**The seasonal status of sperm whale in the liguro-provençal basin: new results for a better conservation management**

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**Abstract**

Since the beginning of this century, it has become clearer that sperm whales (*Physeter macrocephalus*) were present in the liguro-provençal basin in all four seasons of the year. From 2003 to 2011 acoustic/visual surveys were conducted in the liguro-provençal basin with a 12 m sailboat, a towed stereo hydrophone, and 3 to 5 observers on board. The survey effort covered every month, with a total of 2,443 acoustic samples and 8,812 km of effort. Sperm whales were generally found in loose aggregations of 2 to 4 animals but social groups with calves were also detected on occasions: a group size once amounted to 25 individuals. From acoustic data, it was determined that the sperm whale abundance index was at the lowest in January-February (0 whale/100 km), moderate from March to August (1.5-2.3 whales/100 km), and peaked in September-October (4.6 whales/100 km), before decreasing in November-December. The autumn was also marked by the appearance of large social groups. As human-induced threats increase in number, it is necessary to implement efficient management rules to protect the emblematic sperm whale in the western Mediterranean Sea.

**Résumé**

Depuis une décennie, il est apparu que le cachalot (*Physeter macrocephalus*) était présent durant les quatre saisons dans la région liguro-provençale. Pour mieux établir ce statut saisonnier, nous avons conduit des prospections combinant les données acoustiques et visuelles, entre 2003 et 2011. Nous avons employé un voilier motorisé de 12 mètres, équipé en permanence d'un hydrophone remorqué, avec 3 à 5 observateurs à bord. Notre effort de prospection a recouvert tous les mois de l'année, avec une moins grande intensité entre décembre et février, pour un total de 2 443 échantillons acoustiques et 8 812 km parcourus par beau temps. Les cachalots ont été détectés de mars à décembre, le plus souvent en agrégations de 2 à 4 individus, mais avec des groupes pouvant atteindre 25 individus en automne. L'indice d'abondance établi avec les données acoustiques est nul en janvier-février, puis modéré de mars à août (1,5 à 2,3 cachalots/100 km), avant de culminer en septembre-octobre (4,6 cachalots/100 km), puis de diminuer en novembre-décembre (1,1 cachalots/100 km). L'indice calculé avec les données visuelles aboutit à des valeurs un peu inférieures, mais voisines. C'est en automne que l'on a observé des groupes importants, composés de femelles et de juvéniles. Ces résultats précisent les rares éléments disponibles jusqu'à présent et permettent d'avoir une vue consolidée de la présence saisonnière du cachalot dans les régions provençale et ligure. En se fondant sur l'ensemble des données scientifiques, il est possible d'établir une stratégie de protection efficace de cette espèce, car l'habitat du cachalot en Méditerranée est aujourd'hui soumis à de nombreuses pressions anthropiques.

## Introduction

The sperm whale (*Physeter macrocephalus*) is among the eight common species in the western Mediterranean Sea (Duguy *et al.*, 1983). However, its relative abundance has been difficult to assess before passive acoustic survey methodology was developed and implemented in the Mediterranean Sea: from surveys held in 1994, 1995 and 1996, Gordon *et al.* (2000) showed that clicks were audible in 4 % of 5,428 acoustic samples obtained in summer. Gannier *et al.* (2002) gave average summer acoustic relative abundance estimates for the period 1997 to 2000 in the NW Mediterranean Sea: 2.15 whales/100 km in the western part (W of 6°E) and 0.78 whale/100 km in the eastern (Ligurian) part. However, the relative abundance of sperm whales in the NW Mediterranean Sea was potentially variable at the turn of the century because the species was a notable victim of driftnet fisheries since 1970, with a very high mortality likely to affect its status at least during the 1980 to 2000 period (Notarbartolo di Sciara *et al.*, 2004). The western Mediterranean sperm whale abundance status is then difficult to determine with a good degree of accuracy (Rendell *et al.*, 2014).

