NEW RESULTS ON THE DISTRIBUTION AND RELATIVE ABUNDANCE OF THE SPERM WHALE IN THE NORTHWESTERN MEDITERRANEAN

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INTRODUCTION Since 1997, four summer surveys have been dedicated to the distribution of sperm whale in the Mediterranean Sea. We present here the results concerning the western Mediterranean basin, north of 38° latitude, including the International Marine Mammals Sanctuary. This protected zone is one of the main productive areas of the Mediterranean Sea, in term of primary production, and is known to host high abundance of cetaceans in summer. Sperm whale is one of the eight common species in this area but its local abundance, relative to other areas of the Mediterranean Sea, is unknown. Our study aimed to define areas of major importance for sperm whale in the western basin as a whole, in order to know whether the Sanctuary is relevant to the species conservation.

MATERIAL AND METHODS The survey area was divided into 6 regions: the northern Tyrrhenian, the Corso-Ligurian, the Provence, the Gulf of Lion, the Baleares and the Central basin. Visual and acoustic surveys were combined along linear transects conducted at an average speed of 5 knots on a 12m motor sailing boat.

Visual survey implied continuous scanning of the sea surface with 3 observers sharing the 180° sector in front of the boat. An index, from 0 (null) to 6 (excellent), was used to report the observation conditions (Gannier, 1998). When sperm whales sighting occurred, the position was logged, the animals were tentatively approached, and pod size was recorded together with other relevant information (animal size, activity, etc...). From these data, the sighting frequency (number of sightings/km of transect) and relative abundance (number of animals/km) were calculated.

Acoustic survey consisted of one minute listening/recording station every 2nm with a towed hydrophone. A dual channel hydrophone (provided by IFAW) was used in 1997, 1999 and 2000 surveys and a mono hydrophone (MAGREC), with similar specifications, during 1998 survey. A high-pass filter was added to remove excessive noise and a Sony TCD 7 DAT was used for recording. At each station the presence/absence of sperm whale was recorded and underwater noise was scored using a 5 level scale (Gordon *et al.* 2000). The successive positive acoustic station were grouped into 'acoustic sequences', as the same sperm whale (or group) could be detected over several stations (Gordon *et al.* 1998). The number of whales detected was estimated by playing back the entire recording sessions of each acoustic sequence. When more than 3 animals were clicking simultaneously, school size estimate was not possible by ear and we considered the minimum pod size of 3 animals. From these data, acoustic frequency (AF: number of acoustic sequence /km of transect) and relative abundance (minimum number of animals/ km) were calculated.

The survey effort represented 6424 km of transect distributed over the 6 regions and a total of 1894 acoustic stations (Table1). The transect lines were divided into 40nm segments (sample unit) for which visual and acoustic variables were computed in every region. Regional comparisons could then be carried out.

RESULTS Sperm whales did not appear to be homogeneously distributed within the regions investigated. Overall, sperm whale groups were detected more frequently in Gulf of Lion and Baleares than in other regions of the basin.

In the regions north of the 41° parallel (northern Tyrrhenian, Corso-Ligurian, Provence, Gulf of Lion), visual and acoustic detection rates tended to increase from eastern to western regions: from low in the Tyrrhenian and Corso-Ligurian sectors (AF of $2.4.10^{-3}$ to $4.79.10^{-3}$/km), sightings and acoustic detections became significantly more frequent through Provence zone (AF of $9.79.10^{-3}$/km) and the Gulf of Lion (Kruskal-Wallis Test: H=8,28, p=0.004, df=1). In these 4 regions, the use of acoustic technique enabled the detection of more sperm whale groups than the visual survey: sightings occurred at a rate of $1.70.10^{-3}$/km to $7.58.10^{-3}$/km (no sighting in the northern Tyrrhenian sector) when $2.4.10^{-3}$ to $1.6.10^{-2}$ acoustic sequences were detected every km on average (Table 2 and 3). In term of number of animals, these regions were characterized by a relatively low abundance of whales seen at the surface, with between 0 and $7.58.10^{-3}$ whales seen/km (Table 2). The group size never exceeded 2

animals, and whales were generally alone at the surface. In the Gulf of Lion, the estimate number of whales detected acoustically markedly exceeded the number of whales observed at the surface ($7.58.10^{-3}$ whales seen/km against $3.80.10^{-2}$ whale heard/km). Thus, although surface observation tended to show isolated animals at the surface, acoustic survey suggested that several whales were present in the same area, at a scale corresponding to our hydrophone range.

In the regions south of the 41° parallel (Baleares and Centre sectors) visual and acoustic results showed reversed trend: with higher values obtained from the visual survey than from the acoustic one, both for detection rates and relative abundances: in the Baleares for example, an average of $9.69.10^{-2}$ whales/km were observed visually while acoustically, $3.34.10^{-2}$ whales/km were detected. This difference was particularly obvious in the Baleares, where numerous large groups, up to 7 animals, were observed visually while acoustic estimates were limited to 3 animals. In this region, 80% of the acoustic sequences indicated more than 3 animals clicking simultaneuosly and group size were likely to be under-estimated by acoustics.

