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Cetacean diversity at the west coast of La Palma Island (Canary Islands)

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*Little is known about cetacean communities around La Palma Island. Therefore, and in order to determine the presence and distribution of the cetacean species on its west coast, daily censuses were carried out from November 2003 to April 2005. The platform used was a whale watching vessel certified by the Canary Government. Data collected included time, position, species identity, group size and, in some cases, the presence of calves and/or any other outstanding parameter. During the study period, 570 sightings were made, with a mean sighting success of 1.7 sightings per day, showing a high cetacean presence in the area. Thirteen species and one genus (*Globicephala *spp.) were positively matched, three of them included in the Mysticeti suborder and the other ten in the Odontoceti one. The four most sighted species, in decreasing order, correspond to* Tursiops truncatus*,* Steno bredanensis*,* Globicephala *spp. and* Stenella frontalis*. Diversity of sighted species shows a moderate peak during spring time, which is in agreement with the presence of occasional species. Most sightings were located off the central west coast of the island, exceeding 1.5 nautical miles. This is particularly outstanding in relation to Franja Marina de Fuencaliente SCI, where 90% of all sightings were located outside its boundaries. High cetacean presence and diversity off the west coast of La Palma Island seem to be connected with oceanographic and ecological features. Results gained provide, for this region, baseline data on cetacean populations and a useful tool in conservation plans.*

Keywords: cetacean diversity, cetacean distribution, Canary Islands, La Palma

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INTRODUCTION

Cetacean diversity has always been the starting point for investigation on cetacean populations and also, an interesting field for scientists in every ocean (Thiele & Gill, 1999; MacLeod *et al.*, 2004). In the case of the North Atlantic, important investigation efforts on cetacean occurrence have been carried out. Examples of this effort can be found in communications on cetacean distribution in island waters, as in the case of the Azores (Silva *et al.*, 2003), or on cetacean abundance in continental coasts, as in the case of the Mediterranean Sea (Gómez de Segura *et al.*, 2006) or the United States shores (Mullin & Fulling, 2003). These studies have contributed to the progress of the world's research on cetaceans.

Particularly, in the case of the Atlantic Islands, 62 species of cetaceans—out of a total of 84—are found (Hoyt, 2005b). Focusing on the Canarian Archipelago, information about cetacean presence has been compiled through the years, coming both from stranding and sightings (Carrillo, 2003). The Canary Islands are known to receive, at least, 29 cetacean species from resident and migratory groups (M. Carrillo, personal communication, 2007). In an island by island approach, cetacean information from less inhabited islands, as is the case of La Palma, is practically non-existent being limited to stranding information (Canary net of Stranded Cetaceans) and a couple of specific four-days campaigns (Carrillo & Tejedor, 2004).

High cetacean diversity, in islands such as the Canaries, where the tourism industry is the predominant economic source, generates an important whale watching activity. In fact, whale watching in the Canary Archipelago pulls in about 500,000 people every year (Hoyt, 2001, 2005b) and generates more than $6,200,000 (including arrival, lodging, transportation and some other expenses related to whale watching). This places the archipelago in the lead of the activity among the Atlantic islands (Hoyt, 2005a).

Due to the importance and constant increase of this socio-economic activity, the Canary Government issued a regional Decree (D178/2000, BOC 133, of 1.10.2000) regulating whale watching activities (Plasencia *et al.*, 2001). The principal aim of this regulation is to protect cetaceans. Among other duties, operators are required to obtain a whale watching license, and to carry onboard a 'Sectorial Tourism Guide' to whale watching methods certified by the Canary Tourism Authority.

Although this and other measures have helped a lot in the protection of and knowledge about cetaceans in the Canaries, there is still a lot to be done in this field. In this context, the present paper describes, from sighting data obtained during eighteen months, the occurrence and diversity of the cetacean community on the west coast of La Palma Island. This may provide the first step in developing a species list for La Palma Island and an estimation of their status and seasonal variation (Evans & Hammond, 2004). The paper also describes a possible link between high cetacean diversity and environmental characteristics. The prediction of possible

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environmental variables connected to cetacean presence, could be very useful in future investigations on cetaceans, such as those of spatial modelling methods.

