966)	
Killed	1	1833	Civitavecchia, Roma, Italy	Paulus (1966)	
Stranding	1	1839	Marciana, Elba Island, Italy	Parona (1896)	
Stranding	1	30/07/1857	Portoferraio, Elba Island, Italy	Parona (1896)	Total length 21 m (included in Fig. 2)
Stranding	1	1860?	Mondello, Palermo, Italy	Parona (1896)	Referring to Minà Palumbo (1868), no year given. Date doubtful. Total length 8.4 m (included in Fig. 2).
Stranding	1	1860	Montebello (?), Palermo, Italy	Paulus (1966)	Given as 16.51 m long. Possibly the same individual as above, although lengths and locations don't coincide
Stranding	1	1863	Tunis, Tunisia	Paulus (1966)	
Stranding	1	04/03/1866	Santa Marinella, Roma, Italy	Diorio (1866)	Total length 18.8 m (included in Fig. 2)
Stranding	1	10/06/1871	Antignano, Livorno, Italy	Richiardi (1874)	Total length 9 m (included in Fig. 2)
Sighting	2	July 1889	Piombino, Livorno, Italy	Parona (1908)	Total length 17 m (included in Fig. 2)
Sighting	1	1893	Portoferraio, Elba Island, Italy	Parona (1896)	
Stranding	2	18/12/1896	Cagliari, Sardinia, Italy	Parona (1896)	Presumed fin whale by the author
Stranding	1	31/08/1897	La Maddalena, Sardinia, Italy	Parona (1908)	Total length 15.3 m (included in Fig. 2)
Stranding	1	01/09/1897	Marina di Carrara, Italy	Parona (1908)	
Stranding	1	02/06/1898	La Maddalena, Sardinia, Italy	Parona (1908)	Total length 18 m (included in Fig. 2)
Stranding	1	June 1898	Portoferraio, Elba Island, Italy	Parona (1908)	Total length 15 m (included in Fig. 2)
Killed	1	06/09/1901	Livorno, Italy	Salle & Becherucci (1902); Parona (1908)	Total length 22 m – total skeletal lenght 19.05 (included in Fig. 2)
Stranding	1	20/06/1907	San Vincenzo, Livorno, Italy	Ficalbi (1907)	Total length 11.5 m (included in Fig. 2)
Stranding	1	05/09/1908	Marina di Massa, Italy	Parona (1908)	Total length 18.3 m (included in Fig. 2)
Stranding	1	1913	Castel Fusano, Roma, Italy	Lepri (1914)	Wrongly considered *B. acutorostrata* by Carruccio (1913). Total length 6 m (included in Figs 2, 3 and 4)
Stranding	1	27/12/1915	Marina di Pisa, Italy	Ficalbi (1919)	Only skull
Stranding	1	13/12/1916	Piombino, Livorno, Italy	Ficalbi (1919)	Total length 5.4 m (included in Figs 2, 3 and 4)
Sighting	2	22/07/1926	Off Portoferraio, Elba Island, Italy	Borri (1927)	One of the two killed; total length 11.3 m (included in Fig. 2)
Stranding	1	1928	San Giovanni a Teduccio, Napoli, Italy	Pierantoni (1930); Maio, Picariello & Cagnolaro (2001)	Total length 20 m approximately
Stranding	1	1932	Elba Island, Italy	Anonymous (1932)	Total length 13 m (included in Fig. 2)
Stranding	1	13/02/1953	Gromola, Salerno, Italy	Tamino (1953b)	Total length 13.4 m (included in Fig. 2)
Stranding	1	16/11/1953	Island of Ischia, Napoli, Italy	Tamino (1953a)	Total length 5.9 m (included in Figs 2, 3 and 4)

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APPENDIX. *Continued*

Event	No. of species	Date	Locality	Source	Notes
Stranding	1	01/01/1957	Ponza Island, Latina, Italy	Parenzan (1958)	Total length 20 m (included in Fig. 2)
Stranding	1	24/06/1964	Porto Farina, Tunisia	Chakroun (1966)	Probably *B. physalus*
Stranding	1	23/11/1974	Pontedoro, Livorno, Italy	Pezzo, Cancelli & Baccetti (1995)	Total length 17 m (included in Fig. 2)
Stranding	1	16/01/1975	Bastia, Corsica, France	Duguy (1976b)	Total length 5.5 m (included in Figs 2, 3 and 4)
Collision	1	24/01/1976	Zappulla, Messina, Italy	Di Natale & Giuffré (1976)	
Stranding	1	18/10/1979	Piedicorte, Corsica, France	Duguy (1980)	
Stranding	1	18/09/1981	Island of Giglio, Italy	Cagnolaro *et al.* (1986)	Total length 5.9 m (included in Figs 2, 3 and 4)
Stranding	1	11/11/1982	Island of Giglio, Italy	Cagnolaro *et al.* (1986)	Total length 5.45 m (included in Figs 2, 3 and 4)
Stranding	1	01/06/1984	Linguizetta, Corsica, France	Duguy (1985)	
Sighting	1	12/03/1986	Tyrrhenian Sea	Viale (1991)	
