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# Occurrence and distribution of cetaceans in the waters around the Azores (Portugal), Summer and Autumn 1999–2000

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### Abstract

Boat-based surveys were conducted during the summer and autumn months of 1999 and 2000 around the islands of the Archipelago of the Azores to determine occurrence, distribution, and relative abundance of cetaceans. A total of 222 cetacean schools, corresponding to 11 species, were sighted over the two years. Cetaceans were widely distributed in the area surveyed, but the central group of islands recorded the highest relative abundance of cetaceans and the greater species diversity. Within each group of islands, cetaceans were more abundant in the coastal area (to 9 km from shore) than in the offshore area (9 to 28 km). Atlantic spotted dolphins (*Stenella frontalis*), short-beaked common dolphins (*Delphinus delphis*), and bottlenose dolphins (*Tursiops truncatus*) were the most frequently sighted species and were found in all the islands surveyed. Although there was considerable overlap in spatial distribution among these species, common dolphins and bottlenose dolphins occurred in coastal areas, while Atlantic spotted dolphins were more common in offshore and deeper waters.

Key words: cetacean, occurrence, distribution, relative abundance, Archipelago of the Azores

### Introduction

Apart from the sperm whale (*Physeter macrocephalus*), for which there were some studies based on catch data from the whaling days (Clarke, 1956; Ávila de Melo & Martin, 1985), very little is known about the spatial and temporal patterns of distribution and abundance of cetaceans around the Azores Archipelago. So far, the only available information on the presence of cetaceans in the area comes from opportunistic sightings and stranding records (Clarke, 1981; Martin, 1988; Reiner *et al*., 1993; Steiner, 1995; Gonçalves *et al*., 1996). Between 1987 and 1998, IFAW (International Fund for Animal Welfare) conducted a series of research cruises in the Azores. However, this information is still only available as unpublished reports. Furthermore, even these studies focused almost exclusively in the area around the islands of Faial and Pico (central group) and São Miguel (eastern group), and information from the other islands is very scarce.

In the Azores, the whale-watching activity is quite recent, but is growing very rapidly. Beginning in 1993 with a single operator and 468 clients, by 2000 there were around 15 000 clients and 28 boats with official licenses. At the moment, about 83% of the operators are established within the central group of the Archipelago, with 61% developing their activity around the islands of Faial and Pico. The main target species of the activity is the sperm whale, although dolphins also deserve a special interest. The constant growth of the whale-watching activity has led to an increasing concern about cetacean welfare, which prompted the Azorean Regional Government to implement a new management policy and urge the development of research studies on cetaceans. As a consequence, in 1998, a research program was initiated, with two main objectives: (1) to study spatial and temporal distribution and relative abundance of cetaceans in the Archipelago and (2) to assess the short-term reactions of cetaceans to the presence of whale-watching boats. This knowledge should then be used in the development of management plans for specific areas, namely in the definition of a load capacity for the whale-watching activity.

The main objective of this study was to determine the occurrence, distribution, and relative abundance of cetaceans in the waters around the Azorean islands, during the summer season, when the whale-watching activity takes place.

### Materials and Methods

The Archipelago of the Azores (Portugal) is located between 37° to 41°N and 25° to 31°W, extending