The seasonal status of the sperm whale in the liguro-provençal basin could hardly be assessed from early modern literature, as opportunistic sightings were scarce (Beaubrun, 1995), as well as the stranding of fresh carcasses, and the rare seasonal surveys lacked passive acoustic sampling (Gannier, 1998). Since the beginning of the 21$^{st}$ century, it has become clearer that sperm whales were present in the northwestern basin throughout all seasons, and sightings of social schools, once rare, appeared to be more regular in the autumn and early winter (Moulins and Würtz, 2005). From visual and acoustic surveys carried out from 2001 to 2003 with a motor boat on a radial from Antibes to Calvi, Laran and Gannier (2006) were able to determine that sperm whale relative abundance in the central Ligurian Sea peaked in early autumn before reaching a minimum during early winter. However, this study did not focus on the continental slope, an habitat known to be favourable for the sperm whale in the Mediterranean Sea (Gannier *et al.* 2002; Azzellino *et al.*, 2012).

Over the last 20 years, human-induced threats changed in nature and severity: there is a very probable decrease of driftnet mortality in the NW Mediterranean (French thonaille driftnet fishing almost disappeared from 2008 onwards, and pelagic drifnet fishing is now rare in the NW Mediterranean Sea, pers. obs.). But the increase in collision risks (Gannier and Marty, 2015), a consequence of stronger and faster traffic (David and Di-Méglio, 2010), led to a probable increase in human induced direct mortality. The fast augmentation of whale-watching pressure (Mayol *et al.*, 2009) may induce cases of harassment, with probable consequences on the whales' fitness. The higher ambient noise levels induced by vessel traffic probably affects the Mediterranean pelagic habitat and may change the way the sperm whale population use the whole area, spatially and

seasonally. At longer term, the evolution of ecosystem physical and biological characteristics may also induce changes in habitat use (Gambaiani *et al.*, 2009).

The management of the sperm whale population in the Mediterranean Sea can only be achieved with a better knowledge on its present habitat use. This study provided new results on the seasonal status of the species in the liguro-provençal basin.

## Material and methods

From June 2003 to February 2011 we conducted acoustic/visual surveys in the liguro-provençal basin during all months, with a 12 m sailboat, a towed stereo hydrophone and 3 to 5 observers. The area of study was located between 6° and 9°30' E of longitude and north of 42°45' N. Although the survey effort was irregular, it covered all the months, with a total of 2,443 acoustic samples and 8,812 kilometers of effort (Fig. 1). Particular emphasis was placed on the continental slope habitat, although the oceanic habitat was also covered in summer.

