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Cetaceans in the central Mediterranean Sea: Distribution and sighting frequencies

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ABSTRACT

From 1986 to 1989 a series of cruises were conducted in the central Mediterranean Sea, to determine distribution and relative abundance of cetaceans. Observation sessions lasted for a total of 2433 h. The presence of animals was assessed visually. Relative sighting frequencies among species and among subdivisions of the study area were calculated, based on observation time. Seven species were observed, including, in order of decreasing frequency: bottlenose dolphins (*Tursiops truncatus*), striped dolphins (*Stenella coeruleoalba*), fin whales (*Balaenoptera physalus*), sperm whales (*Physeter catodon*), Risso's dolphins (*Grampus griseus*), common dolphins (*Delphinus delphis*) and long-finned pilot whales (*Globicephala melas*). The highest sighting frequencies occurred in the Ligurian-Corsican Sea; cetaceans were scarcest in the Tyrrhenian Sea and in the northern Adriatic Sea. Bottlenose dolphins were found throughout the study area in neritic waters. Fin whales, sperm whales, Risso's dolphins, and striped dolphins were sighted in the offshore waters of the Ligurian-Corsican, Tyrrhenian, and Ionian Seas. The now rare common dolphin was mostly seen in the Sardinian Sea, in the Sicily Channel, and in the Ionian Sea. Pilot whales were observed, occasionally, in the Ligurian-Corsican and Tyrrhenian Seas.

KEY WORDS: Cetacea - Distribution - Abundance - Central Mediterranean Sea.

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INTRODUCTION

Recent knowledge of the cetacean fauna living in the central Mediterranean Sea, summarized by Cagnolaro *et al.* (1983), Duguy *et al.* (1983b), and Notarbartolo di Sciara (in press), largely rests upon: a) stranding reports, both anecdotal (Ktari-Chakroun, 1980; Giacolini & Giacolini, 1984; Cagnolaro *et al.*, 1986; Bello, 1990) and systematic (Centro Studi Cetacei, 1987, 1988, 1989, 1990), and b) opportunistic observations (Pilleri, 1970; Rallo, 1976; Di Natale, 1979; McBrearty *et al.*, 1986; Notarbartolo di Sciara, 1987; Watkins *et al.*, 1987; Carlini, 1988; Giordano, 1988; Podestà & Magnaghi, 1988a, b). Information of this type, however, provides at most a species account for the considered area and contributes little to a much needed knowledge of the ecology of cetaceans in the central Mediterranean Sea. For instance, although studies of stranded cetaceans can help us to understand many important biological details of the cetacean populations living in the waters adjacent to the coast where they were found (Geraci & St. Aubin, 1979), these data cannot be extrapolated to provide information on distribution and abundance of the species concerned. Furthermore, sighting data in which the reliability of the reports cannot be assessed, such as observations provided by amateurs, yachtspeople, and seamen lacking specific training (Pilleri, 1970; Di Natale, 1979; McBrearty *et al.*, 1986) are, in our experience, of very limited scientific value (Zanardelli *et al.*, 1992a). As a consequence, detailed knowledge of distribution and relative abundance of the principal cetacean species found in the different portions of the seas surrounding Italy is today still unavailable. This prevents the formulation of proper management and conservation measures in a marine region in which a large amount of environmental abuse, mostly due to fishing pressure (Magnaghi & Podestà, 1987; Di Natale & Notarbartolo di Sciara, 1990; Notarbartolo di Sciara, 1990) and pollution (Viale, 1978; Capelli *et al.*, 1989; Carlini & Fabbri, 1989; Focardi *et al.*, 1990; Borrell & Aguilar, 1991; Focardi *et al.*, 1991, 1992), could cause the decline of many cetacean populations (Duguy, 1978; Duguy *et al.*, 1983a; Anon., 1991). To provide information on cetacean population status and trends in the Mediterranean Sea, density estimates should be obtained through rigorously planned surveys (Hiby & Hammond, 1989). The aim of this study was to provide baseline information on the distribution and relative abundance of cetaceans in the seas surrounding Italy, by comparing sighting frequencies among different species and different geographic regions. We hope that this will be useful for the planning of such future surveys. Sightings data for these purposes were collected during dedicated cruises conducted from 1986 to 1989, mostly during summer.

