

Movements of sperm whale in the western Mediterranean Sea: preliminary photo-identification results

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Sperm whale residency and movements within the Mediterranean Sea were investigated using photo-identification data collected in summer over a 15 year period (1991–2005). Surveys were conducted from a 12 m motor sailing boat. Although dedicated to cetaceans, surveys did not solely focus on sperm whale photo-identification, so time to track and photograph all individuals forming a group was not always available. From good quality photographs, 44 individuals were identified in the western Mediterranean, including the Ligurian Sea, the Gulf of Lions and waters off the Balearics. Eleven identified whales were photographically re-captures. Within-year re-sightings occurred from 1 to 29 d apart, while five identified whales were re-sighted over several summer seasons, from 1 to 7 y apart. Four whales were seen in more than one year in the northern part of the basin, indicating site fidelity to this feeding area. The combination of photo-identification and acoustic data (size estimation from inter-pulse interval measurements) enabled us to demonstrate a north–south movement of some sexually mature males (around 13 m in length), feeding in the northern regions and joining groups of females off the Balearics for around 20 d. These displacements ranged over ~500 km, with travelling time of seven days or less.

INTRODUCTION

Sperm whales (*Physeter macrocephalus*) are seasonal breeders and males and females are generally segregated. In general, only mature males are found in the higher latitude cold waters, whilst the females and young are limited to tropical and temperate seas. To meet reproduction purposes, it is generally assumed that sexually mature males perform seasonal migrations, while females are more gregarious. However, movement of males is poorly documented worldwide and little is known on the frequency, duration, or geographical extent of these migrations (Whitehead, 2003).

The sperm whale is one of the common species of the Mediterranean Sea. Its summer social distribution within the western Mediterranean basin appears to reflect the general segregation scheme found in the open oceans, with sub-adult and adult males being mostly present in the northern regions and the groups of females and young favouring the southern regions (Drouot et al., 2004a). In the northern Mediterranean Sea, sperm whales are generally observed in loose aggregations, rarely forming cohesive groups at the surface, while in the southern regions they tend to form clusters of up to seven animals, generally including calves. Consistent sightings of calves in different regions such as the Tyrrhenian Sea, the Ionian Sea and the Balearics, strongly suggest that reproductive and breeding activity occurs within the southern part of the basin (south of 41° latitude). However, the timing of the mating season in the area is still unknown. The migration pattern of sperm whale within the Mediterranean basin has never been documented.

Individual sperm whales can be reliably identified from various marks on the trailing edge of the flukes (Arnbom,

1987; Dufault & Whitehead, 1998). We present here photo-identification data collected over 15 years in the Mediterranean Sea, with the aim of providing insight on residency and movement of sperm whales, within the western basin particularly.

MATERIALS AND METHODS

Data were collected from a 12 m motor-sailing boat, during the summers (June to September) of 1991–2005. Although these surveys were mainly dedicated to sperm whale, they were not solely focused on photo-identification. In 1996–2001, distribution surveys were mainly carried out (line transect methodology was applied), which imply sampling effort to be distributed randomly (independently of known areas of sperm whale occurrence). Furthermore, when sightings occurred, little time was available to acoustically track the whale underwater for surface photo-identification; it was thus not possible to collect fluke photographs systematically. During these surveys, distinct regions were sampled in different years (Ionian Sea, Tyrrhenian Sea, Ligurian Sea, Gulf of Lions, Balearic Sea) to assess regional variations in sperm whale relative abundance (Gannier et al., 2002). During the 2002–2005 surveys, extended passive tracking of sperm whales was carried out in the northern basin (Ligurian Sea and Gulf of Lions) and off the Balearics, leading to increased numbers of individual identification.