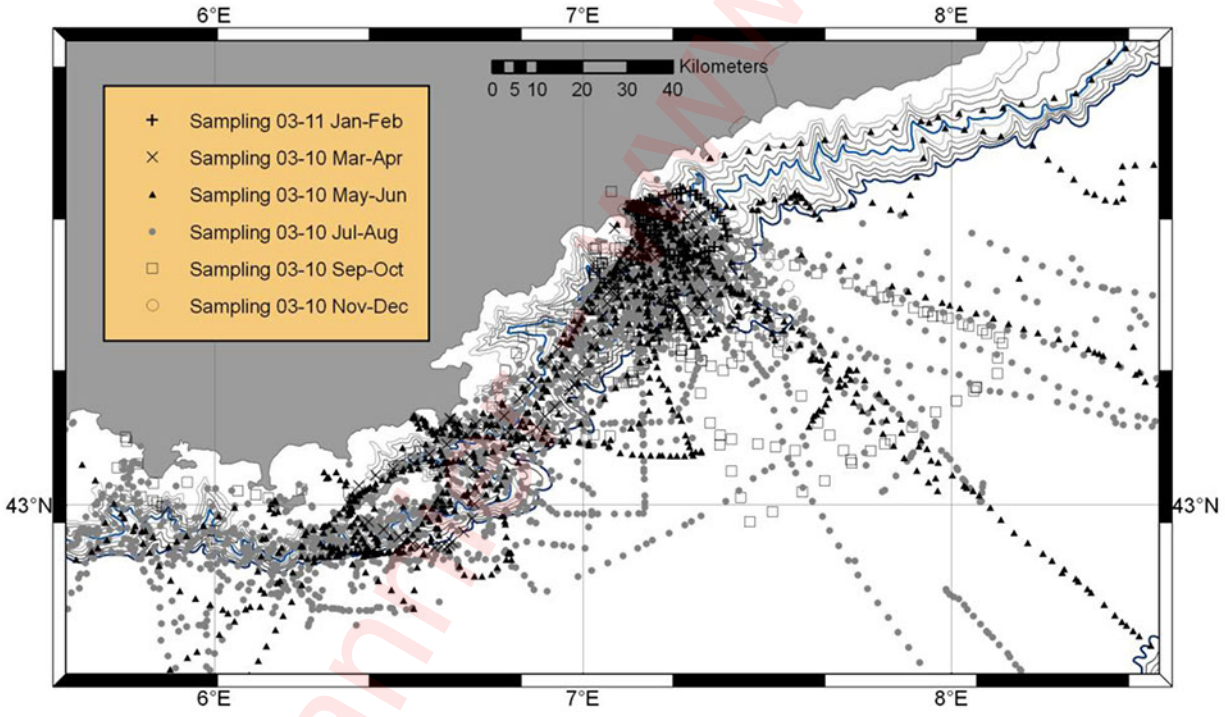


**Figure 1**: Area of study and sampling effort (2003-2011)

The searching methodology included acoustic and visual techniques, and was basically similar to that used in previous studies (Gannier *et al.*, 2002): three observers performed a continuous naked-eye observation of the sea surface, scanning the 180° sector ahead of the boat. Acoustic sampling consisted of 1 min listening stations every 3.7 km (i.e. 2 nautical milles) along

the survey track using a stereo hydrophone with a 100 m towing cable (Magrec HP-30ST). The hydrophone elements were two Benthos AQ-4 fitted with a 29 dB pre-amplifier and 200 Hz high-pass filter. Sensitivity was 156 re 1V/µPa flat +/- 2 dB from 200 Hz to 32 kHz (calibrated). When a sperm whale was detected acoustically, it was either approached through using Rainbow click © software, or passed, depending on the received click level, which was estimated on a 0 to 5 scale (Gordon *et al*., 2000). When the whale was approached, it was generally visually sighted upon its next surfacing. Whales could be acoustically detected either as single individuals or in groups, in which case a minimum cluster size was estimated with Rainbow click. Whenever whale schools were observed at the surface, the cluster size was visually estimated.

The data comprised rows of georeferenced numerical characters among which: acoustic sperm whale click level (0 to 5), noise level (1 to 5), minimal number of whales heard, number of whales within sight, as well as data on other species, weather and sea description, boat location and movement.

Two distinct relative abundance indices were computed, one for acoustic data, and one for visual data, both related to the number of whales detected per unit of effort. In order to reach comparable results, analysis methods similar to those proposed by Gannier *et al*. (2002) were adopted: the daily survey effort was divided into samples about 20 nautical milles (37 km) long, and grouped consecutive positive acoustic samples into acoustic sequences. This method was necessary because a given sperm whale can be heard up to 12 km away with our towed hydrophone device. Every sperm whale acoustic sequence was attributed a school size either equal to the maximum number of individuals detected acoustically, or to the number of individual visually counted. This relative abundance was estimated for two-month periods: January-February, March-April, May-June, July-August, September-October and November-December.

## Results

The sperm whale presence on the slope and oceanic habitat was confirmed from March to November: a total of 131 whales were seen and 194 were counted acoustically in the area of study (Fig. 2). Sperm whales were generally found in loose aggregations of 2 to 4 animals, foraging without marked synchrony, but the maximal school size was 25 individuals, for a social school with calves which was acoustically detected and visually controlled on 27 October 2009. Individuals in small groups were sometimes tightly grouped at the surface. Average cluster sizes were higher in March-April (3.0) and September-October (3.7) than in May-June (1.9) and November-December (1.5).

