

**THE NORTHEASTERN ALBORAN SEA, AN IMPORTANT BREEDING AND
FEEDING GROUND FOR THE LONG FINNED PILOT WHALE (*GLOBICEPHALA*
MELAS) IN THE MEDITERRANEAN SEA**

Ana Cañadas (*,**) and Ricardo Sagarminaga (*)

*ALNITAK Marine Environment Research and Education Center

Nalón 16. 28240 Hoyo de Manzanares. Madrid (Spain).

**Grupo de Investigación de Cetáceos. Laboratory of Archaeozoology, Department of

Zoology, Universidad Autónoma de Madrid

Ctra. Colmenar Viejo, Km. 15, Cantoblanco 28049, Madrid (Spain)

E-mail: alnitak@cetaceos.com

Tel. and fax: +34-918565199

ABSTRACT

Little is known about the long-finned pilot whale's population size, structure, distribution and dynamics in the Western Mediterranean basin. The research region covered since 1992 in southeast Spain, at the edge of the Alboran Sea, is considered an important oceanographic transition zone between the Mediterranean and the Atlantic. The research ship *Toftevaag* carried out surveys covering a total of 10,173 nmi (18,840 km) from April to September each year, 1992-1997, all years pooled. Effort for ten-by-ten-mile quadrats was stratified by depth and sea state to ascertain encounter rates. Tracking of animals was used together with photo-identification in order to analyze home range of groups. Behavior was recorded *ad libitum*, and underwater video taping was used to analyze specific behavior patterns. One hundred and nine sightings of pilot whales were made. The average group size was 41.4 ± 58.4 , ranging from 1 to 350. The average depth at encounters was 848.7 ± 281.2 m. ranging from 300 to 1800 m. Comparison of results on encounter rate and group size with those for other Mediterranean regions, together with site fidelity shown by photo-identification and observations of reproductive behavior, reflect the importance of the Alboran Sea to the species in the Mediterranean.

KEYWORDS: long-finned pilot whale, *Globicephala melas*, Alboran Sea, Mediterranean Sea, distribution, behavior, social structure

The Mediterranean Sea is characterized by warm, salty and nutrient-poor waters (Rodriguez 1982). Its semi-enclosed nature makes it especially sensitive to human pressures such as over-exploitation of resources and contamination. The major renewal of water for this sea occurs through Gibraltar Strait. Ocean-level differences together with local atmospheric pressure and winds define the strength of an inflowing Atlantic surface current. This Atlantic inflow is diverted by topography into one or sometimes two anticyclonic gyres, which finally create the Almería-Oran front (Parrilla and Kinder 1987, Gascard and Richez 1985). This front in turn gives rise to the North African Current, where gradually all the Atlantic influence is lost. The clashing of Atlantic water with the different Mediterranean water masses is responsible for the formation of an important thermohaline front (Cortés *et al.* 1985, Gil 1985, La Violette 1986, Cheney and Doblár 1979, Millot 1987) and regions of upwelling where primary production increases (Rubín *et al.* 1992). The Alboran Sea plays an important role as a transition chamber between the Atlantic Ocean and the Mediterranean Sea, being defined as the “hydrological motor” of this sea (Rodriguez 1982).

Since 1992, the research group Alnitak has conducted a program monitoring the cetaceans in the Northeastern Alboran Sea, where ten species have been identified. The Alboran Sea is characterized by a complex sea floor topography with steep escarpments, canyons and mountains, which further serve to increase upwelling and concentrate productivity. These oceanographic features have resulted in the Alboran Sea being an important feeding and breeding ground for cetaceans and their prey (Rodriguez 1982, Rubin *et al.* 1992), and it has been highlighted as an important region for several species of cetaceans which have suffered decline over the last few years in the Mediterranean (Sagarminaga and Cañadas 1998). For migratory species, which could move in and out of the Mediterranean, the Alboran Sea also plays an important role due to its geographical situation, being a necessary passage between the Mediterranean and the open Atlantic Ocean.

The long-finned pilot whale (*Globicephala melas*) is considered a common species in the Mediterranean (Duguy 1989, Gannier 1995). It is difficult at present to establish the size, structure, distribution and dynamics of its population due to lack of data and heterogeneity of research effort for different regions and for different seasons of the year. Although there is scattered and in most cases non-published information on the presence of long-finned pilot whales around the Strait of Gibraltar (Duguy 1989, Fernández-Casado *et al.* in press), nothing is known about movements in and out of the Mediterranean through this strait. Are pilot whales moving through the strait into the Mediterranean, or do resident pods include this strait in their home range? What mixing exists between different groups of pilot whales in the Mediterranean?

This research program was conducted at the northeastern edge of the Alboran Sea. Here sea conditions are generally favorable for ship-based observations, which in the region of Gibraltar would face the adverse effects of continuous strong winds and unsuitable high seas. The main aim of this on-going study has been to determine the degree of residency of the groups. Photo-identification and tracking of groups encountered in the research region have been used to determine site fidelity and daily and seasonal variations in group structure, behavior and dynamics. Another aim has been to establish the importance of the Alboran Sea region for all long-finned pilot whales in the Mediterranean. For this purpose, a comparative analysis is made here of encounter rate, group size and special behavior patterns for groups of pilot whales studied here and in other areas of the Mediterranean and Atlantic Ocean.

METHODS

Transects

Sighting cruises were carried out on board the 18 m auxiliary powered sailing yacht *Toftevaag* during the months of April, June, July, August and September, 1992 to 1997,

covering the region from Cabo de Palos (37°38'N 0°33'W) to Almerimar (36°20'N 2°55'W [southeastern coast of Spain, see Figure 1]). Thirty to fifty nautical mile (55-90 km) triangular transects were sailed at an average speed of 5 kn (9.3 km/h), as perpendicular to coast and depth contours as possible (see Table 1), in order to cover the divisions of the research region and the depth ranges homogeneously enough for further comparative analysis. Navigation data were directly fed from a GPS navigator to a computer using the LOGGER computer program developed by I.F.A.W (International Fund for Animal Welfare). Effort status, meteorological conditions, sea state, fishing activities, maritime traffic and other environmental data were entered into the computer and in notebooks every 60 min or when conditions changed.