MATERIALS AND METHODS

To compare cetacean sighting frequencies, the seas surrounding the Italian peninsula and islands were divided into seven regions (Fig. 1): Ligurian-Corsican Sea, Tyrrhenian Sea, Sardinian Sea and Channel, Sicily Channel, Ionian Sea, southern Adriatic Sea, and northern Adriatic Sea. Boundaries between regions were defined as follows: 43°02'N and a straight line from Punta Sperone (Corsica; 41°22.0'N, 009°13.3'E) to Punta Falcone (Sardinia; 41°15.5'N, 009°13.6'E) (Ligurian-Corsican/Tyrrhenian); 41°08'N (Ligurian-Corsican/Sardinian); 009°32'E (Sardinian/Tyrrhenian); 38°00'N (Tyrrhenian/Sicily Channel); a straight line from Torre Faro (Sicily; 38°15.8'N, 015°39.2'E) to Villa San Giovanni (Calabria; 38°13.8'N, 015°38.4'E) (Tyrrhenian/Ionian); 015°05'E (Sicily Channel/Ionian); 39°47'N (Ionian/southern Adriatic); 42°44'N (southern Adriatic/northern Adriatic).

Cruise details are given in Table I; the complete cruise tracks are shown in Figure 1. Cruises could not be programmed to sample homogeneously within each region; on the contrary, when possible, cruise tracks were designed to maximize encounters with cetaceans (by utilising available information) in order to increase the number of sightings and the total time spent observing the animals. Most observations were conducted from dedicated sailing vessels, ranging in length between 12 and 15 m, supplemented in the northern Adriatic by observations from a smaller inflatable craft. Opportunistic observations were also made from the R/V *Bannock*, during oceanographic campaigns organized by the Italian National Research Council (Consiglio Nazionale delle Ricerche).

During observations, a minimum of one trained observer was stationed on each side of the boat. Observations were conducted mostly in calm weather and were interrupted when sea state exceeded Beaufort 3 (wind speed of 5.4 ms^{-1}). The total observation time (2432.7 h) consisted of 305 uninterrupted observation bouts (mean bout duration = 7.98 h, SE = 0.20). Bout beginning or ending times were determined, when applicable, by sunrise, sunset, departure or arrival time, deteriorating weather conditions and crossing of the boundary between two regions.

The presence of animals was assessed visually. When possible, school size was determined by approaching the animals and observing them at close quarters. From the sighting location, plotted on a nautical chart with the aid of Loran-C, the distance from the nearest coast was measured and recorded. Water depths, derived from the depth reading on the chart for each sighting location, were grouped into seven depth categories (1 = 0 - 50 m; 2 = 50 - 100 m; 3 = 100 - 200 m; 4 = 200 - 500 m; 5 = 500 - 1000 m; 6 = 1000 - 2000 m; 7 = > 2000 m). Each depth data point was then approximated to the mid-point of the corresponding category; the mid-point of category 7 was arbitrarily fixed at 2500 m.

Sighting frequencies were calculated by dividing the number of school sightings made during each bout by the duration of that bout. This ratio was then multiplied by 100 to avoid an excessive number of decimal points. The sighting frequency of each bout was then considered as a data point. With the exception of depth data, on which an ANOVA could be performed, the significance of all variates was evaluated with the Kruskal-Wallis test.