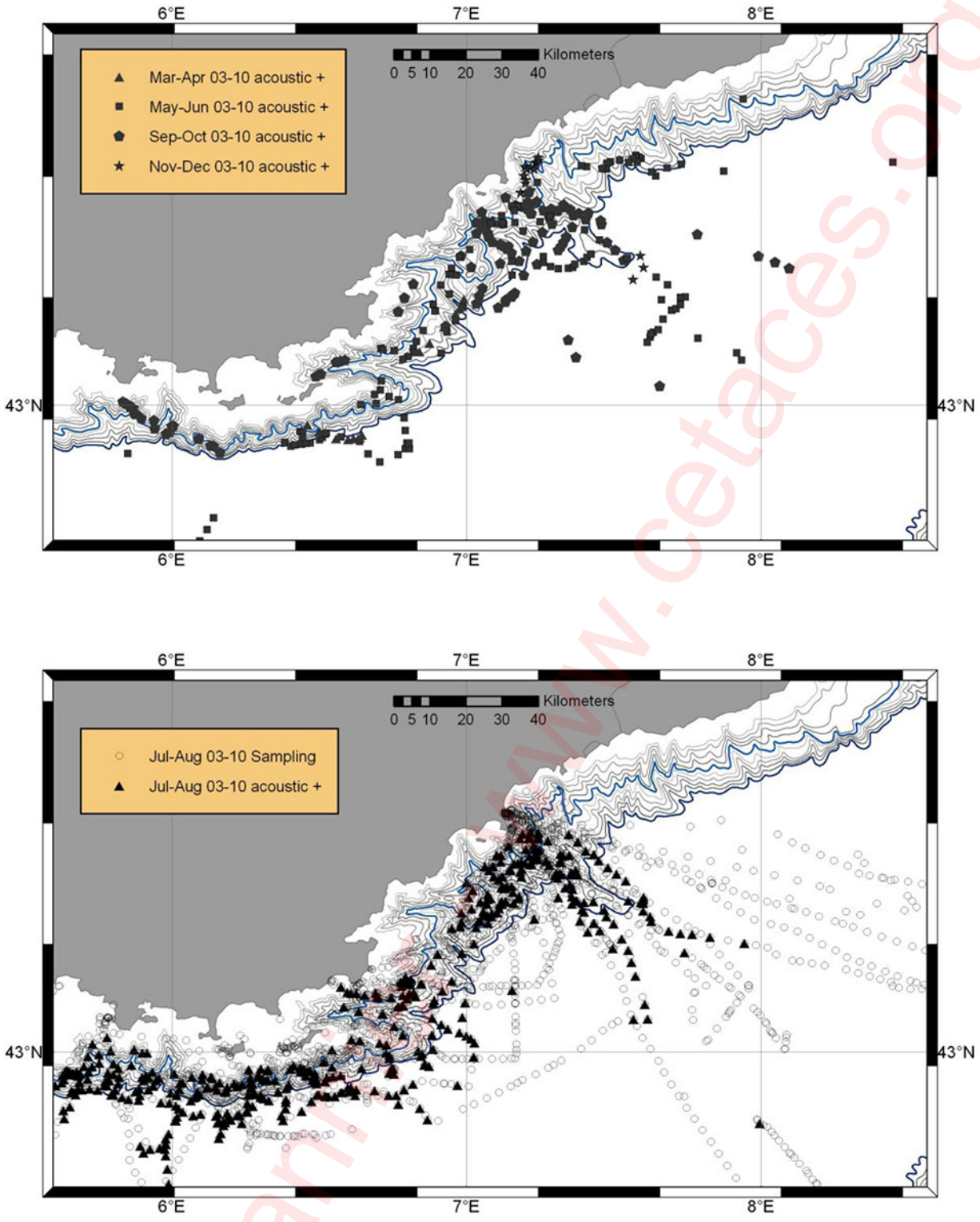


**Figure 2**: Positive acoustic contact on sperm whales 2003-2010.

Top, from September to June; bottom, July and August.