Relative abundance and distribution analysis

For the analysis of distribution and relative abundance, the research region was divided into four major areas (I=north, II=center, III=south and IV=southwest) (see Figure 1), which in turn were subdivided in 10x10 nmi quadrats. Six depth ranges were considered: 0-200, 200-500, 500-1000, 1000-1500, 1500-2000 and >2000 m. Sea state was also taken into account for the analysis, being divided into five categories using the Douglas sea state scale: 1, 1S, 2 and 2S (S=swell) (approximate equivalence to Beaufort wind force scale in offshore, current-free conditions: Douglas 1 - Beaufort 0-2, Douglas 2 - Beaufort 3). Sighting effort was stopped in sea states of 3 Douglas or more. To obtain a relative index of abundance, the encounter rate was calculated by dividing the number of groups encountered in each of the divisions mentioned above by the nautical miles sailed on effort in the division. This was then multiplied by 100 in order to avoid unnecessary decimals:

$$\text{Encounter rate} = \frac{\text{number of groups encountered}}{\text{nautical miles on effort}} \times 100$$

Encounter rates for different areas, quadrats or depth ranges were compared. For comparisons with other regions, a conversion was made using kilometers instead of nautical

miles.

Group size and social structure

A pilot whale group was defined as all the animals sighted at the same time showing similar behavioral characteristics and at distances of less than 1000 m from each other. This definition differs from that of 250 m used by Heimlich Boran (1993) for their short-finned pilot-whale research in the Canary Islands, where a cohesion distance of 250 meters was taken. The choice of this greater distance is influenced by the fact that cohesion of groups was found to vary greatly throughout encounters. Each sighting corresponded to a single group. In the data collected during sightings, a distinction was made between compact groups and dispersed groups. Groups were considered compact when the distance between the animals was less than 50 m and dispersed when the distance was greater than 50 m. The total number of pilot whales in every group was estimated, discriminating, whenever possible, between different subgroups. Subgroups were defined as all the animals in a group within 20 m of each other and behaving synchronously. The discrimination of these subgroups was only possible when the group were dispersed enough to clearly establish divisions. In each case, a classification and counting of the animals into 5 sex/age categories was made using visual cues: calves, juveniles, adult males, mothers or females with calves, and undetermined. These classes were derived from published measurement data (Bloch *et al.* 1993). For the statistical analysis of group size, due to a strong skewed distribution the data were logarithmically transformed in order to normalize them. Derived means were compared between seasons and group-spacing categories.

Photo-identification

Photo-identification was used as a means of “benign tagging” to recognize individuals with conspicuous markings on their fins (Würsig and Jefferson 1990). An auto-focus Canon EOS 1000 camera with 80-300mm zoom lenses was used with 200ASA color slide film. Slides of good quality images showing distinctive identification characteristics were scanned and stored

in a computerized database.

Video-filming

Videotape was recorded with a Sony V200pro 8mm camera and a Sony TR7 Hi-8 camera, both equipped with underwater housings. Panoramic shots from the ship's crows nest were used to support written notes on social structure, group size and specific behavior patterns. Underwater videotaping was also used for behavior analysis.

Group tracking

Once all individuals in a group were photographed, they were tracked from a distance where they would not respond to the ship. During tracking, a constant record of activity and behavior was made. Tracking was used to study daily home ranges together with changes in behavior and group structure.

RESULTS

Encounter rate.

Sighting effort totaled 10,173 nautical miles (18,840 km) for all six years. There were 106 sightings of long-finned pilot whales, lasting 158 hours. Other species encountered in the area were striped dolphins (*Stenella coeruleoalba*), common dolphins (*Delphinus delphis*), bottlenose dolphins (*Tursiops truncatus*), Risso's dolphins (*Grampus griseus*), fin whales (*Balaenoptera physalus*), sperm whales (*Physeter macrocephalus*), Cuvier's beaked whales (*Ziphius cavirostris*), northern bottlenose whales (*Hyperoodon ampullatus*) and false killer whales (*Pseudorca crassidens*). The encounter rate for long-finned pilot whales was 1.042 sightings per 100 nmi (0.563 sightings per 100 km). During sea-state 1 or 1S, the encounter rate was 1.348 sightings per 100 nm (84 sightings, 0.728 sightings per 100 km), and with sea state 2 or 2S, the encounter rate went down to 0.558 per nmi (22 sightings, 0.301 sightings per 100 km). These results show the important effect of sea state on detectability of long-finned

pilot whales, as they are usually seen resting or swimming slowly, not breaching or splashing. An increase of sightings was recorded in the last two years, especially in 1996, with an encounter rate of 2.039 sightings per 100 nmi for 1996 (39 sightings) and 1.393 for 1997 (24 sightings); in comparison with rates of 0.577 for 1992, 0.782 for 1993, 0.855 for 1994 and 0.471 for 1995.

There were no statistical differences between encounter rates for different months, but there was a slight trend of higher encounter rates in June, July and August (Table 1). This was most pronounced for encounters during sea-state 1-1S (Table 1), when the probability of detecting pilot whales in the area surveyed was higher. Analyzing effort with sea-state 1 Douglas, we found that 84% of the sightings were recorded during these three months, which account for 68% of the overall effort under this sea state. This yearly and monthly variation can not be explained by variation in the incidence of different sea states, as the miles sailed under effort for each of the sea states remain more or less constant throughout the years and the months. However the effort during the summer months, due mainly to logistical limitations, was higher than for other seasons of the year, making it at present impossible to make a proper analysis of seasonal encounter-rate variation.