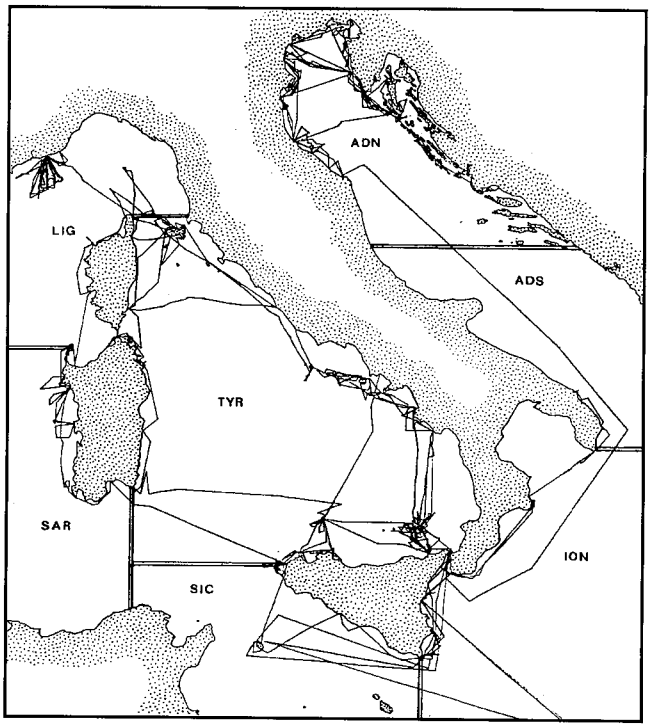

Fig. 1 - The study area with the cruise tracks and the boundaries between regions. LIG, Ligurian-Corsican Sea; TYR, Tyrrhenian Sea; SAR, Sardinia Sea and Channel; SIC, Sicily Channel; ION, Ionian Sea; ADS, Southern Adriatic Sea; ADN, Northern Adriatic Sea.

TABLE I - *Details of cruises in central Mediterranean Sea in the years 1986-1989.*

Vessel	Cruise dates			Region
Bannock	11 Jul	–	22 Jul 1986	ION, SIC
Bannock	13 Sep	–	18 Sep 1986	ION, SIC.
Bannock	15 May	–	16 May 1987	ADN, ADS, ION
Cochabamba	4 Jul	–	17 Jul 1987	TYR
Bannock	28 Jul	–	10 Aug 1987	ION
inflatable	1 Sep	–	4 Sep 1987	ADN
inflatable	27 Apr	–	1 May 1988	ADN
De Gomera	19 Jun	–	28 Aug 1988	ADN
Barbarian	11 Sep	–	5 Oct 1988	ADN
Mazzemarelle	12 Jul	–	28 Jul 1988	LIG
inflatable	8 Sep	–	11 Sep 1988	ADN
inflatable	9 Oct	–	17 Oct 1988	ADN
Highlander	9 Jun	–	31 Jul 1989	TYR LIG SAR
De Gomera	2 Jul	–	4 Oct 1989	LIG TYR SIC ION
Barbarian	4 Jul	–	23 Aug 1989	ADS ION TYR

LIG, Ligurian-Corsican Sea; TYR, Tyrrhenian Sea; SAR, Sardinian Sea and Channel; SIC, Sicily Channel; ION, Ionian Sea; ADS, Southern Adriatic Sea; ADN, Northern Adriatic Sea.

RESULTS

Cetaceans were sighted 246 times, for a total of 3590 counted individuals. Seven species were observed: striped dolphins, *Stenella coeruleoalba* (Meyen, 1833); bottlenose dolphins, *Tursiops truncatus* (Montagu, 1821); fin whales, *Balaenoptera physalus* (Linnaeus, 1758); sperm whales, *Physeter catodon* Linnaeus, 1758; Risso's dolphins, *Grampus griseus* (G. Cuvier, 1812); common dolphins, *Delphinus delphis* Linneaus 1758; and long-finned pilot whales, *Globicephala melas* (Traill, 1809) (Table II). In 45 sightings (328 individuals) the species could not be determined.