For the July-August map, open symbols indicate acoustic samples without sperm whale signal.

From the analysis of acoustic encounter rates, it was determined that sperm whale presence in the liguro-provençal basin was at the lowest in January-February (0 % of positive samples), was moderate in March-April (16.3 % positive acoustic samples), and higher from May to October (a range of 19.7 to 22.5 %) and peaked in November-December (26.8 %), though no whale was heard in December (Table 1).

| | January-February | March-April | May-June | July-August | September-October | November-December |
|---|---|---|---|---|---|---|
| Number of sample segments | 4 | 8 | 54 | 111 | 40 | 7 |
| Survey effort (nautical milles) | 63 | 177 | 1182 | 2393 | 795 | 148 |
| Number of whales visually detected | 0 | 6 | 28 | 45 | 51 | 1 |
| Visual relative abundance w./km | 0.000 (-) | 0.018 (0.063) | 0.013 (0.061) | 0.010 (0.046) | 0.035 (0.179) | 0.004 (0.024) |
| Number of acoustic samples | 28 | 86 | 590 | 1145 | 523 | 71 |
| % Acoustic with sperm whale clicks | 0.0% | 16.3% | 22.5% | 19.7% | 19.9% | 26.8% |
| Number of whales acoustically detec. | 0 | 6 | 51 | 66 | 68 | 3 |
| Acoustic relative abundance w./km | 0.000 (-) | 0.018 (0.063) | 0.023 (0.062) | 0.015 (0.050) | 0.046 (0.174) | 0.011 (0.031) |
| Average cluster size | - | 3.0 | 1.9 | 2.6 | 3.7 | 1.5 |

**Table 1**: Survey effort, sperm whale encounters and relative abundances for the period 2003-2011. Number in brackets are SD.

Both visual and acoustic relative abundance indices peaked in September-October, with respective averages of 3.5 whales/100 km and 4.6 whales/100 km before decreasing sharply in November-December (Table 1). When we accounted for high SD for both estimates, we observed that both relative abundances were quite stable from late-winter to mid-summer, with a slight decrease in July-August compared to May-June (Fig. 3). In November-December, the highest proportion of positive acoustic samples contrasted with the low relative abundance indices, which may be linked to the low cluster size (1.5 individuals) and also to acoustic sequences lasting longer in that season.