Survey area

The Canary Archipelago lies about 115 kilometres off the West African mainland, in the Atlantic Ocean (Figure 1). It is composed of seven islands and four islets with a total surface of 7273 km^2. All of them are independent volcanic edifices with a subsequent narrow shelf (Anguita & Hernán, 2000). This circumstance makes possible the reaching of very deep waters (2000–4000 m) quite close to the coast, which determines some of the oceanographic conditions of the area.

The study area of the present work covers the waters next to the west waters of La Palma, one of the western Canary Islands. In oceanographic terms, this subtropical zone is included in the eastern limb of the subtropical gyre of the North Atlantic (Canary Current). These waters are considered as a transition zone between the cool, nutrient-rich waters of the upwelling regime from the African coast and the warmer oligotrophic waters of the open ocean (Barton *et al.*, 1998). Surface water temperature varies from 25°C, in September and October, to 17°C, in winter (Calvet *et al.*, 2003). In addition, the Canary Islands act as a natural barrier to the main Canary Current, which seems to induce cyclonic and anticyclonic eddies downstream of the islands (Arístegui *et al.*, 1994).

Regarding biological features, the area enjoys an outstanding natural status. A portion of the study area was accepted by the EU to be included in the Natura 2000 Network (D92/43/EEC) as a Site of Community Importance (SCI). The Franja Marina de Fuencaliente SCI was so declared, among other ecological reasons, because of the *Tursiops truncatus* Montagu, 1821 presence (Figure 2). The prosperous zone also includes La Palma Marine Reserve of Fishing Interest, so declared by the Spanish Government in 2001 (Figure 2). These environmental protection areas help to protect and increase the ecological and biological richness of the study area.

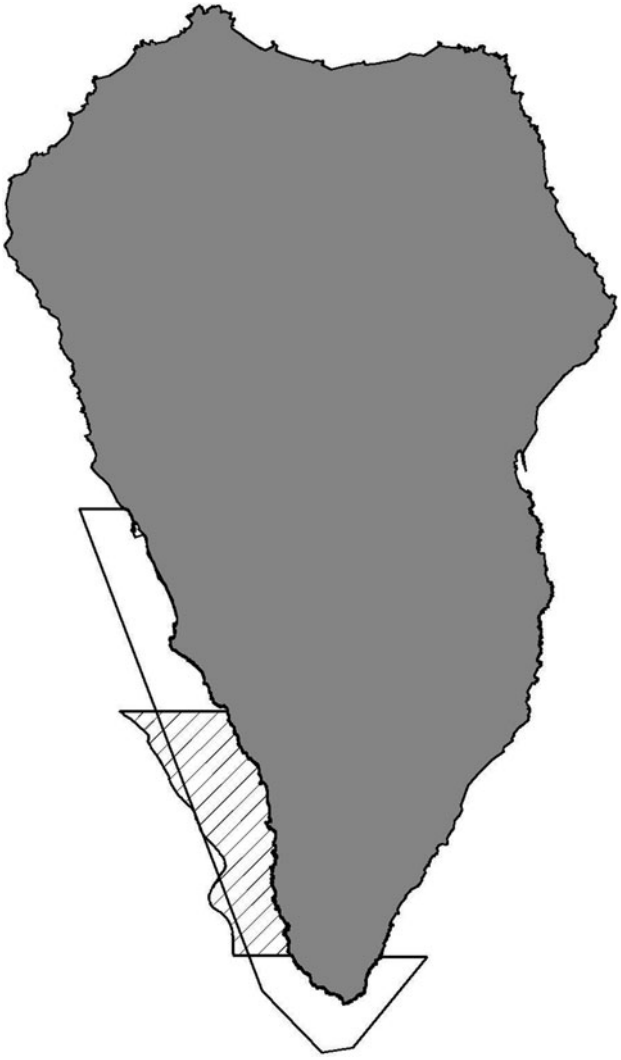

Fig. 2. Franja Marina de Fuencaliente SCI (plain shape) and La Palma Marine Reserve of Fishing Interest (striped shape).