When a sperm whale was detected (acoustically or visually), the boat was manoeuvred to get closer to the surfacing whale, and be placed behind the animal as it initiated its dive. Photographs of the fluke were taken, using

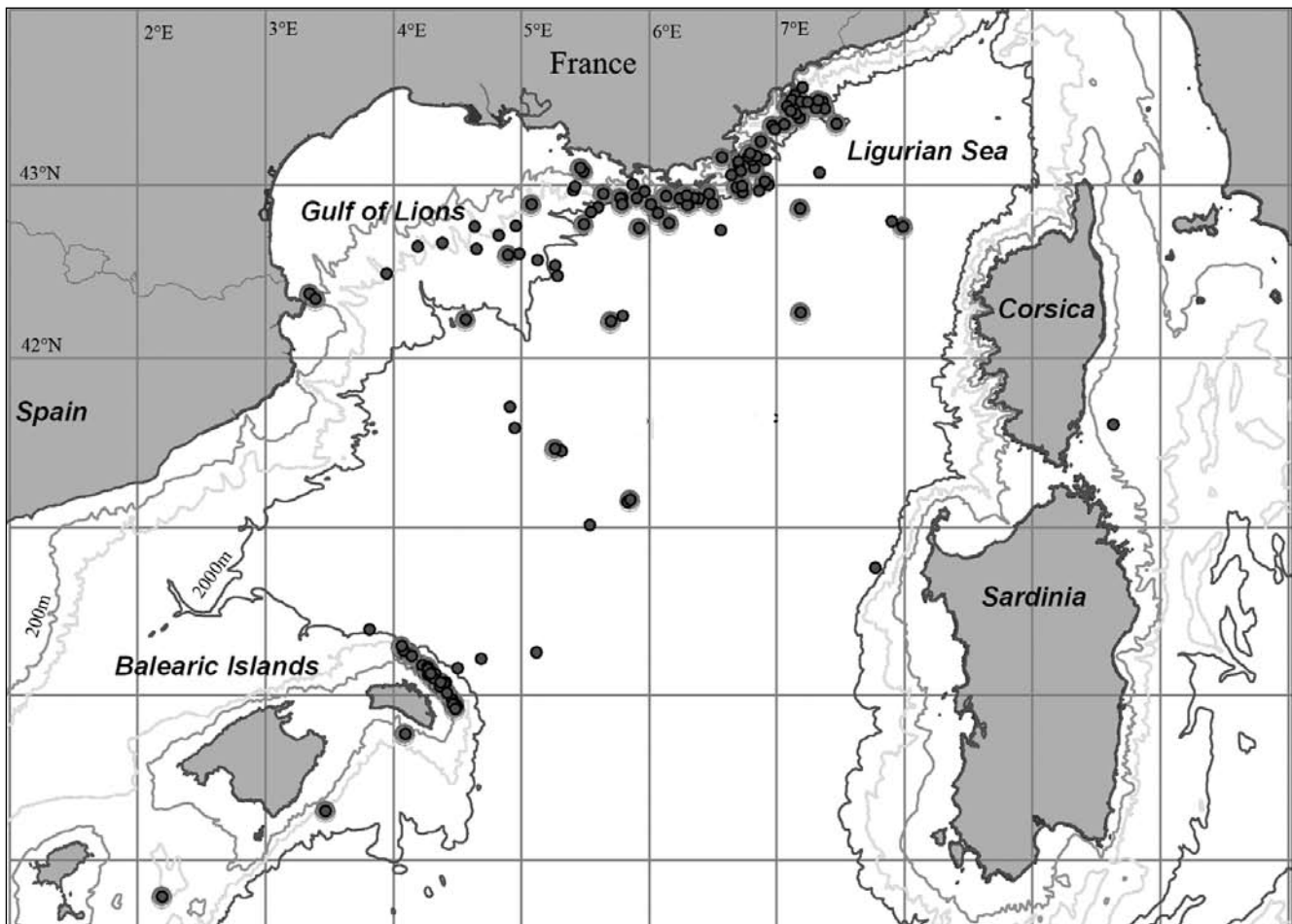


Figure 1. Location of sperm whale sightings in the western Mediterranean Sea.

a 35 mm Nikon autofocus camera, and from 2004, a digital D70 Nikon camera was used. Photographs of the dorsal fin and other parts of the body (head, trunk) were also taken when possible. Furthermore, continuous sound recording of the first 10 min of the dive, after the whale fluked-up, was performed with a dual channel hydrophone, onto a digital audio tape.

Analogue photographs were scanned and the best identification of each individual was stored into a digital

Table 1. Sperm whale sightings and photo-identification effort achieved during GREC Mediterranean surveys (1996–2005).