Sighting	2	March–April 1986	Tyrrhenian Sea	Viale *et al.* (1988)	
Collision	1	23/06/1986	Off Castello Sonnino, Livorno, Italy	Anonymous (1987)	Total length 11.05 m (included in Fig. 2)
Collision	1	28/06/1986	Off Gorgona Island, Livorno, Italy	Anonymous (1987)	Total length 14 m (included in Fig. 2)
Stranding	1	18/08/1986	Gulf of Tunis	Ben Mustapha (1986)	
Stranding	1	20/09/1986	Pizzo Calabro, Vibo Valentia, Italy	Anonymous (1987)	Total length 9.31 m (included in Fig. 2)
Sighting	1	24/11/1986	Vibo Valentia, Italy	Anonymous (1987)	Total length 7–8 m approximately; included in Fig. 4
Stranding	1	21/01/1987	Golfo Baratti, Livorno, Italy	Anonymous (1988)	Total length 20 m approximately
Stranding	1	20/04/1987	Capo Malfatano, Sardinia, Italy	Anonymous (1988)	
Collision	1	22/05/1987	Olbia, Sardinia, Italy	Anonymous (1988)	Total length 12.95 m (included in Fig. 2)
Stranding	1	14/07/1987	Capo S.Elia, Sardinia, Italy	Anonymous (1988)	Total length 8 m approximately; included in Fig. 4
Stranding	1	04/12/1987	Porto Vecchio, Corsica, France	Duguy (1988)	Total length 16 m (included in Fig. 2)
Sighting	1+	16/08/1988	East of Cap Corse, Corsica, France	Gannier & Gannier (1989)	
Dead	1	10/04/1989	Central Tyrrhenian Sea	Anonymous (1990)	Total length 16.8 m (included in Fig. 2)
Collision	1	20/05/1989	Olbia, Sardinia, Italy	Anonymous (1990)	Total length 12 m (included in Fig. 2)
Stranding	1	30/08/1989	Marina di Curinga, Catanzaro, Italy	Anonymous (1990)	Total length 7.5 m (included in Figs 2, 3 and 4)
Sighting	4	October 1989	Central Tyrrhenian Sea	Marini *et al.* (1996b)	Four neonates, included in Fig. 4
Sighting	1	November 1989	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Sighting	1	December 1989	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Sighting	4	January 1990	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Sighting	4	February 1990	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Stranding	1	15/02/1990	Fuscaldo, Cosenza, Italy	Anonymous (1991)	Total length 13 m approximately
Sighting	2	March 1990	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Sighting	5	April 1990	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Sighting	12	May 1990	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Sighting	7	June 1990	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Sighting	9	July 1990	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Bycatch	1	13/07/1990	Palmi, Reggio Calabria, Italy	Anonymous (1991)	Total length 15 m (included in Fig. 2)
Sighting	6	August 1990	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Sighting	4	August 1990	Harbour of Vibo Valentia Marina, Italy	Tethys original data	Probably mother and calf
Sighting	7	September 1990	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Sighting	6	October 1990	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Stranding	1	26/10/1990	Piombino, Livorno, Italy	Anonymous (1991)	Total length 19.2 m (included in Fig. 2)
Sighting	4	January 1991	Central Tyrrhenian Sea	Marini *et al.* (1996b)	
Stranding	1	27/01/1991	Razzoli Island, Sardinia, Italy	Anonymous (1992)	
Stranding	1	9/02/1991	Tabarka, Tunisia	Bradai & Ghorbel (1999)	Total length 18 m approximately
Sighting	2	March 1991	Central Tyrrhenian Sea	Marini *et al.* (1996b)	

Sighting	5	April 1991	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	4	May 1991	Central Tyrrhenian Sea	Marini *et al*. (1996b)	Newborn, included in Fig. 4
Sighting	3	June 1991	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	5	July 1991	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	2	September 1991	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	3	October 1991	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	28	1991–95	Off Island of Ischia, Napoli, Italy	Mussi *et al*. (1999)	