MATERIALS AND METHODS

Fieldwork

Cetacean sighting data were collected during 346 days, from November 2003 to April 2005. The platform was the 'Fancy II', a whale watching motorboat which carries out regular whale watching trips, along the west coast of La Palma Island. The company is provided with the appropriate license ('Blue boat') and a Sectorial Tourism Guide, both requirements demanded by the Canary Decree for whale watching activities (Decree 178/2000). Sectorial Tourism Guides, in whale watching methods, are qualified naturalist guides and experienced observers trained to scan the area searching for cetaceans with 7×50 binoculars. Standing on the ship's flying bridge—approximately 6 m high—during daylight hours, weather permitting (i.e. no rain, Beaufort sea state <5), they search for any cetacean signs.

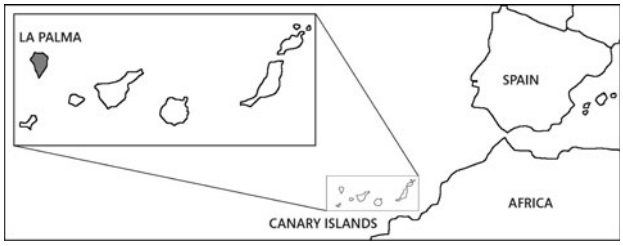

Fig. 1. Location of the Canary Archipelago and La Palma Island.

Every working day, the 'Fancy II' begins its crossing in Tazacorte Port, located in the middle of La Palma west coast. It follows random perpendicular transepts to the shore line, depending on the route and weather situation. In spite of the search pattern not being systematic, it followed mainly regular zigzag transepts. The average speed was 8 knots, but it could vary with sea conditions.

Observations were carried out for continuous periods during daylight hours. Whenever a sighting was detected, the transept was interrupted and the vessel was conducted to the sighting point. Approaching and observation always followed the Code of Conduct established by the Canary

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Government, in the whale watching zone. Sightings data were systematically recorded on pre-prepared data sheets and entered subsequently into a computer database. Data collected for each cetacean group included time, position (by Global Positioning System), species identity, group size, and in some cases, the presence of calves, depth (obtained from the boat's sound), coastal distance or any other parameter collected.

Species were identified to the lowest taxonomic level possible from descriptions in field guides and scientific literature (Carwardine, 1995). Almost every sighting was positively matched to the species taxonomic level, but in the particular case of pilot whales, just genus level was reached. The study area is potentially inhabited by short-finned pilot whales (*Globicephala macrorhynchus* Gray, 1864) (Carrillo & Tejedor, 2004), while long-finned pilot whales (*Globicephala melas* Trail, 1809) have only been identified once in the Canaries by one strand (M. Carrillo, personal communication, 1995). Nevertheless, since the two species cannot be distinguished at sea with certainty, they have all been pooled together just as pilot whales (*Globicephala* genus).

Analysis

Once the information was collected, sightings data were processed in order to characterize the cetacean community identified in La Palma waters. To obtain the species temporal distribution, sightings frequency was estimated by a direct count of the number of sightings. Then this number was analysed monthly, calculating the sighting per effort unit (SPEU) referred to the number of sightings per day:

$$\text{SPEU} = \frac{\text{number of sightings}}{\text{day}}$$

Because trips are similar every day (usually each trip lasts three hours), working days can be used as an effort measure to compare, in general terms, the population tendency in aspects such as temporal distribution or annual presence.

From the most common species, further estimations were carried out. Spatial distribution, group size and composition were analysed. Sightings of the four most frequent species have been located on an island map using the Autodesk Map 2006 software. Whenever data were available, mean depth and coastal distance of those species were analysed. Due to the mobility and swimming speed, the group's size is difficult to estimate. Consequently, we divided the number of individuals sighted in different ranges for every species, according to their usual association pattern (Table 1).

Table 1. Ranges established for group's size in most sighted cetacean species in La Palma Island.

