DISTRIBUTION AND RELATIVE ABUNDANCE OF THE SPERM WHALE IN THE CENTRAL AND WESTERN MEDITERRANEAN

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INTRODUCTION The sperm whale is one of the 8 common species of cetaceans in the Mediterranean Sea. Its conservation status in the Mediterranean Sea is unknown. A decrease of the number of sperm whale observations, and, in particular, of large schools sightings has been suggested (Di Natale and Mangano,1983). Sperm Whale local populations may be threatened by continuous by-catch due to the driftnet fisheries (Di Natale and Notarbartolo di Sciara, 1994). This paper deals with the distribution and relative abundance of sperm whales in the Mediterranean Sea. During the summers 1997 and 1998, we conducted a combined acoustic and visual survey covering homogeneously four distinct regions of the Mediterranean Sea: the North-western basin, the South-western basin, the Tyrrhenian Sea and the Ionian Sea. We estimated relative abundance indices through the use of both acoustic and visual data. We also assessed the distribution of the species in relation to underwater topography.

MATERIAL AND METHODS The survey was conducted during both summer 1997 (from 7th July to 8th August) and 1998 (from 18th June to 13th August). Four distinct regions of the Mediterranean were investigated: the North-western basin, the South-western basin, the Tyrrhenian Sea and the Ionian Sea.
The platform was a 12 metre motor-sailer with a 80HPdiesel engine. For the acoustic sampling, a dual channel hydrophone was used in 1997 (IFAW type) and a mono hydrophone in 1998 (MAGREC HP30/MT). A high-pass filter (MAGREC)was added to remove excessive noise. Either a Sony WMD 6 analog recorder or a Sony TCD 7 DAT were used for the recordings. Each region was divided into sampling boxes where zig-zag cruise tracks were defined. One hour time lag was allowed for locating visually a whale prealably detected by the acoustic. No attempt was made to photo-identify the animals.
The visual survey consisted of a continuous observation, as described by Gannier (1998), with a minimum of three observers (4 on average). The effective effort was defined in term of transect length when wind conditions were less than Beaufort 4. The acoustic sampling :consisted of 1 minute listening every 2 milles along the transect to detect the characteristic sperm whale clicks. From the visual data, two variables were calculated for each box: the *Sighting frequency* (number of sightings per km) and the *Visual Relative Abundance Index* or VRAI (number of animals per km). From the acoustic data, one variable was calculated for each 40 mille segment: the *Acoustic Relative Abundance Index* (ARAI), defined as the ratio of the number of positive samples / total number of acoustic samples. The relationship between the occurrence of sperm whale and the underwater topography was assessed by measuring the water depth, the distance to the nearest coast, and distance to the 200m contour for each sighting location. As regard to the acoustic data, a comparison was made between the mean ARAI values obtained for the continental slope (between 200m and 2000m contour) and the off-shore stratum (off the 2000 contour) segments.

RESULTS An effective visual effort of 5825km and 1614 acoustic samples were achieved during the survey. This effort was quite evenly shared between the regions, given that North-western boxes were covered both in 1997 and 1998 (Table 1). Concerning the visual survey**, t**he sperm whale was sighted on 11 occasions in-effort (13 total) out of 181 in-effort sightings (Figure 3), being the 3rd most frequent species observed (6.6% of the sightings). The mean school size was 2.0 whales (SE=0.519). The schools ranged from solitary animals to a group of seven individuals, but 62% of the sightings were of single animals. Two nursery groups were observed, in the Ionian and in the Tyrrhenian seas. Sperm whales were most frequently sighted in the northwestern basin, with 0.65 sightings/100 km and a VRAI of 0.76 animals/100km (Table 2). A relatively high abundance index is also obtained in the Ionian Sea, due to the large school sighted in this area. The Southwestern basin shows the lowest relative abundance, with an VRAI of 0.08 animals/100km.

The results of the acoustic survey suggest regional variations in relative abundance (Table 3). Higher occurrences were observed in the North-western and South-western basins, with mean ARAI's of 20% and 10%, respectively. These two regions might be seen as a single area of high relative abundance (Kruskall-Wallis Test: h=0.10, with p=0.753). In contrast, the Tyrrhenian Sea appears to be a region of low relative abundance (ARAI=1%), and the Ionian Sea, a region of medium abundance (ARAI=4%). Within the Western Mediterranean region (Table 4), North and South, 3 sectors may be distinguished: a sector of high relative abundance (including the Gulf of Lion , Provence coast and South-Lion); a sector of medium relative abundance (West Corsica, West Sardinia, Baleares and South-Baleares); and a sector of low relative abundance including the Ligurian Sea.
In the Provence and Gulf of Lion sampling boxes, data were obtained during the two successive summers. The mean ARAI's found for these two boxes combined (16.5% in 1997 and 27.5% in 1998) were not significantly different between 1997 and 1998 (T-Test, T=1.27, p=0.22). This suggest a regular frequentation of Provence and Gulf of Lion as summer feeding grounds.

As regards the relationship to topographic features, it was found that sperm whales were more frequent in waters from 200 to 2000m deep (92 % of the sightings), with more than 50% occurring in watersless than 1000m. Only one group was sighted off-shore the 2000m contour. The sightings were distributed at a mean distance of 17 km off the 200m contour. More than 60% of the sightings occurred at less than 10km off the 200m contour. These results strongly suggest a preference of sperm whales for the continental slope waters (Table 5). Futhermore, sperm whales were acoustically detected more often in the continental slope than in oceanic waters (Table 6), as shown by the difference between the ARAI's, 12.5% and 8.3%, respectively.