Distribution with depth

Most of the sightings were made in areas of between 500 and 1200 m depth ($n=90$, or 82.6 % of the sightings) with a peak between 900 and 1000 m (19.8 % of all sightings) (Figure 2). Analyzing encounter rates by depth ranges, we found the same result: the maximum encounter rate was obtained for the range between 500 and 1000 m, both considering all sea-states or only sea-states of Douglas = 1 (Table 3). Whilst only 23% of the effort was made in the depth range of 500 – 1000 m, 59% of the sightings were made in this range. When taking into account only sea-state of Douglas 1, a similar proportion is obtained: 27% of the effort *vs.* 61% of the sightings for this depth range. The average ocean depth at encounters was $849 \pm$

281 m ($x \pm SD$). No significant differences were observed for different areas, months or behaviors displayed.

Group size

The average size of the groups encountered was 41.4 ± 58.4 ($n=114$, range = 1 (lone male) to 350), with a derived mean of 20.9 after logarithmic transformation of the data. Group sizes were significantly smaller during April-June than during July-September (derived means: 9.6 vs. 20.4, $z=2.78$, $P<0.01$; untransformed means 19.4 vs. 43.3) The peak frequency range of group size (Figure 3) was 6-20 individuals ($n=49$ groups, or 45%). The second-most-encountered group size range was between 21 and 60 individuals ($n=34$ groups or 31.2%). The derived mean group size was significantly smaller for compact groups than for dispersed groups (13.2 vs. 36.6, $z=5.5$, $P<0.01$; respective means for untransformed data = 20.7 vs. 62.2). Thirteen groups were observed with 100 or more individuals (10.1% of the total number of sightings). Calves were observed in 65.4% of all groups throughout the study and many of them were newborns (body size less than 2 m, dorsal fin still bent, very marked fetal folds, and very chaotic and clumsy swimming). Although calves were observed in all months from April to September, newborns were only observed in June and July.

Site fidelity

During the preliminary analysis of photo-identification for the first four years of research, 129 individuals with distinctive marks were found. Three individuals of the same group (classified respectively 117, 119 and 121) were observed repeatedly from June to September 1993 in different places of the research region. Twenty individuals were resighted in two consecutive years, four in three years and two in four years.

Observations of reproductive behavior

Certain behavior patterns appear as an important complement in supporting the importance

of the research region as a reproduction site for the species in the Mediterranean. Copulation gatherings were observed on four occasions (July 1992, September 1993, August 1994 and July 1997). Behavior during these sightings differed greatly from the usual resting, travelling slow and slow-motion social and sexual behaviors commonly observed in other sightings. Groups of 200 to 350 individuals were nearly stationary and showed signs of excitement, with zigzagging accelerations, chases, violent head butting and biting. Subgroups distant from each other by less than one hundred meters would compact in circular formations in which a violent turmoil of bodies and splashes impeded any further behavioral analysis from the surface. Underwater direct observation and video footage obtained from inside one of these turmoils showed mating, biting and other body contacts carried out by a large male spinning in vertical position in the middle of the circle.

COMPARATIVE ANALYSIS AND DISCUSSION

Research effort on this species and other cetaceans in the Mediterranean Sea has been very heterogeneous both spatially and temporally in the past. Furthermore, very few of the results obtained either from dedicated surveys or opportunistic reports have been published in refereed scientific journals. The comparisons made here, refer mainly to results from studies carried out in the Liguro – Provençal basin, where cetacean research has been more intense over the last few decades.

Encounter rate and relative abundance.

The encounter rate obtained for this area (1.042) is much higher than those obtained for other parts of the Mediterranean, which ranged from 0.0 to 0.177 (see Table 4). The percentage of sightings of long-finned pilot whales in the Alboran Sea in comparison to other cetaceans is much higher than in other parts of the Mediterranean basin (see Table 5). McBrearty *et al* (1986) gathered information on sightings in the eastern North Atlantic and the

Mediterranean Sea from individual observers and vessels from 1978 to 1982. At the end of their survey, they had a total of 848 reports of sightings in the whole Mediterranean Sea, which was divided into seven geographic areas. Ninety-four of the 114 sightings of long-finned pilot whales (83%) were reported in the area corresponding to the Alboran Sea, and only 20 (17%) in the rest of the Mediterranean Sea. In contrast with this, only 25 sightings are reported by McBrearty *et al* on the Atlantic side of the Gibraltar Strait, and none of the Atlantic areas showed as high a number of sightings of long-finned pilot whales as the Alboran Sea. This report is based upon opportunistic sightings, which can not be confirmed, and no references are given on the effort made on each of the areas. Therefore, even if their results coincide with ours and being the only large scale survey on distribution of long-finned pilot whales in the Mediterranean and NE Atlantic, we can not consider it as an irrefutable source of comparison due to the origin of the data, being mainly obtained from untrained opportunistic observers.

Distribution with depth

The distribution of pilot whale groups by depth agrees with reports of pilot favoring pelagic cephalopods found between 500 and 1500 m depth (Evans 1987, Gannier 1995, Relini and Garibaldi 1992, Desportes and Mouritsen 1993, Guerra 1992). Although it has not yet been possible to relate them directly with pilot whale feeding, half-eaten cephalopods of several species (mainly *Todarodes sagittatus*) as well as four sightings of cephalopod spawning were also observed in the vicinity of pilot whale groups or in areas where they were often observed.

Group size

The group size most commonly observed (between 6-20 individuals) could correspond to single pods as described by Heimlich-Boran (1993) for short-finned pilot whales, using the terminology from killer whale social groupings (Bigg *et al.* 1990): "the largest cohesive group of individuals within a community that travelled together for the majority of time." At the same

time, observations of compact and dispersed groups may indicate that compact groups are usually single pods, while dispersed groups normally comprise several pods.