TABLE II - *Summary of cetacean sightings in the central Mediterranean Sea.*

Species	Groups	%	Specimens
Stenella coeruleoalba	81	38.6	2 145
Tursiops truncatus	67	33.3	445
Balaenoptera physalus	20	10.0	30
Physeter catodon	12	6.0	18
Grampus griseus	12	6.0	200
Delphinus delphis	5	2.5	384
Globicephala melas	4	2.0	40
Unidentified	45		328
Total	246	100	3 590

TABLE III - *Sighting frequencies of seven cetacean species observed during 305 observation bouts in the central Mediterranean Sea.*

Species	$\bar{X}$	SD	SE	Range
Tursiops truncatus	3.21	8.30	0.48	0-59.88
Stenella coeruleoalba	2.48	7.47	0.43	0-53.36
Balaenoptera physalus	0.56	3.09	0.18	0-38.39
Physeter catodon	0.51	2.92	0.17	0-23.36
Grampus griseus	0.48	3.00	0.17	0-34.78
Delphinus delphis	0.18	1.48	0.09	0-17.64
Globicephala melas	0.12	1.02	0.06	0-10.33

$\bar{X}$, mean number of groups sighted/100 h. SD, standard deviation. SE, standard error of the mean. Kruskal-Wallis test: T = 133.7 (P < 0.001).

The overall sighting frequencies observed are compared for species in Table III, and for regions in Table IV. Bottlenose dolphins were the most frequent species seen, followed by striped dolphins, fin whales, sperm whales, Risso's dolphins, common dolphins and pilot whales.

Regional differences in cetacean sighting frequencies indicate that the entire study area may be subdivided into three distinct categories: regions where the overall cetacean sighting frequency is high (Ligurian-Corsican Sea), medium (Sardinian Sea and Channel, Sicily Channel, Ionian Sea and southern Adriatic Sea), and low (Tyrrhenian Sea and northern Adriatic Sea).

Regional differences concerning species sighting frequencies are shown in Tables V - XI. Bottlenose dolphins were predominant in the Sardinian Sea and Channel, the Sicily Channel, and the northern Adriatic Sea. Striped dolphins were the commonest species found in the Ligurian-Corsican Sea, the Tyrrhenian Sea, the Ionian Sea and the southern Adriatic Sea. Fin whales were found mostly in the Ligurian-Corsican Sea, but were also occasionally observed in the Tyrrhenian Sea, the Sardinian Sea and Channel, and the Ionian Sea. Sperm whales were observed in the deep waters of the Ligurian-Corsican Sea, the Tyrrhenian Sea, the Sardinian Sea and Channel, and the Ionian Sea. Risso's dolphins were found in the Ligurian, Corsican, Tyrrhenian and Ionian Seas. The now rare common dolphin was only sighted in the Sardinian Sea, in the Sicily Channel and in the Ionian Sea. Pilot whales were sighted in the Ligurian, Corsican and Tyrrhenian Seas.

Group size descriptive statistics are shown in Table XII. The species with the greatest mean group size (76.8) was the common dolphin. Striped dolphins had the second largest mean group size (26.5), followed by Risso's dolphins (16.7), pilot whales (10.1), and bottlenose dolphins (6.6). The two largest species, the fin whale and the sperm whale, had a mean group size of 1.5.

TABLE IV - *Sighting frequencies (all species combined) of cetaceans in seven regions of the central Mediterranean Sea.*

Regions	*n*	$\bar{X}$	SD	SE	Range
Ligurian-Corsican Sea	26	27.05	22.95	4.50	0-86.37
Sardinian Sea	13	13.34	9.03	2.50	0-24.00
Sicily Channel	20	12.59	19.19	4.29	0-59.88
Ionian Sea	37	12.21	20.07	3.30	0-85.38
Southern Adriatic Sea	9	10.47	25.02	8.34	0-75.00
Tyrrhenian Sea	109	7.01	10.31	0.99	0-52.17
Northern Adriatic Sea	91	4.54	9.19	0.97	0-40.00

n, number of observation bouts. Kruskal-Wallis test: T = 51.21 (P < 0.001).

TABLE V - *Sighting frequencies of six cetacean species observed during 26 observation bouts in the Ligurian-Corsican Sea (common dolphins were not sighted).*

Species	$\bar{X}$	SD	SE	Range
Tursiops truncatus	0.25	1.30	0.26	0- 6.62
Stenella coeruleoalba	12.21	14.98	2.94	0-47.98
Balaenoptera physalus	4.82	8.86	1.74	0-38.39
Physeter catodon	1.78	5.15	1.01	0-20.00
Grampus griseus	0.38	1.93	0.38	0- 9.85
Globicephala melas	0.96	2.75	0.54	0- 9.78

Kruskal-Wallis test: T = 45.9 (P < 0.001).