DISCUSSION The small number of sightings resulted in non-significant comparisons between regions in term of visual abunadance index (VRAI). In general, the acoustic results confirmed trends suggested by the visual resuts, and allowed meaningful statistical comparisons to be undertaken between the regions, due to the increased number of whale detections. Both the acoustic and visual results show that sperm whales are more frequent in the North-western basin than in the other regions surveyed during summer. This region is known for a primary production higher than the

average in the Mediterranean, Alboran sea excepted (Morel and André, 1991). The Gulf of Lion, in particular, remains mesotrophic throughout the summer. Several authors previously noticed a link between sperm whale density and biological productivity, even though a scale effect is sometimes to be found (Jaquet *et al*., 1995). In the Ligurian Sea, although a frontal system enhances primary production in summer (Prieur, 1981), a low abundance was recorded at the time of the survey. This may result from short-term variations in sperm whale distribution, since sperm whale sightings and acoustic detections were reported there later in the season (Gannier, 1998a) and have been recorded from previous surveys (Gannier, 1998; Pavan *et al*., 1997). The relative abundance in the Ligurian Sea may peak later in the summer, and during autumn. In the Southwestern Basin, the acoustic results suggest medium-high abundance of whales, noticeably around the Balearic and Sardinia islands. The results in the Tyrrhenian and Ionian Seas revealed a low occurence of sperm whale group. In the Tyrrhenian Sea, the heavy by-catches caused by the pelagic driftnet fishing activity are considered as a major source of mortality for the species (Di Natale and Notarbartolo di Sciara, 1994). For the Ionian Sea, no comparison is possible with previous findings. The sightings and detections are restricted to the Greek continental slope. In each of these two regions of low relative abundance, a nursery school was observed, in contrast to the Western Basin. This suggests there could be segregation between feeding clusters and nursery schools, the latter being common in the warmer regions of the Mediterranean Sea and the former in the northern regions. This is consistent with the species ecology in other areas of the world (Rice, 1989).

The distribution of the visual sightings strongly suggests that sperm whales have a habitat preference for the continental slope, in waters between 200m and 2000m deep, which is consistent with several surveys conducted in the Mediterranean Sea (Notarbartolo *et al*., 1993; Pavan *et al*., 1997). Gannier (1998) found on the contrary an affinity of sperm whales for the open sea, from visual surveys in the Ligurian Sea.
Sperm whale habitat preferences might be linked to the diet of the species, which mainly feed on mesopelagic cephalopods (Evans, 1987). Several potential preys inhabits the continental slope and oceanic waters in the Mediterranean.

CONCLUSION This study confirms that the sperm whale is still distributed over a large area in the Mediterranean and suggests some striking trends concerning geographical variations in sperm whale school size and composition. The western basin, particularly the Gulf of Lion and Provence slope, may represent important feeding grounds for the sperm whale. A longer-term more localised study is required to assess the consistency of this area as a sperm whale feeding site. Other similar studies using standard methods must investigate the different regions, to make possible a global assessment of the sperm whale status in the Mediterranean.

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Table 1 Visual and acoustic sampling effort.

Region	Number of boxes	Area (km^2)	visual effort (km)	N acoustic sampling
North western Basin	5	43261.7	2419.6	611
South western Basin	3	44044.8	1185.1	316
Tyrrhenian Sea	4	61911.5	1234.2	321
Ionian Sea	3	50199	986.0	293

Total	15	199416.7	5824.9	1614

Table 2. Mean sighting frequency (number of sighting/100km) and visual relative Abundance index (number of animals/100km) and of sperm whales (with n, number of sightings and N, number of animals, SE Standard Error).

Area	n	N	Sighting Frequency (SE)	Visual Abundance Index (SE)
North western Basin	8	10	0.647 (0.34)	0.758 (0.37)
South western Basin	1	1	0.080 (0.08)	0.080 (0.08)
Tyrrhenian Sea	1	5	0.065 (0.06)	0.325 (0.32)
Ionian Sea	1	7	0.121 (0.10)	0.849 (0.69)

Table 3. Mean Acoustic Relative Abundance Index in the four regions. N, number of segments, SE Standard Error).

Area	N	Acoustic Abundance Index (in %)	SE
North Western Basin	36	20.06	3.79
South Western Basin	17	10.28	4.45
Tyrrhenian Sea	20	0.96	0.06
Ionian Sea	15	4.37	4.37

Table 4. Acoustic Relative Abundance Indices for the sampling boxes of the North and South-western Mediterranean (N, number of segments, SE, Standard Error).

Sampling boxes	N	Mean	SE	Min	Max
N1: Ligure	8	0	0	0	0
N2: Provence	12	20.55	5.14	0	55.56
N3: Gulf of Lion	10	25.91	7.41	0	63.38
N4: South Lion	3	61.77	6.12	50	70.59
N5: West-Corsica	3	10.44	8.07	0	26.32
S1: Baleares	3	9.52	9.52	0	28.57
S2: Minorca-Sardinia	6	9.58	5.42	0	31.58
S3: West-Sardinia	8	11.09	8.73	0	70.00

Table 5. Distance to the coast, Bottom Depth and Distance to the 200m contour of the sperm whales sightings made during 1997 and 1998 in the Mediterranean Sea.

	Mean	SE	Min	Max
Distance to Coast (in km)	37.52	10.22	5	117.3
Bottom Depth (in m)			270	2800
Distance to 200m (in km)	17	8.55		

Table 6. Mean Acoustic Relative Abundance Index for the continental slope (200-2000m) and the open sea (>2000m) strata. N, number of segment, SE, Standard Error.

Stratum	N	Mean	SE
Continental slope	62	12.55	2.83

Open sea	25	8.27	3.12