COMPARISON OF CETACEAN POPULATIONS FROM SIMULTANEOUS SURVEYS IN THE GULF OF LION AND LIGURIAN AREAS

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INTRODUCTION While much attention is given to abundance studies in the area of the future International Marine Sanctuary, little effort has been devoted to the Gulf of Lion. However, the analysis of available results suggests that off-shore areas in the gulf of Lion shelter an abundant cetacean population, particularly if large odontocetes are considered (Gannier *et al.*, 1994; Gannier, 1997a). Because of the intense fishery activity in the gulf of Lion, and the unknown conservation status of some mediterranean species, such as the sperm whale (*Physeter macrocephalus*), additionnal results in that area were urgently needed. Additionnaly, it was interesting to have comparative results with the ligurian sector for which abundant litterature is now available (Forcada *et al.*, 1994; 1995; Gannier, 1997b; 1998). We present here the results of comparative surveys conducted simultaneously with two similar small boats in August 1998.

METHODS The field surveys took place from 2 to 20 August from a 10 meter ketch (Ligurian Sea) and a 12 meter motorsailer (Gulf of Lion). Line transect protocoles were similar: both boats moved on predetermined zig-zag tracks off the 200 meters isobath, cruising on diesel engine at a mean speed of 5.5 knots. The sampling design featured a stratification in two sub-areas: a near-shore stratum and an off-shore stratum (Fig. 1). Three observers were in duty during the surveys, searching with naked eyes. Upon detection, measurements of relative position of cetaceans were made with reticuled binoculars; the animals were then approached. Acoustic sampling was conducted from both platforms, with a rate of 0.5 listening per mille. A 30 minutes stop for visual searching was allowed if a sperm whale was acoustically detected in the vicinity of the boat. The sighting conditions were defined on a 0-6 scale from wind, sea state and light (Table 1). The effort covered with a sighting conditions index of over 4 is considered for the data analysis.

Data Analysis

An acoustic relative abundance index A is derived from the sperm whale hydrophone sampling data:

$$\underline{A} = (n \,.\, \underline{s} / L)$$

where **n** is the number of sperm whale agregations detected in an area, **L** is the effective effort in that area, **s** is the mean school size in the area. A sperm whale agregation is defined as a sequence of consecutive positive listenings. The cluster size is obtained aurally by listening to the clicks recordings; school sizes of over 3 individuals are difficult to determine.

The Shannon-Weaver index is used to describe the diversity of both cetaceans communities:

$$H = - \Sigma F_i \log_2 (Ni / Nt)$$

with **Ni** as the number of observed individuals belonging to species **i** and **Nt** the total number of cetaceans sighted in the area during the survey period.

Relative abundances **R** for each stratum were calculated in individual/km.

$$\underline{R} = (n / L) \,.\, \underline{E(s)}$$

where **n** is the number of primary detections of a given species in one stratum, **L** is the effective effort in that stratum, **E(s)** is the mean school size in the area. R is obtained from the density definition given by Buckland *et al.* (1993), when the effective search width is eliminated. It can be

used for comparative purposes provided that **esw** is assumed to be constant across the different areas. Estimates were obtained for each region by an surface-weighted sum of each stratum result. The estimates of variances and CV's were obtained with the delta method, as implemented in *Distance* 2.1 software (Laake *et al*., 1994).

RESULTS From a total of 1302 miles cruised during the period, 1102 were covered with good to excellent sighting conditions. The effective effort was 219 miles for the Gulf of Lion, including 24,6% in excellent conditions, 46,5% in very good conditions, and 28,7% in good conditions. The effective effort was 217 miles in the Ligurian area, including 18,9% in excellent conditions, 50,2% in very good conditions and 30,8% in good conditions. Sighting effort was considered equivalent in both areas.

79 sightings of 6 species were obtained during the course of the survey (table 2). From that total, we considered 12 in-effort sightings in the gulf of Lion, including 7 of striped dolphin (*Stenella coeruleoalba*) and 5 on four other species (figure 3). We considered 21 in-effort sightings in the Ligurian area, including 13 of striped dolphin, 5 of fin whale (*Balaenoptera physalus*) and 3 of sperm whale (figure 4). The distribution of sightings is less heterogeneous in the Ligurian area than in the gulf of Lion, where the in-shore stratum was almost deserted by cetaceans. Fin whales and sperm whales were sighted in the two sectors, although with different frequencies (table 3 and 4). Risso's dolphins (*Grampus griseus*) and bottlenose dolphins (*Tursiops truncatus*) were only sighted in the gulf of Lion. The resulting Shannon index is much higher for the gulf of Lion (1.26) than for the Ligurian area (0.28).