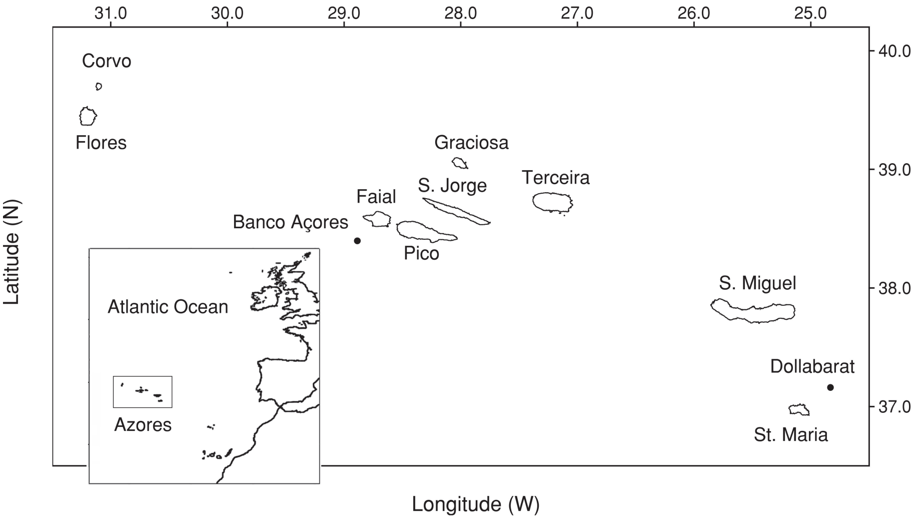


**Figure 1.** Map showing the location of the Archipelago of the Azores in the Atlantic Ocean, and the location of the islands and offshore banks surveyed.

more than 480 km along a northwest–southeast trend and crossing the Mid-Atlantic Ridge (Fig. 1). It is composed of nine volcanic islands divided into three groups—eastern, central, and western—separated by deep waters (*ca.* 2000 m) with scattered seamounts (Santos *et al.*, 1995). Boat surveys were conducted in a 28 km area around each island, except when two islands were very close and these areas overlapped. In this case, the area between the islands was surveyed only once. This area was further stratified into a coastal zone, extending to 9 km (5 nmi) from shore, and an offshore zone, beginning at the limit of the coastal zone and extending to 28 km (10 nmi). This was done to assure that more effort was put into nearshore areas, where most of the whale-watching activity takes place. Zones were divided into smaller survey blocks, according to the coast and bathymetric orientation. In each block, the starting point of the transect-line was randomly chosen, and transects followed a zig-zag pattern, perpendicular to the bathymetry. To guarantee even coverage of all study areas, survey effort (measured in km of transect-line) was proportional to the size of each block. Transects also were conducted in a 9 km area around two offshore banks, near the central and eastern group of islands. All coastal sub-areas combined totaled 6308 $km^2$ and offshore sub-areas 15 596 $km^2$.

Surveys were carried-out from July to December in 1999 and from May to September in 2000. The central group of islands was the only one surveyed every month during the study period. The eastern group was surveyed during the month of September in both years, whereas the western group was only visited in July 2000. The rest of the time was spent surveying the islands in the central group and two offshore banks. Weather and logistical constraints were the main reason for the selection of the study period in each year. In 1999, surveys were conducted in a 12–m yacht sailing at an average speed of 5 knots, whereas in 2000 a 10–m motorboat was used, enabling surveys to be conducted at much higher speeds (9–11 knots). During 1999, observers stood on a platform 1 m above the sea surface and in 2000 the observation platform was 3.5 m in height.

During a transect, between three and four observers searched the area ranging 90° from each side of the trackline out to the horizon, by naked eye and using 7 × 50 binoculars with compass. Another observer recorded weather, effort and sighting information on printed data forms. Observers changed positions every 30 min. Two of the observers worked in the 1999 and 2000 cruises. While on transects, searching effort was maintained from 07:00 to 20:00 h, as long as light and weather conditions were considered adequate. Surveys were only conducted at sea states $\leq$Beaufort 4.

Information on weather and sea conditions, and on the location of the boat (calculated with a Global Positioning System), was collected every 30 min in 1999, and every 15 min in 2000. For each sighting, data recorded included position, time, species identity, number of individuals, presence of calves, direction of movement, and behaviour. Information on sighting angle (measured with the binoculars compass) and radial distance also was collected for each sighting, although it was not included in the analyses presented here. During the

**Table 1.** Number of sightings, sighting rate, number of individuals, and group size (mean, standard deviation (SD) and range) of cetaceans in the Archipelago of the Azores, 1999–2000.