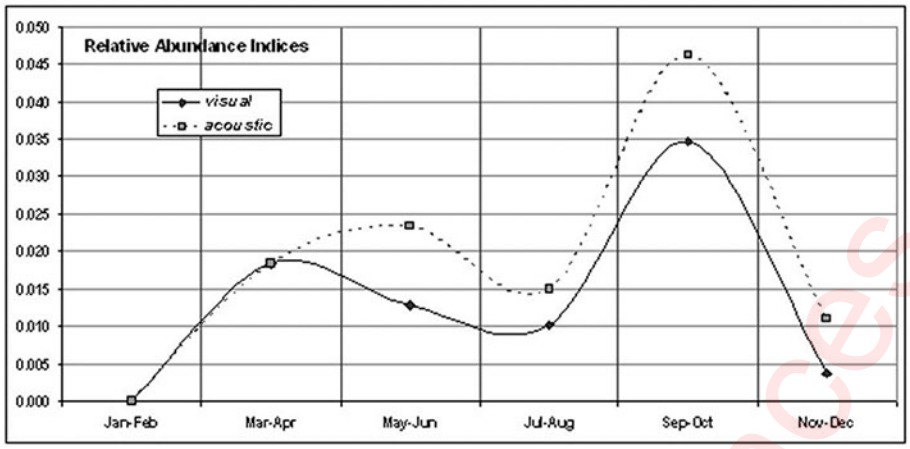


**Figure 3**: Acoustic relatives abundances. Acoustic and visual in whale per km of effort.

## Discussion

Our results showed a marked seasonality in the sperm whale occurrence in the liguro-provençal basin, with a minimal presence during the winter and a maximum relative abundance in September and October. The present study partly confirmed a previous paper focused on the western Ligurian Sea: Laran and Drouot-Dulau (2007) reported the presence of sperm whales throughout the year, 16 % of 217 acoustic samples indicated a sperm whale presence. They obtained a maximum acoustic relative abundance of about three individuals/100 km in September-October, and a minimum of about 0 from December to March. Their records also featured a marked minimum in July compared to June and August. Laran and Gannier (2006) proposed an abundance index combining acoustic and visual data, which showed a high occurrence in December due to the single sighting of a social group (9 individuals) in December 2003. Both studies agree on three main seasonal occurrence characters: a seasonal cycle marked by a minimal presence in the winter, a clear maximum in the autumn, and the occurrence of large social schools -with calves- from October to December, as also observed by Moulins and Würtz (2005). The prominent feature of this seasonal cycle is sperm whale presence from March to December, with a very limited absence period, if any (our survey effort in January-February was low).

The autumn is marked by the appearance of large social groups in the liguro-provençal basin. Drouot *et al*. (2004) stated a summer segregation between groups with small-sized whales, mostly present in the southwestern basin, and larger individuals present in the northwestern basin. From this literature and the present study, it is likely that the presence of social schools in the north of the western Mediterranean Sea occurs from late summer to early winter. Drouot-Dulau and Gannier (2007) documented the mobility of sperm whales from the central western basin to the northern region. Due to the scale of the western basin, social schools could move from their usual

summering ground, for example close to the Balearic Islands (Drouot *et al.*, 2004), to the liguro-provençal region within a couple of days.

It is presently unknown how basin-wide movements of sperm whale schools are linked to the seasonal trophic situation, but Gannier and Praca (2007) showed that sperm whale tended to aggregate close to SST fronts in the NW basin, in summer. We may then assume that movements of social schools in the western basin, their timing and extension, are partly determined by the basin-wide trophic situation, shown to be variable from one year to the next (Bosc *et al.*, 2004).
During the present study, small-sized calves were observed in a social school recorded on 27 October 2009, but it could not be determined whether they were born some weeks or a few months ago. A similar sighting was previously reported by Moulins and Würtz (2005). The sperm whale calving season and grounds are not yet precisely identified but ancillary visual and photographic data associated to published results (Gannier *et al.*, 2002; Drouot *et al.*, 2004) showed that neonates were present among the social schools close to the Balearic Islands in June and July, suggesting that calving takes place during the winter or spring, and preferentially in southern areas of the western basin. However, calving could eventually take place in other areas, including the liguro-provençal basin and during other seasons:

In terms of conservation management, the extended sperm whale presence in the liguro-provençal basin and the consistent occurrence of social schools with calves are to be confronted with increasing threats. The northwestern basin is now largely exempt of bycatch threats, because the EC ban on driftnet seems to have been effectively implemented by French governmental bodies, as observed in 2010 and 2011 (pers. data and Sanctuary Pelagos communication). In the Ligurian Sea, Italian drifnet fishing is no longer common, if it still exists. However, this does not imply that driftnet fishing is no longer a threat in the southwestern Mediterranean basin (Notarbartolo di Sciara *et al.*, 2004).

The collision risk was recently documented (Gannier and Marty, 2015): 6 % of sperm whale flukes display signs of collision or propeller injury (GREC photo-identification catalogue), and fatal ship strikes have been reported at least twice since 2000. Some ferry routes overlap the spem whale continental slope habitat, and there is a maximum traffic from spring to autumn, the season of higher sperm whale occurrence (David and Di-Méglio, 2010). This intense maritime traffic also triggers underwater noise levels which may impact the sperm whale ecology because the species uses the low to medium frequency band both for communication and feeding purposes (Madsen *et al.*, 2002).