Counting individuals in a group of cetaceans is a difficult task. Therefore, comparing group sizes between different authors can be difficult. Even within this study, with a pre-established definition for groups, subgroups and pods (see methods), there is probably a considerable underestimation of group size resulting from counting individuals on the surface. Underwater filming of these groups demonstrated how a few fins on the surface can actually be hiding a much larger group underwater. On the other hand, tracking of pilot whale groups in this research region has shown important daily changes in group structure, with mergings and segregations occurring continuously. Change in group structure can be used by pilot whales to serve different purposes. In other social animals fission of groups has been described as a strategy for increasing foraging efficiency when food becomes scarce (Poole 1985). On the other-hand, fusion of groups has been observed as a response to concentration of an abundant food supply or as a protective strategy against possible dangers such as predators (Poole 1985). Nevertheless a superficial comparison of group sizes encountered here and in other regions of the Mediterranean does reflect a noticeable difference, with average group sizes in the Alboran Sea being much larger than elsewhere. Sightings of large groups of more than a hundred individuals are rare in regions such as the Liguro-Provençal basin, despite intense research effort (Notarbartolo di Sciara 1993, Gannier 1995). In comparison with other areas of the Northeastern Atlantic ocean, group sizes in the Alboran Sea were found also by McBrearty *et al* (1986) to be considerably larger with average group sizes showing a seasonal variation of 9.5 individuals from October to May and 23.4 from June to September (McBrearty *et al* 1986); this agrees with the results obtained here. A possible reason for the increase in group size during the summer months in the Alboran Sea, and the behavioral events described above, could be that this region is an important area for the reproduction in this species. As

demonstrated by molecular evidence, mating appears to occur reciprocally between pods and never inside the pod (Amos *et al.* 1993). Therefore, pods could aggregate during the summer months in order to increase opportunities for mating. Only one similar record of mating has been made in the Ligurian Sea in late September 1975 (Vallon *et al.* 1977), in a region where cetacean research has been intense for many years.

Behavior

Studies on pilot whales harvested in Japan and the Faroe Islands, have shown the gregarious nature of these animals. Their social structure is very complex and kin bonds extremely strong (Amos *et al.* 1993, Andersen 1993). Although sexual activity is common within matrilineal structured groups, mating with reproductive purpose requires males to copulate with females of other groups in order to avoid inbreeding (Amos *et al.* 1993, Heimlich-Boran 1993). Maternal bonds are extremely strong, with mothers, often assisted by other females in the group, nursing their calves over a long period of time (Martin and Rothery 1993). Field research on free ranging short-finned pilot whales in the Canary Islands supports biological findings of studies on harvested animals. Here males exhibited high levels of association with reproductive females from other groups in contrast with a low association with reproductive females within their group (Heimlich-Boran 1993). Mating therefore seems to occur between separate social groups, probably when different pods meet during the period of conception.

The high productivity of the research region, resulting from the combination of the inflowing Atlantic oceanographic mass and local physiography, offer what could be considered ideal conditions for cephalopod-eating odontocetes such as the long-finned pilot whale. However, the repeated observations of reproductive sexual activity with mixing of males during gatherings of very large groups suggests that reproduction may be an important factor in the importance of the region to this species.

ACKNOWLEDGMENTS

The authors would like to thank the more than 500 volunteers who have contributed with look-out watches on board the *Toftevaag* and with financial support of the research. We are also especially grateful to IFAW's supply of the LOGGER program and the bio-acoustic equipment. We would also like to thank Dr. A. Morales, Dr. J. Boran, Dr. M. Rosen and K. Young for their valuable comments and advice on this paper.

LITERATURE CITED

- Amos, B., Bloch, D., Desportes, G., Majerus, T., Bancroft, D., Barret, J.A. and Dover, G.A. 1993. A review of molecular evidence relating to social organisation and breeding system in the long-finned pilot whale. Report of the International Whaling Commission. (Special Issue 14):209-217
- Andersen, L.W. 1993. Further studies on the population structure of the long-finned pilot whale, *Globicephala melas*, off the Faroe Islands. Report of the International Whaling Commission (Special Issue 14):219-231
- Angelici, F. M. and Marini, L. 1992. Sightings of *Delphinus delphis* (Cetacea, Odontoceti) in the Otranto Channel (Southern Adriatic sea and Northern Ionian Sea). *Hystrix* (n.s.) 4, (1):91-93
- Barberis, S., Bonaccorsi, R., Chiarlone, F., Chiesa, O., Davico, A., Davico, L., Massajoli, M. and Trucchi, R. 1995. A preliminary study presenting data collected during a WWF research campaign in the Ligurian Sea (summer 1994). Pages 107-109 in *European Research on Cetaceans - 9. Proceedings of the 9th Annual Conference of the European Cetacean Society*. Lugano, Switzerland, 9-11 February, 1995 (Ed. P.G.H. Evans) European Cetacean Society.
- Beaubrun, P., David, L., Di-Méglio, N., Gannier, A. and Gannier, O. 1997. First Aerial Survey in the North-west Mediterranean: preliminary results. Pages 100-103 in *European Research on Cetaceans - 11. Proceedings of the XIth Annual Conference of the European Cetacean Society*. Stralsund, Germany, 10-12 March, 1997. (Ed. P.G.H. Evans, E.C.M. Parsons and C.L. Clark) European Cetacean Society.
- Bigg, M.A., Olesiuk, P.F., Ellis, G.M., Ford, J.K.B. and Balcomb, K.C. 1990. Social organization and genealogy of resident killer whales (*Orcinus orca*) in the coastal waters of British Columbia and Washington State. Report of the International Whaling