DISCUSSION The Corso-Ligurian sector, where the Sanctuary lies, displayed significantly lower detection rates and relative abundance than regions further west. From visual observations and analysis of the acoustic recordings, it appeared that animals in the northern regions were mainly involved in feeding activity, performing cycles of 50min dives and 10min surfacing. The Gulf of Lion was a favoured region: whales observed in this area were mostly adult or sub-adult animals (>12m), involved in prolonged dives (Drouot and Gannier, 2001). No grouping has been observed at the surface, however, the acoustic data indicated clusters of feeding individuals (Drouot *et al.*, 2000). In the continuity of the Gulf of Lion, the Baleares sector showed similarly relative high abundance (visually). In fact, nursery groups, including calves, were observed around the Balearic Islands (Drouot and Gannier, 2001). Thus, the Gulf of Lion would sustain a suitable food chain to support a large relative abundance of sperm whale during summer, when the Baleares appeared to provide the species with both suitable feeding and breeding conditions. The superficial current flows westerly from the Ligurian Sea through the Gulf of Lion and down to the Balearic Islands (Millot, 1987) and might play a major role in the distribution of sperm whale preys. These regional differences in sperm whale abundance might also be related to the topography: the northern Tyrrhenian Sea includes almost exclusively continental shelf and upper slope waters while the

Gulf of Lion features several deep sub-marine canyons and the Baleares Islands offer steep continental slopes. The Ligurian Sea encompasses various facies of topography.

This combined survey highlighted respective advantages of the acoustic and visual techniques. In regions such as the Gulf of Lion, acoustic survey substantially increased the number of whales detected on the line transect and allowed the detection of submerged (feeding) whales that would have been otherwise missed by visual observers. However, our method and equipement did not seem to be appropriate in areas where large groups of whales were present and spent longer periods at the surface (without emitting regular clicks): acoustic technique could not replace visual method for estimating large group sizes.

Although, this summer study showed the Sanctuary was not favoured by sperm whales, results from cold seasons may bring important elements to evaluate the role of this protected area in the conservation status of this species.

CONCLUSION This study showed that Mediterranean sperm whales may be better protected by extending effective protection to areas such as the Gulf of Lion and the Baleares Islands, where the species is abundant during summer. The regular presence of new-born calves in the latter region further urges the need for such protective measures.

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Table 1. Distribution of survey effort, as transect length with good observation conditions (index>3) and number of acoustic station in low background noise (underwater noise index<3).

	Transect length (km)	Transect length (km) in I >3	Number of acoustic stations	Number of acoustic station in noise<3	Number of 40nm segments
Tyrrhenian	895	589	234	192	15
Corso-Ligure	2058	1548	584	473	39
Provence	963	583	301	254	36
Gulf of Lion	731	553	244	200	12
Baleares	971	494	274	224	20
Centre	906	450	257	230	16
Total	6524	4219	1894	1573	138

Table 2. Visual survey results: Sighting Rate (number of sightings /km) and relative abundance (number of animals seen /km) of sperm whale in the 6 regions.
N refers to the number of 40nm segments

	N	Sighting Frequency	Sd	Relative Abundance	Sd
Tyrrhenian	13	0	0	0	0
Corso-Ligure	33	$1.70.\ 10^{-3}$	$5.71.10^{-3}$	$1.70.\ 10^{-3}$	$5.71.\ 10^{-3}$
Provence	15	$4.59.\ 10^{-3}$	$1.43.10^{-2}$	$5.56.\ 10^{-3}$	$1.54.\ 10^{-2}$
Gulf of Lion	12	$7.58.\ 10^{-3}$	$2.02.10^{-2}$	$7.58.\ 10^{-3}$	$2.02.\ 10^{-2}$
Baleares	14	$2.96.\ 10^{-2}$	$7.29.\ 10^{-2}$	$9.69.\ 10^{-2}$	$2.85.\ 10^{-1}$
Central basin	11	$1.32.\ 10^{-2}$	$3.91.\ 10^{-2}$	$8.43.\ 10^{-2}$	$2.75.\ 10^{-1}$

Table 3. Acoustic survey results: Acoustic Frequency (number of acoustic sequences/km) and relative abundance (number of animals heard /km) of sperm whale in the 6 regions.
N refers to the number of 40nm segments.

	N	Acoustic Frequency	Sd	Relative Abundance	Sd
Tyrrhenian	13	$2.41.10^{-3}$	$5.89.10^{-3}$	$4.83.\ 10^{-3}$	$1.34.\ 10^{-2}$
Corso-Ligure	33	$4.79.\ 10^{-3}$	$1.24.\ 10^{-2}$	$5.32.\ 10^{-3}$	$1.32.\ 10^{-2}$
Provence	18	$9.79.\ 10^{-3}$	$1.25.\ 10^{-2}$	$1.60.\ 10^{-2}$	$2.45.\ 10^{-2}$
Gulf of Lion	12	$1.69.\ 10^{-2}$	$1.85.\ 10^{-2}$	$3.80.\ 10^{-2}$	$5.39.\ 10^{-2}$
Baleares	19	$1.23.\ 10^{-2}$	$2.98.\ 10^{-2}$	$3.34.\ 10^{-2}$	$8.95.\ 10^{-2}$
Central basin	15	$7.23.\ 10^{-3}$	$2.38.\ 10^{-2}$	$2.17.\ 10^{-2}$	$7.15.\ 10^{-2}$