Year	Number of sightings	Number of individuals	Number of sightings with photo-ID	Number of individuals with fluke photos
1996	2	2	2	2
1997	8	10	3	2
1998	11	22	5	5
1999	17	38	5	4
2000	4	10	3	5
2001	13	44	10	10
2002	19	46	15	21
2003	17	42	13	24
2004	17	37	11	11
2005	23	60	12	21
Total	131	311	80	105

catalogue. Only high-quality ($Q > 3$, e.g. Arnbohm, 1987) photographs were used for analyses. Photographs of individuals with distinctive marks allowing identification were matched to one another by eye. Sightings of photo-identified whales were considered as 're-captures' (or 're-sightings') when sightings were a minimum of one day apart. Group size was defined as the number of whales in the area, including surfacing individuals and submerged animals detected acoustically, using RainbowClick software, developed by the International Fund for Animal Welfare (IFAW).

When good acoustic recordings were available (clicks showing a clear pulsed structure and no other whale clicking in the background), inter-pulse intervals (IPIs) were measured from regular click sequences emitted at the beginning of the dive (e.g. Drouot et al., 2004a). The mean IPI of each individual click sequence was used to estimate the whale body length (in m), according to Gordon's (1991) equation:

$$\text{Body length} = 4.833 + 1.453 \times \text{IPI} - 0.001 \times \text{IPI}^2$$

RESULTS AND DISCUSSION

Survey effort

A total of 105 sperm whale flukes were photographed from 1996 to 2005, from approximately 311 individuals encountered during 131 sightings in the Mediterranean (Table 1). From 2001 onwards, the photo-identification

Table 2. Sperm whale re-sightings in the western Mediterranean Sea.

	Region	Date	Group size
<i>Within-year re-sightings</i>			
SW 1	Ligurian Sea	07 August 2003	2
	Ligurian Sea	08 August 2003	1
SW 2	Gulf of Lions	24 August 2005	4
	Gulf of Lions	26 July 2005	3
SW 3	Balearics	09 July 2002	1
	Balearics	11 July 2002	1
SW 4	Balearics	09 July 2002	6
	Balearics	10 July 2002	4
SW 5	Gulf of Lions	08 July 2002	1
	Balearics	12 July 2002	7
SW 6	Balearics	17 July 2001	2
	Ligurian Sea	15 August 2001	2
<i>Between-year re-sightings</i>			
SW 7	Ligurian Sea	06 August 1998	2
	Ligurian Sea	03 August 2004	1
	Ligurian Sea	11 July 2005	1
	Ligurian Sea	20 July 2005	1
	Ligurian Sea	22 July 2005	1
SW 8	Ligurian Sea	13 August 2002	2
	Ligurian Sea	08 August 2003	1
	Ligurian Sea	15 July 2004	2
	Ligurian Sea	21 July 2004	1
SW 9	Ligurian Sea	04 August 2001	3
	Ligurian Sea	22 July 2004	1
	Gulf of Lions	13 July 2005	4
SW 10	Gulf of Lions	25 June 1999	1
	Balearics	13 July 1901	6
	Balearics	09 July 2002	6
	Balearics	09 July 2002	6
SW 11	Ligurian Sea	05 August 1999	1
	Ligurian Sea	05 July 2002	3
	Balearics	12 July 2002	7
	Ligurian Sea	8 August 2002	1
	Ligurian Sea	13 August 2002	1
	Balearics	27 June 2003	5
	Ligurian Sea	03 August 2003	2
	Ligurian Sea	08 August 2003	1
Ligurian Sea	04 July 2004	1	

efficiency increased as sampling surveys were progressively substituted by passive tracking surveys: 28 fluke photographs were obtained during the period 1996 to 2001 against 77 from 2002 to 2005.

Considering only the flukes with distinct features and for which good quality photographs were available, 44 sperm whales were considered to have been identified with certainty within the western Mediterranean. Among these, eleven individual whales were photographically re-captured. Twenty-six individuals were sighted only once in the northern part of the basin (Gulf of Lions and Ligurian Sea) and seven individuals off the Balearics.

Within- and between-year recaptures

Six individuals (SW1–6) were sighted during the same summer season only, 1 to 29 d apart (Table 2). Four of these animals were re-sighted in the same region, within 1 to 4 d (one in the Ligurian Sea, one in the Gulf of Lions, and two off the Balearics), while two individuals (SW5 and SW6) were seen both in the northern regions and off the Balearics during the same summer. Three individuals (SW7, 8, 11) were seen both within the same year, and between years.