- Commission. (Special Issue 12):383-405.
- Bloch, D., Lockyer, C. and Zachariassen, M. 1993. Age and growth parameters of the long-finned pilot whale off the Faroe Islands. Report of the International Whaling Commission (Special Issue 14):163-207
- Carpentieri, P., Marini, L. and Consiglio, C. 1994. A cetacean survey in the Aegean Sea: work in progress. Pages 108-110 *in* European Research on Cetaceans-8. Proceedings of the VIII Annual Conference of the European Cetacean Society. Montpellier, France, 2-5 March: 108-110. (Ed. P.G.H. Evans) European Cetacean Society
- Casinos, A., and Vericad, J.R. 1976. The cetaceans of the Spanish coasts: a survey. *Mammalia*, 40 (2):267-289.
- Cerioni, S., Forni, L., Lo Tenero, A., Nannarelli, S. and Pulcini, M. 1995. A cetacean survey in Taranto Gulf: work in progress. Pages 102-103 *in* European Research on Cetaceans-9. Proceedings of the IX Annual Conference of the European Cetacean Society. Lugano, Switzerland, 9-11 February. (Ed. P.G.H. Evans). European Cetacean Society.
- Cheney, R.E. and Doblal, R.A. 1979. Alboran Sea 1977: Physical characteristics and atmospherically induced variations of the oceanic frontal system. Tactical Analysis Division. U.S. Naval Oceanographic Office. Technical Note 3700-82-79, 24 pp.
- Consiglio, C., Marini, L., Angradi, A. and Sanna, A. 1990. A medium-term sighting scheme on cetaceans in the central Tyrrhenian sea: work in progress. Pages 44-45 *in* European Research on Cetaceans-4. Proceedings of the IV Annual Conference of the European Cetacean Society. Mallorca, Spain, 2-4 March. (Ed. P.G.H. Evans). European Cetacean Society.
- Cortés, M.D., Gil, J. and García, A. 1985. General distribution of chlorophyll, temperature and salinity in the northwestern sector of the Alborán Sea (August, 1982). *Rapport de la Commission Internationale sur la Mer Méditerranée* 29 (9). 7 pp.

- Desportes, G., and Mouritsen, R. 1993. Preliminary results on the diet of long-finned pilot whales off the Faroe Islands. Report of the International Whaling Commission (Special Issue 14):305-324
- Di Natale, A. 1983. New information about the pilot whale, *Globicephala melaena* Traill, in the Central Mediterranean Sea. XVIII. Congress and Plenary Assembly of the Commission Internationale pour l'Exploration Scientifique de la Méditerranée, Cannes, December 2-11
- Duguay, R. 1989. Les mammifères marins de la Méditerranée occidentale. Bulletin de la Société Zoologique de France 114 (3):89-95.
- Evans, P.G.H. 1987. The natural history of whales and dolphins. Fact-on-file, London.
- Fabbri, F., and Lauriano, G. 1992. Greenpeace report on two years of research in the Ligurian sea. Pages 69-74 in European Research on Cetaceans - 6. Proceedings of the VI, Annual Conference of the European Cetacean Society. San Remo, Italy, 20-22 February, 1987. (Ed. P.G.H. Evans) European Cetacean Society.
- Fernández-Casado, M., Stephanis, R., Ploner, R. and Vargas, F. (in press). Aproximación al estudio de las poblaciones de las distintas especies de cetáceos en el Estrecho de Gibraltar: Resultados preliminares. Actas de las IV Jornadas de Flora, Fauna y Ecología del Campo de Gibraltar. Tarifa, Spain, 15-17 October 1999. Instituto de Estudios Campogibraltares.
- Franco, I., and Más, J. 1994. Distribution and evaluation of cetaceans in the Alboran Sea. Page 103 in European Research on Cetaceans - 8. Proceedings of the VIII, Annual Conference of the European Cetacean Society. Montpellier, France, 2-5 March, 1994. (Ed. P.G.H. Evans) European Cetacean Society.
- Gannier, A. 1995. Résultats des campagnes et Exploitation. Thesis: Les cétacés de Méditerranée nord-occidentale: estimation de leur abondance et mise en relation de la

- variation saisonnière de leur distribution avec l'écologie du milieu. Montpellier, 1995. 438 pp.
- Gannier, A., Beaubrun, P. and Di-Meglio, N. 1994. Cetacean occurrence in the Gulf of Lion and surroundings. Pages 87-91 *in* European Research on Cetaceans - 8. Proceedings of the VIII Annual Conference of the European Cetacean Society. Montpellier, France, 2-5 March, 1994. (Ed. P.G.H. Evans). European Cetacean Society.
- Gascard, J.C., and Richez, C. 1985. Water masses and circulation in the western Alboran Sea and in the Straits of Gibraltar. *Progress Oceanography* 15:157-216
- Gil, J. 1985. La influencia del viento en las capas superficiales y su relación con los movimientos convectivos subsuperficiales. Informe Técnico del Instituto Español de Oceanografía 36. 10pp
- Giordano, A., and Tringali, M. 1992. Presence and individual recognition of long-finned pilot whale, *Globicephala melas*, in the Liguro-Provençal basin. Pages 103-104 *in* European Research on Cetaceans-6. Proceedings of the VI, Annual Conference of the European Cetacean Society. San Remo, Italy , 20-22 February. (Ed. P.G.H. Evans). European Cetacean Society.
- Guerra, A. 1992. Mollusca. Cephalopoda. Fauna Iberica. CSIC. Vol. 1.
- Grau, E., Aguilar, A. and Filella, S., 1980. Cetaceans stranded, captured or sighted in the Spanish coasts during 1976-1979. *Bulletin del Instituto Catalan de Historia Natural* 45 (Sección Zoología, 3):167-179.
- Heimlich-Boran, J.R. 1993. Social organisation of the short-finned pilot whale, *Globicephala macrorhyncus*, with special reference to the comparative social ecology of delphinids. PH.D. Thesis, Cambridge University. 198 pp.
- Lauriano, G., and Notarbartolo di Sciara, G. 1995. The distribution of cetaceans off northwestern Sardinia. Pages 104-106 *in* European Research on Cetaceans-9.