| Species | No. sightings | Sightings/100 km | No. individuals | Group size | | |
|---|---|---|---|---|---|---|
| | | | | Mean | SD | Range |
| *Stenella frontalis* | 47 | 0.87 | 686 | 14.60 | 12.26 | 1–60 |
| *Delphinus delphis* | 33 | 0.61 | 523 | 14.94 | 10.71 | 1–40 |
| *Tursiops truncatus* | 28 | 0.52 | 316 | 11.29 | 9.25 | 1–45 |
| *Grampus griseus* | 16 | 0.30 | 94 | 5.88 | 3.86 | 1–15 |
| *Physeter macrocephalus* | 14 | 0.26 | 30 | 2.14 | 1.70 | 1–6 |
| *Mesoplodon* sp. | 12 | 0.22 | 44 | 3.67 | 1.97 | 2–8 |
| *Hyperoodon ampullatus* | 7 | 0.13 | 33 | 4.71 | 2.06 | 3–9 |
| *Pseudorca crassidens* | 7 | 0.13 | 50 | 7.14 | 4.74 | 3–17 |
| *Globicephala macrorhynchus* | 3 | 0.06 | 33 | 11.00 | 6.56 | 5–18 |
| *Stenella coeruleoalba* | 1 | 0.02 | 50 | | | |
| *Balaenoptera borealis* | 1 | 0.02 | 2 | | | |
| *Balaenoptera* sp. | 1 | 0.02 | 1 | | | |
| Unidentified small cetacean | 37 | 0.69 | 239 | 6.83 | 7.72 | 1–30 |
| Unidentified large cetacean | 15 | 0.28 | 23 | 1.53 | 1.06 | 1–5 |
| Total | 222 | 4.13 | 2124 | | | |

1999 cruise, we decided never to interrupt transects to confirm sightings, due to the low speed of the vessel. As a result, a large number of individuals or groups sighted remained unidentified. In 2000, whenever a sighting far from the boat was detected, we interrupted the transect to confirm species identification and allow estimation of group size.

Mean cetacean sighting rates (number of sightings per 100 km surveyed) were compared between years, months, and areas using Mann–Whitney or Kruskal–Wallis tests. A Kolmogorov–Smirnov test was conducted to examine differences in the relative abundance of cetaceans in relation to time of day, by comparing the frequency of cetacean sightings to the frequency of survey effort, measured at one-hour searching intervals. Depth at each cetacean sighting was derived from bathymetric charts. The number of sightings of different species per each 500–m depth interval was compared with the likelihood ratio G-test. The relationship between mean group size and water depth was analyzed for the most frequently sighted species using the Spearman rank correlation test. Statistical procedures followed Zar (1996).

## Results

In 1999, a total of 1657 km of transect-line were surveyed, whereas in 2000 we surveyed 3715 km. Eighty-one groups of cetaceans were seen in 1999, resulting in a mean sighting rate of 4.89. In 2000, the number of cetaceans sighted increased almost twofold ($n=141$), but the mean sighting rate was lower (3.80). However, differences observed in the mean cetacean sighting rate between years were not statistically significant (Mann–Whitney, $U=23722.0$, $n=438$, $P>0.5$). Therefore, we decided to pool data from both years in all the analysis performed.

A total of 222 cetacean schools and 2124 individuals were sighted in both years, yielding an average of 4.13 sightings per 100 km surveyed (Table 1).

About 77% ($n=170$) of the schools were identified, corresponding to 11 different species. Of these, the Atlantic spotted dolphin (*Stenella frontalis*) was the most abundant, registering the highest sighting rate (0.87) and exhibiting the largest number of individuals. Short-beaked common dolphins (*Delphinus delphis*) (hereafter simply called common dolphin) and bottlenose dolphins (*Tursiops truncatus*) were the second and third most frequently sighted species, with 0.61 and 0.52 sightings per 100 km surveyed, respectively. Together the three species comprised more than 48% of the sightings and 71% of the individuals observed.

Risso's dolphins (*Grampus griseus*), sperm whales and beaked whales of the genus *Mesoplodon*, followed in terms of sighting rates. Balaenopterid whales were only seen on two occasions, one of which corresponded to sei whales (*Balaenoptera borealis*) and in the other the species remained unidentified.