TABLE VI - *Sighting frequencies of six cetacean species during 109 observation bouts in the Tyrrhenian Sea (common dolphins were not sighted).*

Species	$\bar{X}$	SD	SE	Range
Tursiops truncatus	2.08	6.20	0.60	0-31.55
Stenella coeruleoalba	2.20	5.85	0.56	0-29.41
Balaenoptera physalus	0.16	1.19	0.12	0- 8.95
Physeter catodon	0.48	2.69	0.26	0-20.66
Grampus griseus	0.93	4.23	0.41	0-34.78
Globicephala melas	0.09	0.99	0.10	0-10.33

Kruskal-Wallis test: T = 42.8 (P < 0.001).

TABLE VII - *Sighting frequencies of four cetacean species observed during 13 observation bouts in the Sardinian Sea and Channel (Risso's dolphins and pilot whales were not sighted).*

Species	$\bar{X}$	SD	SE	Range
Tursiops truncatus	4.61	5.57	1.55	0-15.38
Stenella coeruleoalba	1.65	4.05	1.13	0-12
Balaenoptera physalus	0.65	2.36	0.66	0- 8.51
Physeter catodon	1.80	6.48	1.80	0-23.36
Delphinus delphis	2.66	5.52	1.53	0-17.64

Kruskal-Wallis test: T = 15.9 (0.01 > P > 0.025).

TABLE VIII - *Sighting frequencies of three cetacean species observed during 20 observation bouts in the Sicily Channel (fin whales, sperm whales, Risso's dolphins and pilot whales were not sighted).*

Species	$\bar{X}$	SD	SE	Range
Tursiops truncatus	10.19	17.80	3.98	0-59.88
Stenella coeruleoalba	0.40	1.80	0.41	0- 8.05
Delphinus delphis	0.50	2.24	0.50	0-10

Kruskal-Wallis test: T = 33.4 (P < 0.001).

TABLE IX - *Sighting frequencies of six cetacean species observed during 37 observation bouts in the Ionian Sea (pilot whales were not sighted).*

Species	$\bar{X}$	SD	SE	Range
Tursiops truncatus	1.72	4.80	0.79	0-22.22
Stenella coeruleoalba	3.70	10.09	1.68	0-53.36
Balaenoptera physalus	0.53	2.25	0.37	0-10.79
Physeter catodon	0.88	3.92	0.65	0-21.34
Grampus griseus	0.96	4.22	0.70	0-22.22
Delphinus delphis	0.30	1.81	0.30	0-11.01

Kruskal-Wallis test: T = 14.4 (0.025 > P > 0.05).

TABLE X - *Sighting frequencies of two cetacean species observed during 9 observation bouts in the Southern Adriatic Sea (fin whales, sperm whales, Risso's dolphins, common dolphins and pilot whales were not sighted).*

Species	$\bar{X}$	SD	SE	Range
Tursiops truncatus	2.78	8.33	2.78	0-25
Stenella coeruleoalba	3.85	8.55	2.85	0-25

TABLE XI - *Sighting frequencies of the only cetacean species, the bottlenose dolphin, observed during 91 observation bouts in the northern Adriatic Sea.*

Species	$\bar{X}$	SD	SE	Range
Tursiops truncatus	4.33	9.09	0.96	0-40

Differences among species in water depth and distance from the nearest coast at the sighting locations are summarized, respectively, in Tables XIII and XIV, and in Figure 2. Fin whales, sperm whales, pilot whales, and striped dolphins clearly showed pelagic habits, at large distances from land and mostly in deep waters, offshore from the continental slope. Bottlenose dolphins, on the contrary, confirmed their neritic habits. Risso's dolphins and common dolphins were intermediate: *G. griseus* showed a marked preference for deep waters close to the coastline; *D. delphis* instead was observed mostly in slope waters far from the coast.