Sighting	2	January 1992	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	3	February 1992	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	2	March 1992	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	2	April 1992	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	12	May 1992	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	3	June 1992	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	1	August 1992	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Sighting	2	September 1992	Central Tyrrhenian Sea	Marini *et al*. (1996b)	
Stranding	1	22/11/1992	Marina di Pisa, Italy	Anonymous (1995)	Total length 5.92 m (included in Figs 2, 3 and 4)
Sighting	1	1993–94	Off north-western Sicily, Italy	Giordano *et al*. (1995)	
Stranding	1	02/03/1994	Arbus, Sardinia, Italy	Anonymous (1996b)	
Collision	1	20/05/1994	Pula, Sardinia, Italy	Anonymous (1996b)	Total length 13 m (included in Fig. 2)
Collision	1	25/05/1995	Off Livorno, Italy	Anonymous (1997a)	Total length 15.15 m (included in Fig. 2)
Dead	1	23/09/1995	Off Livorno, Italy	Anonymous (1997a)	Total length 12.8 m (included in Fig. 2)
Stranding	1	03/02/1996	Palmi, Reggio Calabria, Italy	Anonymous (1997b)	Total length 6.6 m (included in Figs 2, 3 and 4)
Stranding	1	21/03/1996	Secche della Meloria, Livorno, Italy	Anonymous (1997b)	Total length 8 m (included in Figs 2, 3 and 4)
Stranding	1	12/05/1996	Licola, Napoli, Italy	Anonymous (1997b)	Total length 20 m approximately
Sighting	94	1996–98	Off Island of Ischia, Napoli, Italy	Mussi *et al*. (1999)	
Stranding	1	26/07/1997	Gaeta, Latina, Italy	Anonymous (1998)	Total length 15 m approximately
Stranding	1	11/12/1997	Procida, Napoli, Italy	Anonymous (1998)	Total length 14 m (included in Fig. 2)
Collision	1	07/02/1998	Darsena Toscana, Livorno, Italy	Anonymous (2000)	Total length 13.8 m (included in Fig. 2)
Stranding	1	26/12/1998	Gioia Tauro, Reggio Calabria, Italy	Anonymous (2000)	Total length 18 m approximately
Stranding	1	11/07/1999	Off Piombino, Grosseto, Italy	Anonymous (2001)	
Subregion D					
Stranding	1	1771	Adriatic Sea	Cappellini (1877)	Considered '*B. rostrata*' by the author – recognized as *B. physalus* by Giglioli (1880), Lepri (1914)
Stranding	1	05/05/1827	Andrano, Lecce, Italy	Manni di San Cesario (1827); Parona (1896); Bello (1990)	Total length 15.75 m (included in Fig. 2)
Stranding	1	1831	Muggia, Trieste, Italy	Parona (1896)	
Stranding	1	12/07/1862	Pag Island, Croatia	Kolombatovic (1894); Parona (1896)	Total length 12.8 m (included in Fig. 2)
Stranding	1	23/01/1953	Pag Island, Croatia	Pavletic, Canadjia & Magerle (1962)	Total length 11.5 m (included in Fig. 2)
Stranding	1	23/06/1976	Gulf of Trieste, Italy	Princi & Bussani (1976); Pilleri & Gihr (1977)	Total length 10 m (included in Fig. 2)
Sighting	2	06/06/1979	Off the estuary of the river Po, Ferrara, Italy	Rallo (1979)	Presumed *B. physalus*
Stranding	1	23/05/1986	Lido delle Nazioni, Ferrara, Italy	Anonymous (1987)	Total length 7 m (included in Figs 2, 3 and 4)
Sighting	2	21/05/1990	Off Bari, Italy	Tethys original data	
Dead	1	16/07/1990	Off Cervia, Forlì, Italy	Anonymous (1991)	Total length 14.2 m (included in Fig. 2)
Stranding	1	03/08/1991	Carovigno, Brindisi, Italy	Anonymous (1992)	
Sighting	1	Summer 1991	Off Othonoi, Greece	Politi *et al*. (1992)	
Sighting	8	Summer 1991–93	Otranto Channel	Politi, Airoldi & Notarbartolo di Sciara (1994)	
Sighting	3	1993–96	Northern Adriatic Sea	Stanzani, Bonomi & Bortolotto (1997)	
Stranding	1	19/05/1998	Torre a Mare, Bari, Italy	Anonymous (2000)	Total length 20 m approximately
Sighting	2	10/08/2000	Near Split, Croatia	Affronte (2000)	Probably mother and calf
Sighting	1	18/09/2000	Off Bellaria, Rimini, Italy	Affronte (2000)	
Sighting	3	06/10/2000	Off Trieste, Italy	Affronte (2000)	
Sighting	1	22/10/2000	Off Opatija, Croatia	Affronte (2000)	
Stranding	1	November 2000	Karinsko More, Croatia	Affronte (2000)	