Detections of striped dolphins were analysed for each platform. For the boat in charge of the Ligurian area sampling, 87.5% of 16 primary detections were obtained within a perpendicular distance of 300 meters. For the boat in charge of the gulf of Lion sampling, 81.8% of 22 primary detections were obtained within the same perpendicular distance. This suggests that a wider detection range may have been achieved in the gulf of Lion. For the striped dolphin, the relative abundance estimate is significantly (T-test, $p<0.05$) higher in the Ligurian area, with 0.67 ind/km (CV=35%), than in the gulf of Lion, with 0.35 ind/km (CV=53%). The same situation arises for the fin whale, with a relative abundance of 0.013 ind/km (CV=109%) in the gulf of Lion and 0.002 ind/km (CV=53%) in the Ligurian area. In the gulf of Lion, relative abundances of 0.10 ind/km (CV=90%) and 0.024 ind/km (CV=90%) have been estimated for the Risso's dolphin and the bottlenose dolphin, respectively. In both cases, this is due to sightings obtained in the inshore stratum (table 5). For the sperm whale, 9 acoustic detection sequences were obtained in the gulf of Lion against 7 for the Ligurian sector (figure 5 and 6). The resulting acoustic abundance indices are 0.033 ind/km in the gulf of Lion and 0.034 ind/km in the Ligurian area. Detections occurred in both strata.

DISCUSSION Few studies provide comparison of abundances between different areas in the Mediterranean. Forcada *et al*. (1994) give estimates of the striped dolphin for the Ligurian sea and a wide area encompassing the rest of the Northwestern basin: they find the Ligurian sea to be slightly more populated. From a limited effort and set of data, Gannier *et al.* (1994) suggest that striped dolphin populations are perhaps equally abundant in the western and eastern parts of the Northwestern basin.

In a recent paper, Gannier (1999) suggest that striped dolphins and fin whales are more abundant in the Ligurian sea and off the Provençal shore than in the gulf ol Lion. For medium and large-sized pelagic odontocetes, the situation tends to be opposite, with higher relative abundance in the gulf of Lion and off the Provençal shore than in the Ligurian sea. This study also suggests that diversity is higher in the gulf of Lion than in other areas of the Northwestern Mediterranean.

The absence of the pilot whale from our records in the two areas seems to be anecdotic, since we observed the species during the survey period in the Provençal basin (separating the two survey areas), and shortly afterwards in the Ligurian sea.
One problem inherent to slow boat surveys is the possibility of a bias arising from distribution shifts, whenever they occur across the survey area during the sampling. For this study, this aspect was alleviated by simultaneaoulsy sampling the two regions, for which a comparison was sought.

CONCLUSIONS These results suggest that large odontocetes are quite abundant in the gulf of Lion, while fin whales and striped dolphins are more frequent in the Ligurian sea. The sperm whale seems to be equally frequent in both areas. It is becoming clear that the summer cetacean population is not homogeneous in the Northwestern basin. A diversity and density gradient is apparent on an east-west axis across the whole area, with the gulf of Lion sheltering a cetacean community of higher diversity in summer, while the Ligurian sea is characterized by higher densities of the two dominant species, the fin whale and the striped dolphin.

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Table 1 Sighting conditions index derived from environmental parameters.

wind speed (Beaufort)	**0**	**1,2-**	**2+,3**	**4**	**5**	**6,7**	**>8**
sighting conditions index	6	5	4	3	2	1	0
index (swell or cloudy sky)	5	4	3	2	1	1	0

Table 2 Summary of the sightings during the survey period.

species	**n sightings**	**mean school size**	**max school size**	**min school size**
striped dolphin	54	19,5	150	1
bottlenose dolphin	1	-	9	9
Risso's dolphin	2	-	35	3
pilot whale	2	-	25	4
sperm whale	7	1,1	2	1
fin whale	17	1,4	3	1

Table 3 In-effort sightings during the gulf of Lion transect (with the frequency Fi and the diversity contribution Hi).

species	**n sightings**	**N individuals**	**Ni / Nt**	**diversity Hi**
striped dolphin	7	92	0,652	0,402
bottlenose dolphin	1	9	0,063	0,251
Risso's dolphin	2	38	0,269	0,509
pilot whale	0	0	0	0
sperm whale	1	1	0,007	0,050
fin whale	1	1	0,007	0,050

Table 4 In-effort sightings during the Ligurian transect (with the frequency Fi and the diversity contribution Hi).

species	**n sightings**	**N individuals**	**Ni / Nt**	**diversity Hi**
striped dolphin	13	247	0,961	0,055
sperm whale	5	6	0,023	0,125
fin whale	3	4	0,016	0,095

Table 5 Relative abundance indices R (individual/km) for the striped dolphin, the Risso's dolphin, the bottlenose dolphin and the the fin whale.

area	Lion stratum 1	Lion stratum 2	**LION**	Ligure stratum 1	Ligure stratum 2	**LIGURE**
R (CV%)	0,01	0,59	**0,35 (53)**	0,49	0,83	**0,67 (39)**
R (CV%)	0,20	0	**0,10 (90)**	0	0	**0**
R (CV%)	0,048	0	**0,024 (90)**	0	0	**0**
R (CV%)	0	0,005	**0,002 (109)**	0	0,025	**0,013 (53)**