Species	Ranges (number of individuals)					
Tursiops truncatus Montagu, 1821	0–20	21–40	41–60	61–80	81–100	>100
Stenella frontalis Cuvier, 1829	0–30	31–60	61–90	91–120	>120	
Steno bredanensis Lesson, 1828	0–10	11–20	21–30	>31		
Globicephala genus	0–10	11–20	21–30			

RESULTS

Sighted species

During this study, 570 sightings were made on the west coast of La Palma, with a mean sighting success of 1.7 sightings per day (minimum: 1.2; maximum: 2.0). Thirteen cetacean species and one genus (*Globicephala* spp.) were positively matched, three of them included in the Mysticeti suborder and the other ten in the Odontoceti suborder. Non-identified sightings were assigned to non-stated general groups, such as pilot whales, beaked whales or dolphins. These species together with the number of sightings effected during the 18 month period of study, its percentage from the total number of sightings, and the SPEU by species (referred to the number of sightings per worked day), are detailed in Table 2.

Odontoceti suborder species represent the largest amount of sightings (567 sightings; 99.4%) while Mysticeti suborder species, correspond to just 0.6% of all sightings, with an effort of 0.01 sightings per day. To date, *Tursiops truncatus* corresponds, by far, to the highest number of sightings known in La Palma (39.2%) followed by *Steno bredanensis*, with almost half the number of encounters. Next most sighted species were *Globicephala* spp. (13.0%) and *Stenella frontalis* (11.9%).

Temporal cetacean distribution

Regarding the temporal distribution, the number of sighted species does not seem to follow a seasonal pattern. However, an upward trend can be observed in springtime (6–8 species/month between March and June) and the reverse in winter time (3–4 species/month in December and January). This diversity maximum occurs during the period of time when sporadic and occasional species, such as Mysticeti ones, show up. Bryde's whale and fin whale were sighted in La Palma surroundings during April 2004, in accordance with the accepted migratory pattern. Notwithstanding, Sei whale was sighted in June 2004, contrary to its acknowledged temporal pattern in the Canary Islands.

Regarding most sighted species, *Tursiops truncatus* presence is constant throughout the year (SPEU = 0.646), with a higher value of sightings/effort in the summer months (mean sighting success: 1.03 SPEU from June to September). *Globicephala* genus individuals were seen following a constant pattern of presence throughout the year (SPEU = 0.214), except for two peaks, in January 2003 (0.46 sightings/day) and in December 2003–January 2004 (0.66 and 0.44 sightings/day, respectively). *Stenella frontalis* presence is constant and frequent throughout the whole year (SPEU = 0.197), being always observed from January to May.

Remaining species were sighted occasionally, except for the *Delphinus delphis* (Table 2). In this case, the sighting frequency followed a marked seasonal pattern, as reported in previous north-east Atlantic studies (López *et al.*, 2004). Common dolphin seems to frequent the area from January to May (98% of *Delphinus delphis* sightings; N = 41, where N is the number of samples studied). Just one sighting took place out of these months (October 2004) and it was one single individual.

Spatial cetacean distribution

Most of the sightings related to the present study were concentrated in an area located between Punta Gorda and Punta de la

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Table 2. Cetacean species encountered off La Palma.

Name	No. of sightings	%	SPEU
Mysticeti	**3**	**0.6**	**0.009**
Balaenoptera borealis Lesson, 1828 (Sei whale)	1	0.2	0.003
Balaenoptera edeni Anderson, 1879 (Bryde's whale)	1	0.2	0.003
Balaenoptera physalus Linnaeus, 1758 (fin whale)	1	0.2	0.003
Odontoceti	**567**	**99.4**	**1.638**
Tursiops truncatus Montagu, 1821 (bottlenose dolphin)	224	39.2	0.646
Steno bredanensis Lesson, 1828 (rough-toothed dolphin)	118	20.6	0.341
Stenella frontalis Cuvier, 1829 (Atlantic spotted dolphin)	68	11.9	0.197
Delphinus delphis Linnaeus, 1758 (common dolphin)	41	7.2	0.118
Physeter macrocephalus Linnaeus, 1758 (sperm whale)	10	1.8	0.029
Stenella coeruleoalba Meyen, 1833 (striped dolphin)	9	1.6	0.026
Mesoplodon densirostris Blainville, 1817 (dense beaked whale)	5	0.9	0.014
Grampus griseus Cuvier, 1812 (Risso's dolphin)	1	0.2	0.003
Ziphius cavirostris Cuvier, 1823 (Cuvier's beaked whale)	1	0.2	0.003
Pseudorca crassidens Owen, 1846 (false killer whale)	1	0.2	0.003
Globicephala spp. (pilot whales)	74	13.0	0.214
Beaked whales	12	2.1	0.035
Dolphins	3	0.5	0.009
Total	**570**	**100**	**1.647**

Bombilla, on the central western coast of the island (Figure 3). Moreover, in most cases (90% of all sightings), locations exceeded 1.5 nautical miles from the coast and 500 m depth.