Mixed-species aggregations were also found. These included, most frequently, interactions observed in the Ligurian-Corsican Sea between fin whales and striped dolphins (three occasions), in which the latter rode the «bow wave» of the former. Mixed schools of striped and Risso's dolphins were also observed in three instances, in the Tyrrhenian and Ionian Seas. On rarer occasions other

TABLE XII - *Group size statistics for seven cetacean species observed in the central Mediterranean Sea.*

Species	*n*	$\bar{X}$	SD	SE	Range
Delphinus delphis	5	76.80	52.95	23.68	9-150
Stenella coeruleoalba	81	26.48	48.33	5.37	1-300
Grampus griseus	12	16.67	16.43	4.74	3-55
Globicephala melas	4	10.00	2.66	1.33	1-13
Tursiops truncatus	67	6.64	7.72	0.94	1-40
Balaenoptera physalus	20	1.50	0.83	0.19	1-4
Physeter catodon	12	1.50	1.73	0.50	1-7

n, total number of groups sighted.

TABLE XIII - *Descriptive statistics for water depth (m) at sighting locations for seven cetacean species in the central Mediterranean Sea.*

Species	*n*	$\bar{X}$	SD	SE	Range
Globicephala melas	4	2063	875	438	750-2500
Balaenoptera physalus	20	1775	974	218	25-2500
Stenella coeruleoalba	81	1490	836	93	25-2500
Physeter catodon	12	1433	845	244	450-2500
Grampus griseus	12	958	531	153	750-2500
Delphinus delphis	5	785	995	445	75-2500
Tursiops truncatus	67	139	240	30	25-1500

n, total number of groups sighted for each species. $\bar{X}$, mean water depth. ANOVA: F-ratio = 44.9 ($P > 0.001$).

TABLE XIV - *Descriptive statistics of distance (km) from the nearest coast for the sightings of seven cetacean species in the central Mediterranean Sea.*

Species	*n*	$\bar{X}$	SD	SE	Range
Globicephala melas	4	31.75	16.94	8.47	13-48
Balaenoptera physalus	20	31.35	19.60	4.39	2-67
Delphinus delphis	5	26.20	14.87	6.65	9-50
Stenella coeruleoalba	81	24.41	16.27	1.81	2-65
Physeter catodon	13	24.00	11.64	3.23	11-46
Grampus griseus	12	13.25	13.64	3.94	2-54
Tursiops truncatus	67	11.79	16.64	2.03	1-98

n, total number of groups sighted for each species. $\bar{X}$, mean distance from the nearest coast. Kruskal-Wallis test: T = 60.1 ($P > 0.001$).

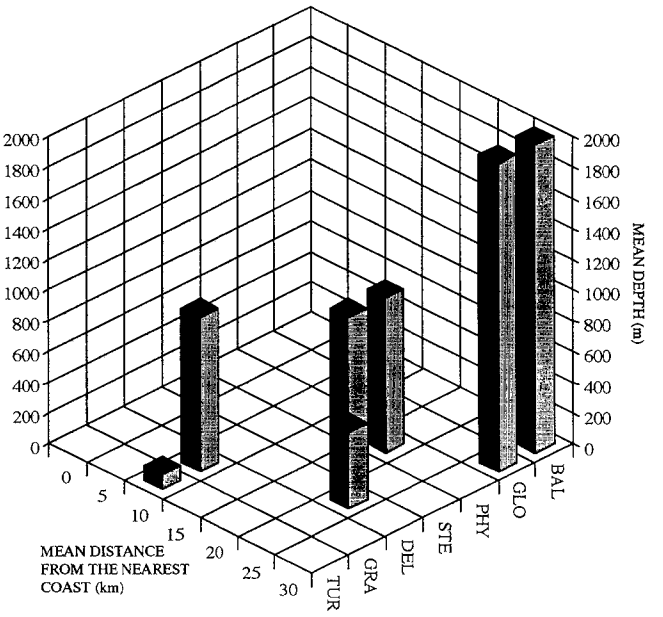

Fig. 2 - Relationship between water depth and distance from the nearest coast for seven cetacean species sighted in the central Mediterranean Sea. BAL, *Balaenoptera physalus*; GLO, *Globicephala melas*; PHY, *Physeter catodon*; STE, *Stenella coeruleoalba*; DEL, *Delphinus delphis*; GRA, *Grampus griseus*; TUR, *Tursiops truncatus*.