- Proceedings of the IX, Annual Conference of the European Cetacean Society. Lugano, Switzerland, 9-11 February. (Ed. P.G.H. Evans). European Cetacean Society.
- La Violette, P. E. 1986. Short-term measurements of surface currents associated with the Alborán Sea Gyre during Donde Va? *Journal of Physical Oceanography* 16:262-279.
- Marchessaux, D. 1980. A review of the current knowledge of the cetaceans in the Eastern Mediterranean Sea. *Vie Marine* 2:59-66.
- Marini, L., Consiglio, C., Angradi, A. M. and Sanna, A. 1991. Preliminary results of the first year of a sightings survey of cetaceans in the Central Tyrrhenian Sea. Pages 22-25 *in* European Research on Cetaceans-5. Proceedings of the V. Annual Conference of the European Cetacean Society. Sandefjord, Norway, 21-23 February. (Ed. P.G.H. Evans). European Cetacean Society.
- Marini, L. Consiglio, C., Maria, A. Sanna, A. and Valentini, T. 1992. Cetacean sighting campaign in the Central Tyrrhenian sea: Results of the Second year of activity. Pages 66-68 *in* European Research on Cetaceans - 6. Proceedings of the VI. Annual Conference of the European Cetacean Society. San Remo, Italy, 20-22 February, 1992. (Ed. P.G.H. Evans). European Cetacean Society.
- Marini, L. Consiglio, C., Catalano, B. and Valentini, T. 1993. Cetaceans in the Central Tyrrhenian sea: third (and last?) year of sightings. Preliminary results. Pages 148-150 *in* European Research on Cetaceans-7. Proceedings of the VII. Annual Conference of the European Cetacean Society. Inverness, Scotland, 18-21 February. (Ed. P.G.H. Evans). European Cetacean Society.
- Martin, A., and Rothery, P. 1993. Reproductive parameters of female long-finned pilot whales (*Globicephala melas*) around the Faroe Islands. Report of the International Whaling Commission (Special Issue 14):263-304
- McBrearty, D. A., Message, M. A. and King, G. A. 1986. Observations on small cetaceans in the

- north-east Atlantic Ocean and the Mediterranean Sea: 1978-1982. Pages 225-249 *in* M.M. Bryden and R. Harrison, eds. *Research on dolphins*. Oxford Science Publications, Oxford, UK.
- Millot, C. 1987. Circulation in the Western Mediterranean Sea. *Oceanologica Acta* 10,2: 143-149.
- Notarbartolo di Sciara, G., Venturino, M. C., Zanardelli, M., Bearzi, G., Borsani, J. F. and Cavalloni, B. 1993. Cetaceans in the central Mediterranean Sea: Distribution and sighting frequencies. *Bolletín Zoologica* 60:131-138.
- Parrilla, G., and Kinder, T.H. 1987. Oceanografía física del mar de Alborán. *Boletín del Instituto Español de Oceanografía* 4(1):133-165.
- Politi, E., Airoidi, S. and Notarbartolo di Sciara, G. 1994. A preliminary study of the ecology of cetaceans in the waters adjacent to Greek Ionian Islands. Pages 111-115 *in* *European Research on Cetaceans - 8. Proceedings of the VIII. Annual Conference of the European Cetacean Society*. Montpellier, France, 2-5 March, 1994. (Ed. P.G.H. Evans) European Cetacean Society.
- Politi, E., Bearzi, M., Notarbartolo di Sciara, G., Cussino, E. and Gnone, G. 1992. Distribution and frequency of cetaceans in the waters adjacent to the Greek Ionian waters. Pages 75-78 *in* *European Research on Cetaceans-6. Proceedings of the VI. Annual Conference of the European Cetacean Society*. San Remo, Italy, 20-22 February, 1987. (Ed. P.G.H. Evans) European Cetacean Society.
- Pulcini, M., Angradi, A. M. and Sanna, A. 1993. Distribution and frequency of cetaceans in the Ligurian-Provençal basin and in the North Tyrrhenian Sea (Mediterranean Sea). Pages 144-147 *in* *European Research on Cetaceans - 7. Proceedings of the VII Annual Conference of the European Cetacean Society*. Inverness, Scotland, 18-21 February, 1993. (Ed. P.G.H. Evans). European Cetacean Society.
- Poole, T. 1985. *Social behaviour in mammals*. Blackie & Son Ltd. Glasgow and London.

- Raga, J. A., Raduán, M. A. and Blanco, C. 1985. Contribución al estudio de la distribución de cetáceos en el Mediterráneo y Atlántico ibérico. *Miscelanea Zoologica* 9:361-366.
- Relini, L. O., and Garibaldi, F. 1992. Feeding of the pilot whale, *Globicephala melas*, in the Ligurian sea. A preliminary note. Pages 142-145 in *European Research on Cetaceans - 6. Proceedings of the VI. Annual Conference of the European Cetacean Society*. San Remo, Italy, 20-22 February, 1992. (Ed. P.G.H. Evans). European Cetacean Society.
- Rey, J. C., and Cendero, O. 1979. Les cetacés vus en mer et échoués sur les cotes espagnoles en 1977 et 1978. *Conseil International pour l'Exploitation de la Mer*. C.M 1979/N: 2:1-2
- Rodriguez, J. 1982. *Oceanografía del mar Mediterráneo*. Ed. Pirámide, Madrid, Spain.
- Rubín, J. P., Gil, J., Ruiz, J., Cortés, M. D., Jiménez-Gómez, F., Parada, M. and Rodriguez, J. 1992. La distribución ictioplanctónica y su relación con parámetros físicos, químicos y biológicos en el sector norte del Mar de Alboran, en julio de 1991 (Resultados de la Campaña "Ictio.Alboran 0791"). Instituto Español de Oceanografía. Informe Técnico N. 139, Madrid.49pp.
- Sagarminaga, R., and Cañadas, A. 1998. A comparative study on the distribution and behaviour of the common dolphin (*Delphinus delphis*) and the striped dolphin (*Stenella coeruleoalba*) along the south-eastern coast of Spain. Pages 175-181 in *European Research on Cetaceans - 12. Proceedings of the XII. Annual Conference of the European Cetacean Society*. Monaco, 20-24 January, 1998: 175-181. (Eds. P. G. H. Evans & E. C. M. Parsons). European Cetacean Society. Cambridge, England. 436pp.
- Vallon, D., Guigo, C. and Duguay, R. 1977. Le Globicéphale noir, *Globicephala melaena* (Traill, 1809) en Méditerranée occidentale. *Rapport de la Commission Internationale sur la Mer Méditerranée* 24 (5):25-26
- Würsig, B., and Jefferson, T. A. 1990. Methods of photo-identification for small cetaceans. *Report of the International Whaling Commission*. (Special Issue 12): 43-52.