Five whales were re-sighted in different years (SW7–11), between 1 and 7 years apart. These individuals were all seen in the northern basin, four of them being sighted at least twice in the Ligurian Sea (Table 1). These inter-annual recaptures in up to seven summer seasons indicate that some individuals remain, or return repeatedly, in the northern basin in summer, suggesting site fidelity over periods of years to the northern basin feeding area (Drouot et al., 2004b). Long term fidelity of males to relatively small feeding areas (about 30 km span) have been demonstrated in the canyon of Kaikoura, New Zealand (Jaquet et al., 2000) and in the Bleik Canyon off Andenes, Norway (Ciano & Huele, 2000).

Within the northern Mediterranean basin, the maximum distance observed between the inter-annual recaptures ranged from 78 to 175 km, with most of the re-sightings located in an area spanning around 200 km over the continental slope (Figure 1). These results provide an insight on the movement of sperm whales between summer seasons and suggest that individual sperm whales may not have marked territory within the northern basin but rather use the entire continental slope to search for food. Some individuals seen on the continental slope were also sighted in offshore waters of the Ligurian Sea, suggesting a change in feeding areas. Several studies confirm the presence of feeding sperm whales in the deep waters of the Ligurian Sea (Gordon et al., 2000; Gannier et al., 2002; Laran & Gannier, 2006).

North–south displacements

Four whales identified in the northern basin (Ligurian Sea and Gulf of Lions) were also observed off the Balearic Islands. These include (Table 1):

—SW 11: photographically captured nine times between 1999 and 2004. In 2002, it was first identified in the Ligurian Sea, early in July, with two other diving/feeding whales (loose aggregation). A week later, on 12 July, SW11 was observed in the Balearics, among a group of seven whales, comprising females and calves. The same whale was re-sighted twice, solitary, in the Ligurian Sea in early August. Therefore, this individual undertook a round trip from the Ligurian Sea to the Balearics within one month, travelling 440 km south in seven days (maximum) and 416 km back, assuming the sperm whale was moving in a straight line. Assuming the whale took the same amount of time on its trip back, the whale remains in the Balearics a maximum of 20 d. Whale SW11 was shown to have undertaken the same north–south movement in summer 2003, as it was identified in a group of five whales in the Balearics on 27 June and re-encountered solitarily one month later, in early August (on 3 and 8 August), in the Ligurian Sea.

—SW 6: first sighted east of the Balearics, off Majorca, on 17 July 2001, it was re-sighted one month later in the Ligurian