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APPENDIX. *Continued*

Event	No. of species	Date	Locality	Source	Notes
Subregion E					
Stranding	1	1846	Capo S. Panagia, Sicily, Italy	Parona (1908)	
Killed	1	20/09/1894	Gallipoli, Lecce, Italy	Parona (1896); Bello (1990)	Total length 20 m approximately
Sighting and collision	4	09/01/1897	Capo Spartivento, Italy	Parona (1908)	Presumed fin whales by the author
Stranding	1	1937	Kerkennah Islands, Tunisia	Heldt (1949)	
Stranding	1	1938	Kerkennah Islands, Tunisia	Heldt (1949)	
Killed	1	1941	Skira, Tunisia	Heldt (1949)	
Stranding	1	1945	South-west Peloponnese, Greece	Frantzis *et al.* (in press)	
Stranding	1	05/02/1949	Kerkennah Islands, Tunisia	Heldt (1949)	Total length 13 m (included in Fig. 2)
Stranding	1	Spring 1954	Argostoli, Greece	Frantzis *et al.* (in press)	
Stranding	1	26/02/1956	Kerkennah Islands, Tunisia	Postel (1956)	
Sighting	1	July 1992	South-west Peloponnese, Greece	Frantzis *et al.* (in press)	
Stranding	1	October 1979	Kastos, Greece	Frantzis *et al.* (in press)	
Stranding	1	30/12/1980	Kelibia, eastern Tunisia	Ktari-Chakroun (1981)	Total length 14.5 m (included in Fig. 2)
Stranding	1	17/03/1987	Oued Maltine, Gulf of Gabes, Tunisia	Bradai & Ghorbel (1999)	Total length 19.2 m
Stranding	1	02/07/1987	Messina, Sicily, Italy	Anonymous (1988)	Total length 22 m approximately
Sighting	3	11/07/1989	Off Capo Spartivento, Italy	Tethys original data	
Sighting	2	15/08/1989	Off Melito Porto Salvo, Italy	Tethys original data	
Sighting	1	08/05/1990	Off Catania, Sicily, Italy	Tethys original data	
Stranding	1	20/02/1991	Ellouza, Gulf of Gabes, Tunisia	Bradai & Ghorbel (1999)	Total length 13.7 m
Sighting	1	Summer 1991	Off Antipaxoi, Greece	Politi *et al.* (1992)	
Stranding	1	16/08/1992	Houmt Souk, Gulf of Gabes, Tunisia	Bradai & Ghorbel (1999)	Total length 17 m
Stranding	1	03/03/1993	Ribera, Agrigento, Italy	Anonymous (1994a)	Total length 18.8 m (included in Fig. 2)
Sighting	9	1993–94	Off eastern coast of Sicily Island, Italy	Giordano *et al.* (1995)	
Stranding	1	27/01/1994	El Ketf, Gulf of Gabes, Tunisia	Bradai & Ghorbel (1999)	Female, total length 7.87 m (included in Fig. 4)
Sighting	10+	March 1994	Around Island of Lampedusa, Sicily, Italy	Marini *et al.* (1996d)	Females with calves; one of them probably lactating
Sighting	1	Summer 1994	Gulf of Taranto, Italy	Cerioni *et al.* (1996)	
Sighting	1	11/08/1997	Meganisi, Greece	Frantzis *et al.* (in press)	
Stranding	1	03/11/1997	North-western Peloponnese, Greece	Frantzis *et al.* (in press)	
Subregion F					
Stranding	1	03/091953	Chalkis, Greece	Frantzis *et al.* (in press)	
Sighting	1+	1987–95	Aegean Sea	Öztürk (1995)	
Stranding	1	1987–95	Kuþadasý, Turkey	Öztürk, pers. comm.	
Sighting	2	1993–94	Aegean Sea	Marini *et al.* (1996a); Carpentieri, Corsini & Marini (1999)	
Stranding	1	25/12/1997	Kavala, Greece	Frantzis *et al.* (in press)	
Sighting	7	February–May 1998	Saronikos Gulf, Greece	Frantzis *et al.* (in press)	
Subregion G					
Stranding	1	1860	Alexandria, Egypt	Paulus (1966)	
Stranding	1	December 1926	Mersa Matruh, Alexandria, Egypt	Flower (1932)	Total length 11.7 m (included in Fig. 2)
Stranding	1	January 1956	Ashquelon, Israel	Marchessaux (1980)	Total length 16.5 m (included in Fig. 2)
Sighting	2	September 1977	Island of Gavdos, south of Crete	Marchessaux (1980)	
Sighting	1	1987–95	Fethiye, Turkey	Öztürk, pers. comm.	
Sighting	1	1987–95	Antalya, Turkey	Öztürk, pers. comm.	
Stranding	1	1987–95	Antalya, Turkey	Öztürk, pers. comm.	
Stranding	1	1987–95	Adana, Turkey	Öztürk, pers. comm.	
Stranding	1	March 2000	Yumurtalýk, Turkey	A. Dede, ECS-ALL Discussion List, 11 March 2002	Total length 10.3 m
Sighting	3+	21/10/2001	Larnaka Bay, Cyprus	Frantzis & Economou, pers. comm.	One newborn, total length approximately 4 m (included in Fig. 4), photographed; a small group of larger individuals seen nearby