Seismic surveys, once restricted to research activities, at least in the NW Mediterranean Sea, have recently increased in frequency and power, due to oil research permits released by the French government in the nearby Gulf of Lion. This contributes to worsen the underwater noise ambiance and could probably affect the attractivity of the NW basin for sperm whales. The western Mediterranean Sea could be impacted at the population level by area avoidance and a decrease in

demographic parameters caused by stress (Wright *et al.*, 2011). Naval military exercises periodically take place in the liguro-provençal basin, and anti-submarine warfare training with sonar emissions is common. Although there is no evidence of a serious impact of sonar on sperm whales, it is established that long-lasting or repeated exposure to high sound intensities can cause detrimental effects on cetaceans auditory systems (Finneran *et al.*, 2010).

Whale-watching activity has rapidly increased since the late nineties, both in terms of number of boats involved and of the area coverage (Mayol and Weber, 2009). Furthermore, aircrafts are being increasingly used to detect and track cetaceans, leading to additional pressure on whales. Because sperm whales tend to be distributed closer to the shore compared to fin whales, in the liguro-provençal basin (Azzellino *et al.*, 2012), they represent a prime target for whale watching operators. Existing guidelines (ACCOBAMS, 2004) appear to be poorly implemented, at least in the open sea, and there are cases of obvious harassment caused by whale watching operators (pers. obs.). Sperm whales engaged in vital foraging activity on the continental slope can have their dive/surface cycle significantly affected when approached closely by boats or swimmers (pers. data). The presence of social schools with calves from late summer to early winter ought to be accounted for in impact assessments in the liguro-provençal basin, because calves have limited mobility and are probably more vulnerable to whale-watching, intense sounds and ship strikes.

## Conclusion

The extended seasonal presence of sperm whales in the liguro-provençal basin was documented in this study, as well as the use of this area by social schools with calves. There is a general increase of human activities in the region, with the exception of driftnet fishing, and some of them are potentially detrimental to sperm whales. It is necessary to implement efficient management rules to protect the sperm whale population in all of the Mediterranean Sea, in particular the emblematic Pelagos Sanctuary.

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## Literature

ACCOBAMS, 2004.- Guidelines for commercial cetacean-watching activities in the Black Sea, the Mediterranean Sea and contiguous Atlantic area: 1-34.

Azzellino A., Panigada S., Lanfredi C., Zanardelli M., Airoldi S., Notarbartolo di Sciara G., 2012.- Predictive habitat models for managing marine areas: spatial and temporal distribution of marine mammals within the Pelagos Sanctuary (Northwestern Mediterranean sea). *Ocean & Coastal Management*, 67: 63-74

Beaubrun P.C., 1995.- *Atlas préliminaire de distribution des cétacés de Méditerranée*. CIESM et Musée Océanographique de Monaco: 1-87.

Bosc E., Bricaud A., Antoine D., 2004.- Seasonal and interannual variability in algal biomass and primary production in the Mediterranean Sea, as derived from four years of SeaWiFS observations. *Global Biogeochemical Cycles*, 18, GB 1005, 10.029/2003GB002034: 1-17.

David L., Di-Méglio N., 2010.- Prévention des collisions entre navires et grands cétacés (Rorqual et Cachalot). Etude 09.016.83400, Rapport final. http//www.sanctuaire-pelagos.org/fr/documents/etudes-scientifiques.

Drouot V., Gannier A., Goold J.C., 2004.- Social distribution and behaviour of sperm whales (*Physeter macrocephalus*) in the Mediterranean Sea *J. Mar. Biol.Asso. UK,* 84: 675-680.

Drouot-Dulau V., Gannier A., 2007.- Residency and movements of sperm whale in the western Mediterranean Sea, preliminary photo-identification results. *J. Mar. Biol. Asso. UK,* 87: 195-200.