Most sighted species also follow this distribution pattern, as shown above (Figure 3). Just in *Steno bredanensis* encounters, a high number of sightings were made closer to the coast (60% appeared between two miles and the coast) and, in consequence, lower depths (from 100 to 500 m depth). On the other hand, 78% from *Globicephala* genus encounters exceeded the 1000 m depth, being frequently found from four miles onwards. It is also worth highlighting that the deepest locations of *Tursiops truncatus* were reached in the company of pilot whales (*Globicephala* genus), exceeding in every case 1000 m depth.

Group size

Group size was studied for the four most often sighted species. In the case of *Tursiops truncatus*, the size of the sighted groups varied from 1 to 200 individuals, although most sightings were of groups formed by 21 to 40 specimens (47%; N = 165), followed by those of 1 to 20 (36%, N = 165). Group size seems to vary throughout the year, the smallest ones (0–20 animals) appearing in winter, increasing (21–40 animals) in spring and showing the biggest associations (41–60 animals, with 200 individuals peaks) in summer. Only on one occasion a solitary animal was detected. Regarding group structure, just twice were calves part of the sighted group.

As far as *Steno bredanensis* is concerned, more than half of the sightings (55%) were of groups from 11 to 20 specimens (N = 58). On at least four occasions, females with calves were observed frequenting the area.

In those *Globicephala* genus sightings when group size was measured, associations from 2 to 30 individuals were observed. When dividing data into ranges of ten individuals each, the most common number of specimens forming a group (67%, N = 49) was from 11 to 20. Curiously on nineteen occasions (38%, N = 49) herds of specifically 15 individuals were found, and at least on eight occasions calf presence was detected.

Likewise, in the case of *Stenella frontalis*, the most common range (66%, N = 53) is the one that goes from 0 to 30 individuals, followed by the one of 31–60 specimens (28%, N = 53). Ninety-four per cent of sightings correlate with groups smaller than 60 specimens. At least on nine occasions, calves were part of the sighted group.

DISCUSSION

Five hundred and seventy cetacean sightings made during 346 working days on the west coast of La Palma, evidently indicate the high cetacean presence in this area. The sighting success in the present study (1.7 sightings per day) was in good agreement with results from the Canary Net of Stranded Cetaceans and those from Carrillo & Tejedor (2004). They estimated a SPEU of 1.8 sightings per day, very close to the value presented in this paper. Moreover, the frequency of sightings is nearly constant, without significant seasonal variations. That is throughout this period, at least once a day a sighting was made on the west coast of La Palma.

Furthermore, La Palma, as well as other Canary Islands (Politi, *et al.*, 1997; Ritter, 2001), seems to show a high cetacean diversity. Thirteen species and *Globicephala* genus were positively matched, confirming the presence in the island of, at least, half of the cetacean species present in the Archipelago (M. Carrillo, personal communication, 2007). Present results also confirm the presence of species only known to be in La Palma waters by strands or short campaigns (Carrillo & Tejedor, 2004). Compared to those studies, the presence of *Kogia breviceps* Blainville, 1838 and *Orcinus orca* Linnaeus 1758, was not confirmed with our results. Notwithstanding, four species were registered for the first time in the island waters. These species are *Balaenoptera borealis* Lesson, 1828 (Sei whale), *Grampus griseus* Cuvier, 1812 (Risso's dolphin), *Pseudorca crassidens* Owen, 1846 (false killer whale) and *Steno bredanensis* Lesson, 1828 (rough-toothed dolphin). These new records were just seen once, except for the last one, *Steno bredanensis*, which, surprisingly, was the second