Table 1. Distribution of effort per depth range (all years pooled). First column includes effort with all sea states (1, 1S, 2 and 2S). Second column includes only effort with sea state 1 Douglas (see text). % = percentage of total effort.

Depth range (meters)	All sea states			Sea state 1		
	nmi	km	%	nmi	km	%
0-200	3920	7260	36%	1220	2259	28%
200-500	2075	3843	20%	806	1493	19%
500-1000	2510	4649	23%	1158	2145	27%
1000-1500	1631	3021	15%	742	1374	17%
> 1500	629	1165	6%	352	652	8%

Table 2. Encounter rates of long-finned pilot whales per month (all years pooled). First column includes sightings during effort under all sea states (1, 1S, 2 and 2S). Second column includes only sightings during effort under sea state 1 Douglas (see text).

Month	All sea states	Sea state 1
April	0.517	1.170
June	0.981	2.327
July	1.421	2.510
August	1.120	2.350
September	0.718	1.040

Table 3. Encounter rates of long-finned pilot whales per depth range (all years pooled). First column includes sightings during effort under all sea states (1, 1S, 2 and 2S). Second column includes only sightings during effort under sea state 1 Douglas (see text).

Depth range (m)	All sea states	Sea state 1
0-200	0	0
200-500	0.567	0.992
500-1000	2.568	4.058
1000-1500	1.872	2.559
1500-2000	0.859	1.142

Table 4. Encounter rates obtained in Mediterranean Sea for long-finned pilot whales. Effort in nautical miles and encounter rates are number of groups sighted per 100 nautical miles searched. ER = encounter rate, CM = Central Mediterranean, NW = Northwestern Mediterranean, SW = Southwestern Mediterranean

Area	Date	Sight.	Effort (nmi)	Effort (km)	ER (nmi)	ER (km)	Source
Ionian Sea-CM	1991-93	0	4114	7619	0.000	0.000	Politi <i>et al.</i> , 94
Gulf of Lion-NW	1993	0	245	454	0.000	0.000	Gannier <i>et al.</i> , 94
Ligurian Sea-NW	1990-91	0	2828	5238	0.000	0.000	Fabbri and Lauriano, 92
Ligurian Sea-NW	1992	0	1300	2408	0.000	0.000	Pulcini <i>et al.</i> , 93
Ligurian Sea-NW	1994	0	1017	1884	0.000	0.000	Barberis <i>et al.</i> , 95
NW	1996	1	1540	2852	0.065	0.035	Beaubrun <i>et al.</i> , 97
NW	1988-94	16	9065	16788	0.177	0.095	Gannier, 95
NW and CM	1986-89	4	11434	21176	0.035	0.019	Notarbartolo di Sciara <i>et al.</i> , 93
Alboran Sea-SW	1992-96	106	10173	18840	1.042	0.563	ALNITAK (<i>this paper</i>)

Table 5. Proportion of sightings of long-finned pilot whales (Gm) in Mediterranean with respect to sightings of other species. Total = bottlenose, common, striped and Risso's dolphins; fin whales, sperm whales and Cuvier's beaked whales.

Area	Date	Sightings			Source
		Gm	Total	%	
Eastern Mediterranean	1993	0	+52	0	4, 6
Central Mediterranean	1978-1992	11	1211	0.9	1, 3, 5, 7, 8, 9, 10, 11, 12
Central + NW Med.	1986-1989	4	246	2.0	28
NW Mediterranean	1970-1996	29	1484	2.0	1, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23
North Africa (individuals)	1974-1993	12	337	3.6	2
S Balearic I. (SW Med.)	1978-1982	8	101	7.9	1
<i>Alboran Sea (SW Med.)</i>	<i>1970-1997</i>	<i>218</i>	<i>1190</i>	<i>18.3</i>	<i>1, 16, 23, 24, 25, 26, 27</i>

Sources: 1= McBrearty *et al.* 1986, 2= Franco and Mas 1994, 3= Angelici & Marini 1992, 4= Carpentieri *et al.* 1994, 5= Cerioni *et al.* 1995, 6= Marchessaux 1980, 7= Politi *et al.* 1992, 8= Politi *et al.* 1994, 9= Consiglio *et al.* 1990, 10= Marini *et al.* 1991, 11= Marini *et al.* 1992, 12= Marini *et al.* 1993, 13= ALNITAK (unpublished data), 14= Barberis *et al.* 1995, 15= Beaubrun *et al.* 1997, 16=Casinos and Vericad 1976, 17= Fabbri and Lauriano 1992, 18= Gannier *et al.* 1994, 19= Gannier 1995, 20= Grau *et al.* 1980, 21= Lauriano and Notarbartolo di Sciara 1995, 22= Pulcini *et al.* 1993, 23= Raga *et al.* 1985, 24= Rey and Cendero 1979, 25= Aguilar *et al.* 1984, 26= Casinos and Vericad 1976, 27= ALNITAK, 28= Notarbartolo di Sciara *et al.* 1993.