species were involved in such interactions. On 30 June 1989, a group of ten pilot whales was observed interacing energetically with what was estimated to be a group of seven sperm whale females and young in the southern Tyrrhenian Sea (40°39.75'N, 013°29.66'E). After considerable commotion and splashing at the surface, lasting for several minutes, both species seemed to settle down and intermingle in a resting mode. A further instance of mixed-species aggregation involved an individual bottlenose dolphin, observed on 12 July 1986 in the Sicily Channel (36°59'N, 013°03'E) riding the bow wave of the research vessel in a clearly dominant position amidst a school of nine common dolphins.

DISCUSSION

This work represents the first attempt at comparing distribution and relative abundance of the seven commonest cetacean species among different regions of the seas surrounding Italy. However, because the data presented here were not the product of rigorously planned sampling schemes, the results should be considered with some caution. The sighting frequencies given here, the best indication of cetacean relative abundance in the central Mediterranean Sea available today, must await further research effort to be converted into absolute indices of abundance. In particular, although cruises within each region sampled a wide spectrum of environmental variables, notably water depth and distance from the coast, the non-randomized choice of cruise tracks within

each region may have resulted in a biased estimate of the real sighting frequency of any particular species in that region. Furthermore, since this research was conducted mostly during the summer (Table I), seasonal changes in distribution and abundance of species known to be migratory, such as the fin whale, will not appear in these data.

The greater observation time spent in regions where striped dolphins are more abundant than bottlenose dolphins (e.g., the Tyrrhenian Sea, the Ligurian-Corsican Sea, and the Ionian Sea) explains why striped dolphins were the species most frequently sighted (Table II). However, when corrected for effort, the overall sighting frequency of bottlenose dolphins yielded the highest value (Table III). As expected, bottlenose dolphins were most common in regions where neritic waters are predominant (e.g., the Sicily Channel and the northern Adriatic Sea) or important (e.g., along the wide shelf of Sardinia's west coast, and in the waters surrounding the Tuscan Archipelago in the northern portion of the Tyrrhenian Sea). Bottlenose dolphins are also rather common along the often narrow continental shelf throughout the study area, except for the Ligurian coastline west of the Cinqueterre region, where their occurrence is considered exceptional (Podestà & Magnaghi, 1988a). Bottlenose dolphins were observed in pelagic waters only rarely.

By contrast, striped dolphins were almost exclusively pelagic (as indicated by the small standard error values in Tables XIII and XIV), being only exceptionally found in water shallower than 100 m. In the Ligurian-Corsican Sea striped dolphins were the most frequently sighted cetacean species throughout the study area, attaining a value of 12.21 groups sighted/100 h (Table V).

Fin whales, generally considered to be a summer immigrant into the Mediterranean Sea (Paulus, 1966; Duguy & Vallon, 1976), were found throughout the study area where pelagic waters occur. Their concentration, however, was greatest in the highly productive Ligurian-Corsican Sea, where their preferred food, the euphausiid *Meganyctiphanes norvegica*, is most abundant (Zanardelli *et al.*, 1992b; Relini *et al.*, 1992). Fin whales were mostly sighted at great distances from the coast, in deep waters (Fig. 2). The small standard error of depth and distance data for this species (Tables XIII and XIV) seem to indicate that fin whales in the central Mediterranean are markedly pelagic, and that their distribution is unconnected with slope habitat.

Sperm whales, among the most pelagic of the odontocetes, were predictably found in regions where deep waters predominate (Ligurian-Corsican Sea, Tyrrhenian Sea, Sardinian Sea and Channel, and Ionian Sea). Their distribution did not show any particular pattern, except for a propensity to frequent the deep waters adjacent to the continental slope. Although speculations about sperm whale movements across the Mediterranean Sea have been made in the past (Bolognari, 1951), no inference on this subject can be drawn from our data.