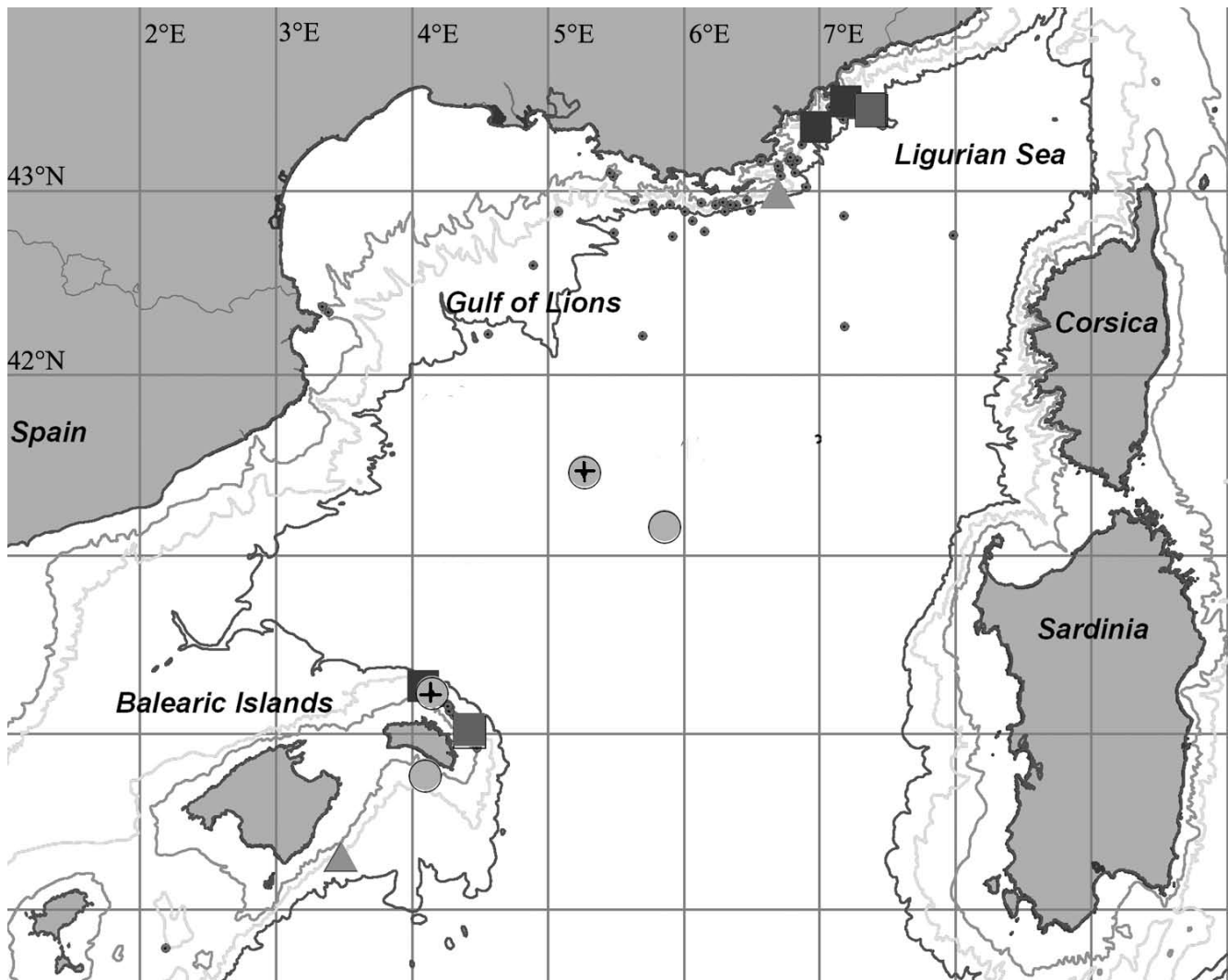


Figure 2. Photo-identified whales (dots) and long distance re-captures of sperm whales between the Balearic Islands and the north-western Mediterranean Sea. □, SW11; △, SW6; ○, SW10; ⊕, SW5.

Sea. These two sightings were 490 km apart. During both sightings the whale was observed alone at the surface, while one other sperm whale was diving in the area (as detected acoustically). In the Balearics the whale SW6 was sighted around 110 km away from the groups of females.

—SW 10: identified in late June 1999 in offshore waters of the Gulf of Lions and re-sighted around 175 km south, off the Balearics, in July 2001 and 2002.

—SW 5: sighted in the offshore waters of the Gulf of Lions in early July 2002 and re-sighted off the Balearics four days later. The distance between these two sightings was 166 km.

The sightings of these two latter whales may have occurred as the whales were travelling south to meet groups of females, because these whales were seen in offshore waters of the Gulf of Lions (in the centre of the study area, Figure 1), alone (no whale was detected acoustically in the area), and had joined a group of 6–7 individuals (including calves) in the Balearics.

Good quality recordings of the beginning of the dive were available for three (SW 6, SW 10, SW 11) of the four individuals shown to undertake movement between the north-western basin (Ligurian Sea and the Gulf of Lions) and the Balearics. The mean IPIs of these three individuals

were 5.1 ms, 5.6 and 5.7 ms, leading to body length estimates of 12.3 m (SW 6), 12.9 m (SW 10) and 13.1 m (SW 11), respectively. Considering the sexual dimorphism of the species, these three individuals were considered as male (Rice, 1989). Furthermore, it has been shown, from whaling data, that males reach sexual maturity at 25 y of age, when they are around 13 m in length (Best et al., 1984). Thus, two of these animals undertaking north–south excursions (SW 10 and 11), were considered as sexually mature males, both joining larger groups of females (Table 1). The smaller whale (SW6), which was not ascertained to have reached sexual maturity, was not associated with a group of females and was observed alone at the surface (with one other whale diving in the area) in the eastern waters of the Balearics. These results indicate a north–south movement of sperm whales in the western Mediterranean Sea, with some sexually mature males identified in the northern basin joining groups of females in the Balearic region. However, these north–south movements may not be exclusively profitable to sexually mature males, as sub-adult males also appear to undertake such displacements.