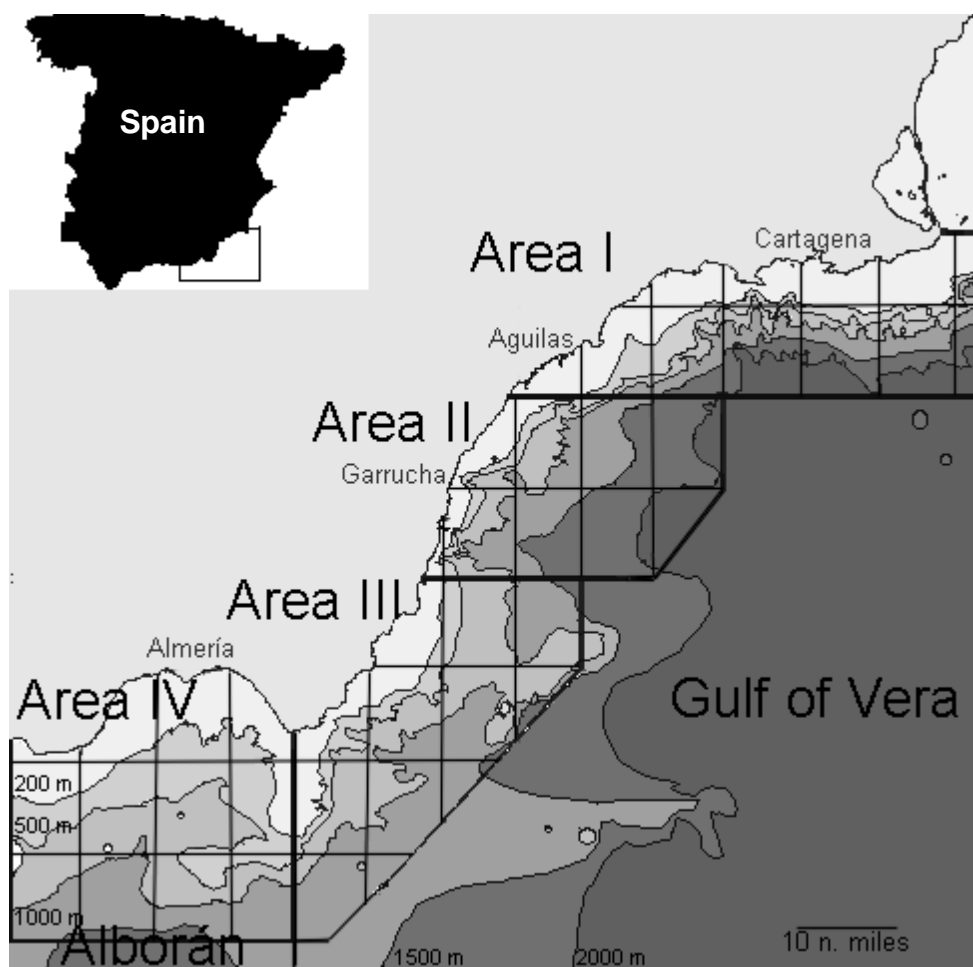


Figure 1. Research area

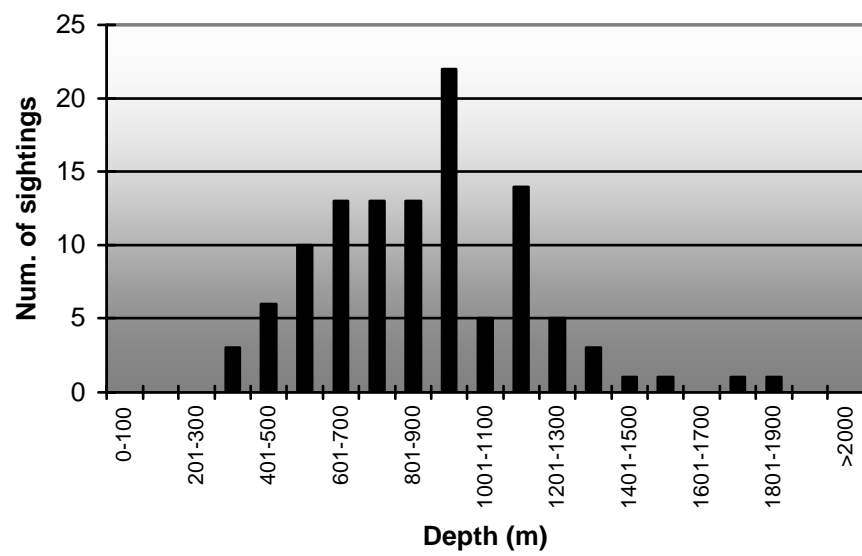


Figure 2. Frequency of depth at encounters (represented by number of sightings).

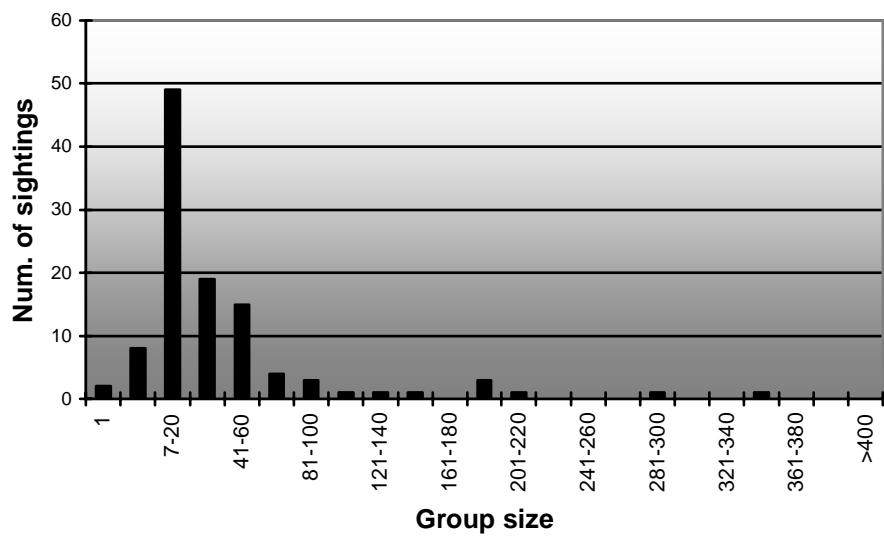


Figure 3. Frequency of group size of long-finned pilot whale groups encountered (represented by the number of sightings).