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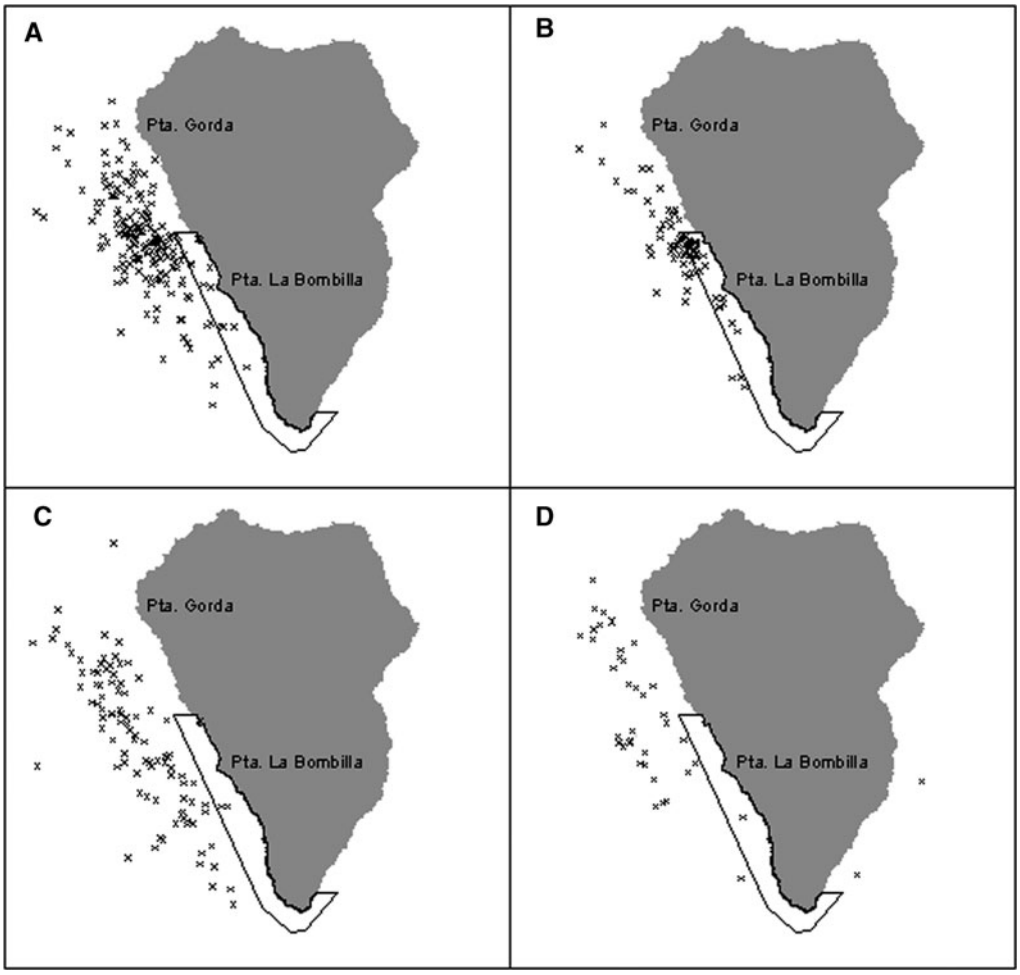

Fig. 3. Location of the four most sighted cetacean species in La Palma Island. (A, *Tursiops truncatus*; B, *Steno bredanensis*; C, *Globicephala* genus; D, *Stenella frontalis*).

most sighted species in the present study (118 sightings; 39.3% of all sightings). It is also significant that this species appeared from January to May, which is in agreement with results on temporal distribution of *Steno bredanensis* in another Canary Island. According to Pérez-Vallazza & Haroun (2005), rough-toothed dolphins turned up in Gran Canaria Island waters from February to August, vanishing in autumn and the beginning of winter.

About Mysticeti sighted species, they are known to have a typical 'balaenopterid life cycle' (Ritter & Brederlau, 1998), supposedly being on their migration route when reaching the Canaries. Bryde's and fin whales appeared in La Palma when they were expected to do so (spring/summer time), but the Sei whale, sighted in June, is only supposed to frequent the archipelago in winter. In any case, very little is known about the stocks of Mysticeti that frequent the archipelago.