These north–south excursions of sperm whales were observed in late June–early July. Best et al. (1984) showed that, in the northern hemisphere, the ovarian activity of

sperm whales seems to be at its highest in June/July, which supports the hypothesis that conception might peak in that period. However, the species is known to have a prolonged mating season, with conception occurring from December to August in the North Atlantic (Evans, 1997). Therefore, if these north–south movements within the western Mediterranean are driven by mating purposes, it is likely that they span over several months. It would be interesting to determine the frequency of these male excursions to the southern regions. In fact, if the Balearics are to be considered as a breeding area for the species, their relatively close proximity (around 500 km) to the north-western basin feeding areas (Ligurian Sea, Gulf of Lions) could justify frequent excursions, as opposed to the situation found in the open ocean where males are constrained to long-range migrations. One sperm whale (SW11) was shown to spend 20 d off the Balearics before heading back to the Ligurian Sea. In the Pacific, the residence period of males off the Galapagos Islands was shown to be one month or more within a year (Whitehead, 2003). In the Caribbean, mature males were shown to spend a relatively short time off Dominica (6.4 d on average), during winter months (Gordon et al., 1998).

The consistent presence of calves within groups of females and the visit of sexually mature males from the northern part of the basin may suggest that the Balearics are a mating area for sperm whales in the western Mediterranean Sea. Males inhabiting the northern basin may also visit other breeding areas, such as the Tyrrhenian Sea, where both single animals and groups of females with calves have been observed (Mangano, 1983; Notarbartolo di Sciara et al., 1993; Marini et al., 1996; Drouot et al., 2004a).

Our photo-identification data were collected during the summer season only; more winter surveys are required to determine whether there is some seasonality in these north–south movements, or if they occur throughout the year. Nuutila (2004) also reported the presence of mature males, solitary, paired or associated with female groups, around the Balearics in summer. More data need to be collected to investigate whether the presence of males in this region is a seasonal event or if some of them are present all year round. In the eastern part of the Mediterranean Sea, Frantzis et al. (2003) reported that both males and mixed groups co-habit in the waters off Crete (Greece) all year round. In the open ocean, although there is some evidence of seasonality in the density of mature males on the breeding ground (Whitehead, 2003), in some areas such as off the Galapagos Islands (Hope & Whitehead, 1991) and northern Chile (Whitehead, 2003), some large mature males seem to remain on the breeding grounds throughout the year.

Identification of one male (SW 11) undertaking north–south movements in two consecutive summer seasons suggests that some individuals repeatedly use the same breeding area. Whether this identified whale met the same group of females in subsequent years is unknown, as not all the whales forming the groups were seen fluking-up; photo-identification could thus not be undertaken for each individual (two other whales were photo-identified from each group sighted with SW11, in 2002 and 2003, and no match was found). These data did not allow us to determine the individual movement of males around the Balearics.

Off the Galapagos Islands, males have been shown to rove between groups of females, spending only a few hours with any one group (Whitehead, 1993). Re-association of males with one particular group often occurred over periods of a few days, but never over more than one week (Whitehead, 1993). Further surveys should aim to follow mixed groups for several days to assure all individuals forming the groups are being photo-identified.

The social distribution and movement pattern of sperm whales within the Mediterranean Sea might be more complex than a segregation of males in the north, performing excursions to join the females in southern latitudes. Although mostly males are observed in the northern Mediterranean in summer (Drouot et al., 2004a), some might co-habit with groups of females in the southern regions, as it seems to be the case off Greece (Frantzis et al., 2003). Furthermore, groups of females are not strictly restricted to southern regions, as large schools including calves have been reported in December 2001 and 2003 in the Ligurian Sea (Moulin & Wurtz, 2005; Laran & Gannier, 2006). Further seasonal surveys would provide not only a better understanding of males' movements, but might also produce some new insights on the movement of females.

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