Duguy R., Casinos A., Di N atale A., Filella S., Ktari-Chakroun F., Lloze R., Marchessaux D., 1983.- Répartition et fréquence des mammifères marins en Méditerranée. *Rapp. Comm. int. Mer Médit.,* 28: 223-230.

Finneran J.J., Carder D.A., Schlundt C.E., Dear R.L., 2010.- Growth and recovery of temporary threshold shift at 3 kHz in bottlenose dolphins: experimental data and mathematical models. *J. Acoust. Soc. Am.* 127(5): 3256-3266.

Gannier A., 1998.- Variation saisonnière de l'affinité bathymétrique des Cétacés dans le bassin liguro-provençal. *Vie et Milieu,* 48: 25-34.

Gannier A., Drouot V., Goold J.C., 2002.- Distribution and relative abundance of the sperm whale in the Mediterranean Sea. *Mar. Ecol. Prog. Ser.,* 243: 281-293.

Gannier A., Praca E., 2007.- SST fronts and the summer sperm whale distribution in the NW Mediterranean Sea. *J. Mar. Biol. Asso. UK,* 87: 187-193.

Gannier A., Marty G., 2015.- Sound propagation in stratified waters affects whales ability to detect approaching vessels. *Mar. Pollut. Bull. 95)*: 283-288. http//dx.doi.org/10.1016 /j.marpolbul. 2015.03.029.

Gambaiani D.D., Mayol P., Isaac S.J., Simmonds M.P., 2009.- Potential impacts of climate change and greenhouse gas emissions on Mediterranean marine ecosystems and cetaceans. *J. Mar. Biol. Asso. UK,* 89(1): 179-201.

Gordon J.C.D., Matthews J.N., Panigada S., Gannier A., Borsani J.F., Notarbartolo di Sciara G., 2000.- Distribution and relative abundance of striped dolphins, and distribution of sperm whales in the Ligurian Sea cetacean sanctuary: results from a collaboration using acoustic monitoring techniques. *J. Cetacean Res. Manage*., 2: 27-36.

Laran S., Gannier A., 2006.- Variation saisonnière de la présence du cachalot (*Physeter macrocephalus)* dans le Sanctuaire Pelagos (Mer Ligure). *Mésogée,* 61: 71-78.

Laran S., Drouot-DULAU V., 2007.- Seasonal variation of striped dolphins, fin- and sperm whales' abundance in the Ligurian Sea (Mediterranean Sea). *J. Mar. Biol. Asso. UK,* 87: 345-352.

Madsen P.T., Wahlberg M., Mohl B., 2002.- Male sperm whale (*Physeter macrocephalus*) acoustics in a high-latitude habitat: implications for echolocation and communication. *Behav. Ecol. and Sociobiol*., 53: 31-41.

Mayol P., Weber P.-H., 2009.- Le whale-watching en Méditerranée française: mise à jour de la base de données des opérateurs. Etude 09.044.83400, Rapport final. http//www.sanctuaire-pelagos.org/fr/documents/etudes-scientifiques.

Moulins A., Würtz M., 2005.- Occurrence of a herd of female sperm whales and their calves (*Physeter macrocephalus*), off Monaco, in the Ligurian Sea. *J. Mar. Biol. Asso. UK,* 85: 213–214.

Notarbartolo di Sciara G., Bearzi G., Cañadas A., Frantzis A., 2004.- High mortality of sperm whales in the northwestern Mediterranean, 1971-2003. *Rep.Scientific Comm. of the Int. Whaling Commn* SC/56/BC10 : 3pp.

Rendell L., Simião S., Brotons J.M., Airoldi S., Fasano D., Gannier A., 2014. Abundance and movements of sperm whales in the western Mediterranean basin. *Aquatic Conservation: Marine and Freshwater Ecosystems 24(S1)*: 31-40.

Wright A.J., Deak T., Parsons E.C.M., 2011.- Size matters: management of stress responses and chronic stress in beaked whales and other marine mammals may require larger exclusion zones. *Mar. Pollut. Bull.,* 63 : 5-9.