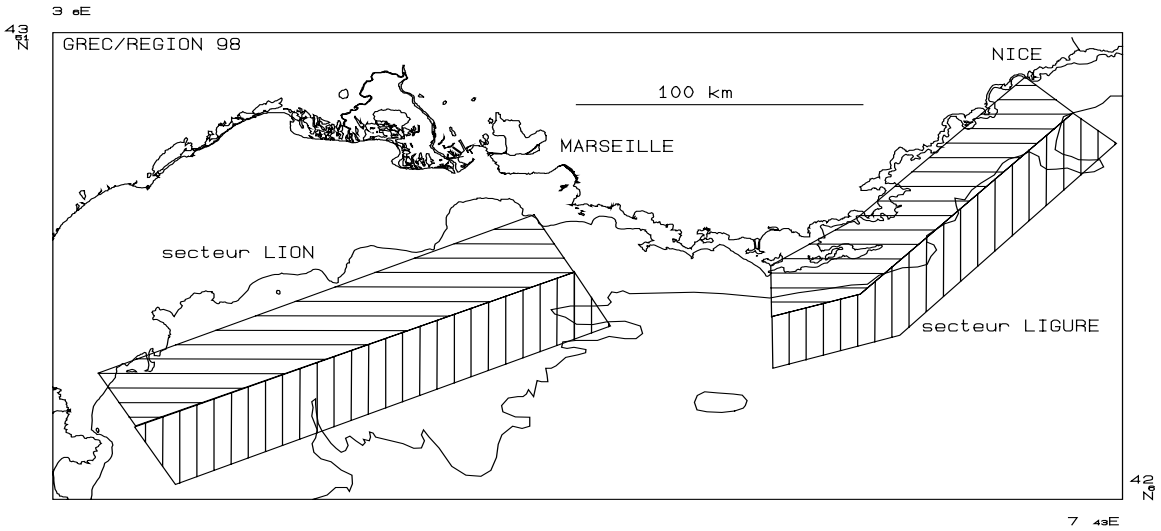

Fig. 1 Areas of study.

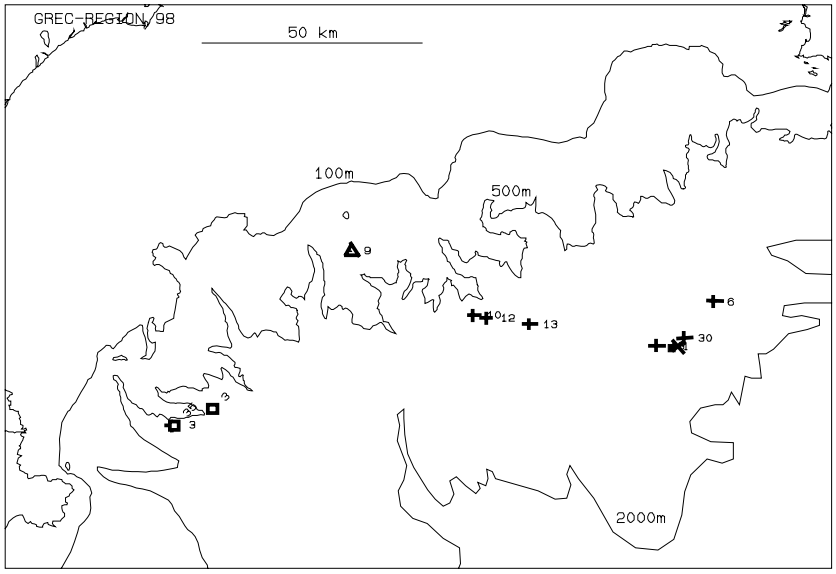

Figure 2: In-effort sightings in the gulf of Lion. (+ Dauphin bleu et blanc; x Rorqual commun; □ Dauphin de Risso; ■ Cachalot; Δ Grand dauphin; numbers are school sizes)

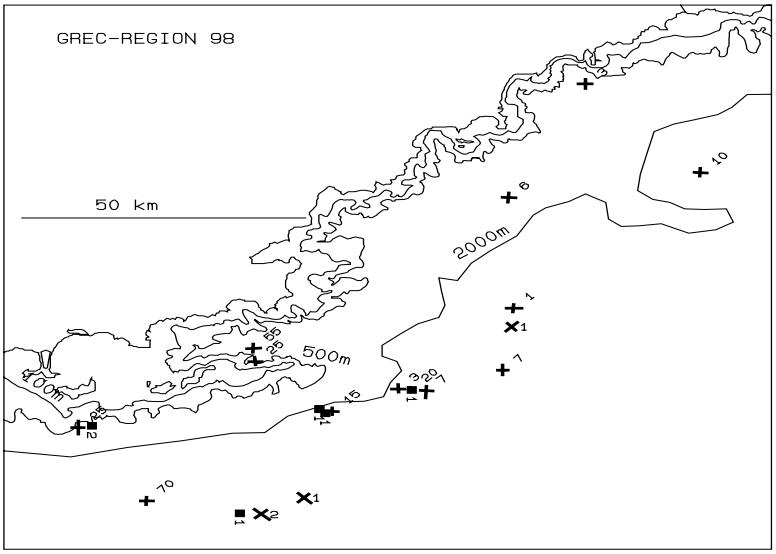

Figure 3: In-effort sightings in the Ligurian sea