Regarding spatial cetacean distribution, most sightings were made in the middle west coast of La Palma, exceeding 1.5 nautical miles from the coast and 500 m depth. Curiously, this area where almost 90% of all sightings occurred, stands outside the Franja Marina de Fuencaliente SCI boundaries or in its limits, which is relevant for its conservation implications. Regarding *Tursiops truncatus* Montagu, 1821 (one of the SCI's objects of declaration), its presence is also common outside the SCI boundary (95% of this species' sightings occurred outside the protection body). This confirms conclusions derived from other studies in the Canaries, such as those in Franja Marina de Mogán SCI (Gran Canaria Island). In that particular case, sightings of bottlenose dolphins outside the SCI boundary represented 85% of all of these species sightings (H. Martín, personal communication). On the other hand it is worth highlighting that, many *Tursiops truncatus* sightings were concentrated in the centre of the study area. This particular position could be defined by an opportunistic feeding behaviour in the area connected with its foraging behaviour (Díaz López & Bernal Shirai, 2006). As far as group structure is concerned, at least in the four most sighted species calf presence was detected. This leads us to believe that this could be a breeding area for some cetacean species.

Considering our results, oceanographic characteristics seem to play a decisive role in the La Palma cetacean community, both on diversity and on the total number of animals, which is in agreement with previous studies carried out in the archipelago (Ritter, 2001). Canary Islands' waters enjoy a complex oceanographic system. In order to study the surrounding currents, in the development of the international collaboration programme from NOAA 'The Global Drifters Programme: satellite-tracked surface drifting buoys', a group of drifting buoys were thrown in the seas of the north of the Canarian Archipelago (29°10′N 15°30′W). Figure 4 shows one of this buoy's paths (id 20334) which is visibly held back in the eddies formed off the south-west coast of La Palma.

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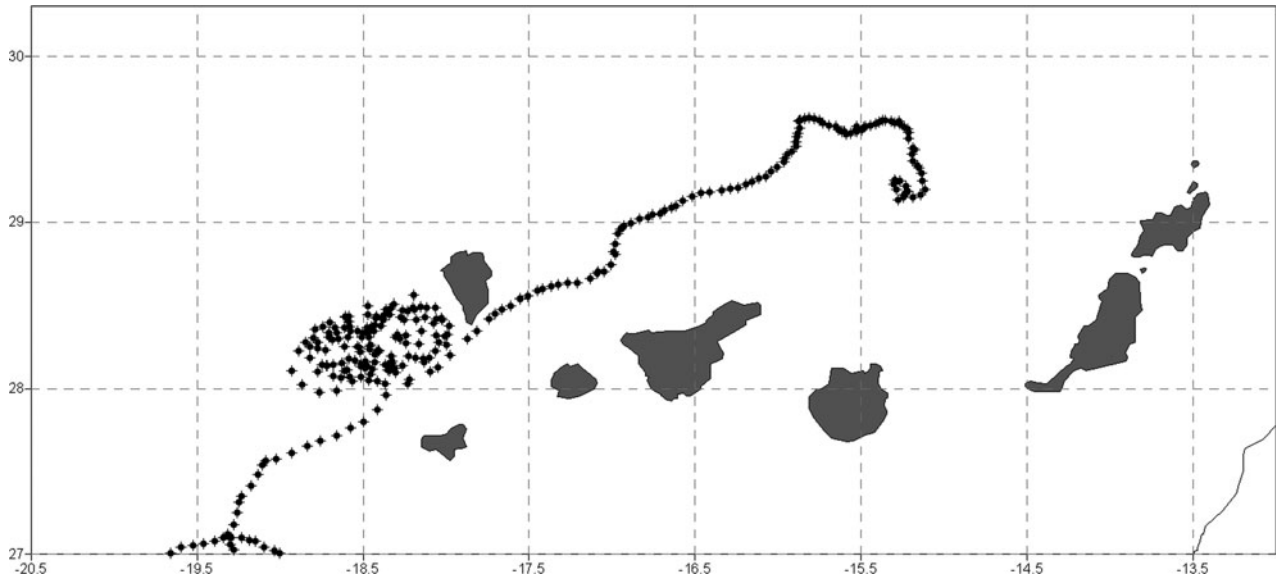

Fig. 4. Path of the drifting buoy (id 20334) thrown in 2000.