Risso's dolphins were typically found in the outer-slope habitat of the deepest regions (Ligurian-Corsican, Tyrrhenian and Ionian Seas), mostly where slope and coastline are closest (e.g., off western Liguria, off the island of Capri, and off the Ionian coast of Sicily near Syracuse) (Fig. 2). This may be due to the particular ecological requirements of their preferred cephalopod prey.

Common dolphins, once perhaps the most frequent cetacean species throughout the Italian seas (Cagnolaro *et al.*, 1983; Di Natale, 1983), are now extremely rare in the study area, for reasons unknown (Duguy *et al.*, 1983a; Viale, 1985; Di Natale, 1987). This is also reflected in our data. Sightings of this species in the waters west of Sardinia might have involved large groups meandering from the region of Gibraltar and the Alboran Sea, where common dolphins are apparently still abundant (Hashmi, 1990). Sightings made in the Ionian Sea are less surprising, as common dolphins can be still found rather frequently along the eastern side of this region (Politi *et al.*, 1992). Depth data for this species (Fig. 2, Table XIII) are indicative that in the central Mediterranean Sea *D. delphis* is found in shallower water than is *S. coeruleoalba* ($T = 2.35$, $P < 0.05$).

Long-finned pilot whales, common in the western Mediterranean Sea (Casinos & Vericad, 1976; Hashmi, 1990), are well known in Italy, as demonstrated by a long history of strandings, sightings and captures both in the Ligurian Sea (Giglioli, 1880; Podenzana, 1888; Paulus, 1960; Cagnolaro, 1969; Poggi, 1982; Cagnolaro *et al.*, 1986; Podestà & Magnaghi, 1988b) and in the Tyrrhenian Sea (Riggio, 1882; Carruccio, 1904; Police, 1909; Tamino, 1953; Pilleri, 1970; Carlini, 1988). No information, however, exists concerning the abundance of this species. Our records indicate that pilot whales can generally be considered rather uncommon throughout the Italian seas, except for the Ligurian-Corsican region, where they are occasionally observed in deep waters far from the coast.

It is interesting to note that minke whales *Balaenoptera acutorostrata* Lacépède 1804, killer whales *Orcinus orca* (Linnaeus 1758), false killer whales *Pseudorca crassidens* (Owen 1846), Cuvier's beaked whales *Ziphius cavirostris* G. Cuvier 1823, and rough-toothed dolphins *Steno bredanensis* (G. Cuvier 1828), all of which are known occasionally to occur in the Mediterranean Sea (Notarbartolo di Sciara, in press), were not observed during this study. Of all these species, only the Cuvier's beaked whale regularly strands in Italy (Centro Studi Cetacei, 1987, 1988, 1989, 1990); its absence from our sighting record is thus a further corroboration that *Z. cavirostris*, rather than being rare, is an unobtrusive, shy and extremely difficult cetacean to observe at sea (Heyning, 1989). By contrast, the lack of sightings of the other, more conspicuous species is indicative of their rarity in the study area.

The heterogeneity of cetacean distribution and sighting frequencies throughout the study area, which

allowed its subdivision into three different levels of cetacean abundance, was entirely predictable except for in the Tyrrhenian Sea. It is no surprise that the Ligurian-Corsican Sea, which includes perhaps the most productive pelagic waters of the entire Mediterranean Sea (Jacques, 1990), harbours a richer cetacean fauna than neighbouring marine regions with a lower primary productivity, such as the Sardinian Sea and Channel, the Sicily Channel, and the Ionian Sea. Likewise, it could be predicted that the semi-enclosed, shallow Adriatic Sea, today recognized as one of the most degraded parts of the Mediterranean Sea (Anon., 1989) has a very reduced cetacean fauna. Instead, the reasons for the observed scarcity of cetaceans in the Tyrrhenian Sea are unclear. Possible explanations of this include disturbance by fishing activities, especially large scale pelagic driftnet fishing which is particularly heavy in this region during summer (Di Natale & Notarbartolo di Sciara, 1990; Notarbartolo di Sciara, 1990), disturbance by intense maritime traffic, and contaminant load (Focardi *et al.*, 1990, 1991, 1992).

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