The Canary Islands act as an obstacle to the main current, inducing the development of cyclonic and anti-cyclonic eddies downstream of the islands (Arístegui *et al.*, 1994). When cyclonic eddies are induced, as sometimes occurs in La Palma and its surroundings (Figure 5), rich waters come to the surface in the centre of them. This spout produces an increase in productivity and an irregular chlorophyll wake downstream (Arístegui *et al.*, 1997). This increase in phytoplankton biomass has, definitely, consequences over the high levels of the food chain (Gómez, 1991). Therefore, the high cetacean presence in the study area could be related to these biological consequences of island-induced cyclonic eddies.

Furthermore, those islands with marked orography, like La Palma, represent an obstacle to the wind-way, generating calm areas leeward of the islands. Both, absence of wind power and high insulation, favour warming and stratification of the sea column, causing warm pluming structures leeward of the wind (Violette, 1974). This oceanographic feature and its direct consequences on sea temperature characteristics may also explain the high cetacean presence in the La Palma west coast. A similar connection between the distribution of short-finned pilot whales off Tenerife Island and sea surface temperature was found by Montero & Arechavaleta (1996).

In addition to oceanographic processes, and mainly caused by them, food availability could favour cetacean presence in the area. Species such as pilot whales are generally found in deep waters, which may be related to the distribution of deep-water squid, their main prey (Weir *et al.*, 2000). Other cetacean prey, such as the chub mackerel (*Scomber japonicus* Houttuyn, 1792), can be found in Canarian waters during the whole year without seasonal trends (Castro, 1991). As an example, chub mackerel appears especially in the wakes formed at the south-western areas of the islands. Also *Thunnus* spp. frequent the area in some periods. Studies on catch per effort unit (CPEU) in the Canaries developed by González Ramos (1992), show a connection between the mesoscale oceanographic features and the fishing of skipjack tuna (*Katsuwonus pelamis* Linnaeus) and chub mackerel. Skipjack tuna travels to areas rich in food and with an appropriate temperature for its physiological needs. It turns up at mid-spring in the Canary Islands, especially in the south-western areas (González, 1992). The above mentioned study also proved that skipjack is connected with the 'island mass effect', responsible for the warm water production and the subsequent increase in food concentration, in these areas of the islands.

Information acquired through this study enables a better understanding of the Canarian cetacean community. Presence and high cetacean diversity can be secured at the west coast of La Palma Island, where this fact was not already confirmed. This presence seems to be constant in time for the studied area, except for those occasional species with a seasonal temporal pattern. Oceanographic conditions of these waters, together with ecological ones (such as food availability) may create the right conditions to gather a high cetacean presence. Insights gained can play an important role, not only as baseline data on cetacean populations in this area but also as a tool in the establishment of future conservation guidelines for cetaceans.

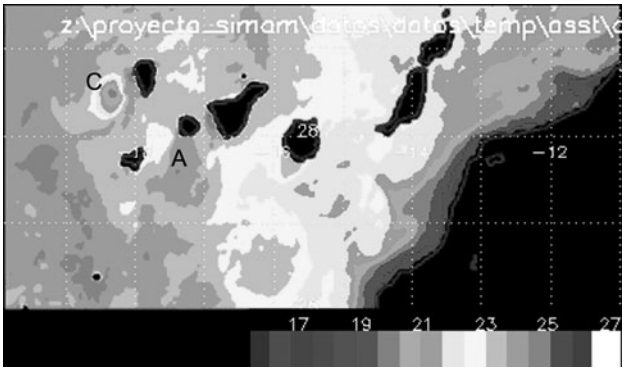

Fig. 5. Sea surface temperature image (August, 2007) showing cyclonic (C) and anticyclonic (A) island-induced eddies (modified from Pérez-Marrero, J. *et al.*, 2005).

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