Common dolphins and spotted dolphins had the largest group sizes (14.9 and 14.6, respectively), but the latter presented a wider range in the number of individuals (Table 1). Mean group size and range were very similar among the beaked whales, with the northern bottlenose whale (*Hyperoodon*

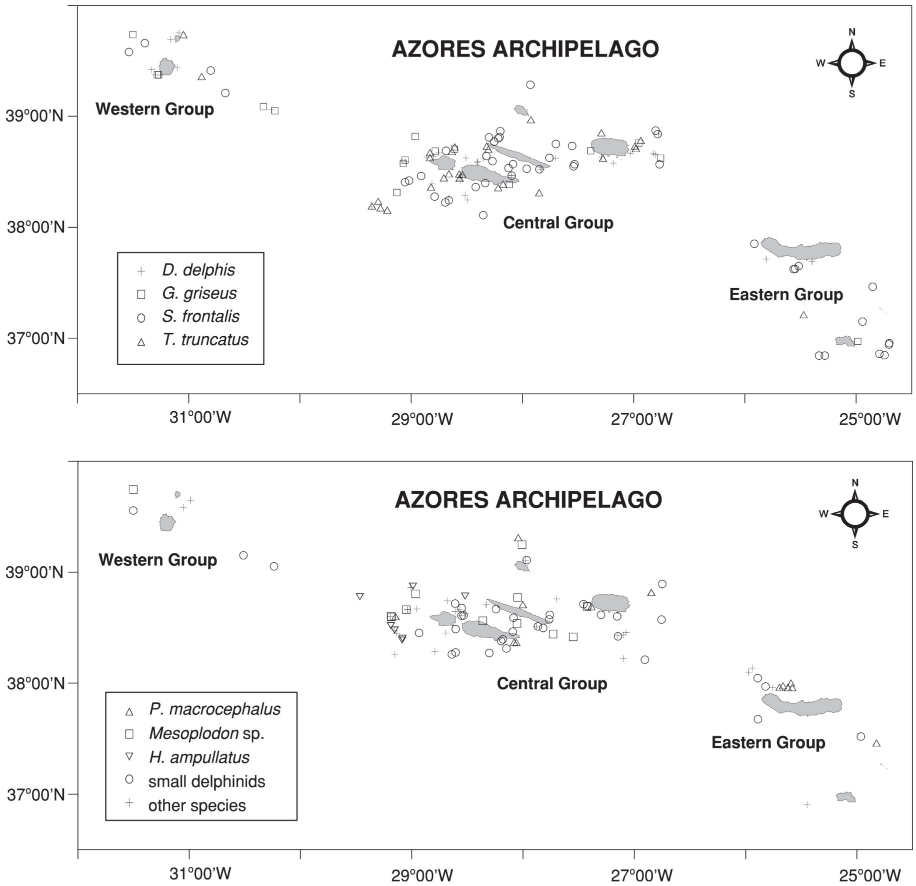


**Figure 2.** Location of sightings of each cetacean species or species group in the Archipelago of the Azores during the 1999 and 2000 boat surveys.

*ampullatus*) showing a mean group size slightly higher than the *Mesoplodon* species.

Cetaceans were sighted throughout the area surveyed, although there seemed to be a higher concentration around the central group of islands (Fig. 2). However, because survey effort also varied considerably within and among groups of islands, number of sightings should not be seen as representative of the abundance. Geographical differences in the relative abundance of cetaceans were examined by comparing the mean sighting rate among the three groups of islands and between coastal and offshore zones. There were significant differences in the mean sighting rate among the areas considered (Kruskal–Wallis ANOVA, KW=27.53, $n$=430, $P$<0.00005) (Fig. 3). The highest values were recorded in the coastal and offshore zones within the central group (6.40 and 5.36, respectively), followed by the coastal zone of the western group (3.51). The eastern group had the lowest sighting rates, with 1.70 and 1.50 recorded for the offshore and coastal zones, respectively. The coastal zones of the central and western groups recorded higher sighting rates than the offshore zones, although within each group of islands, differences found in the mean sighting rate by area were not statistically significant (Kruskal–Wallis ANOVA, eastern group: KW=5.50, $n$=123, $P$<0.5; central group: KW=4.77, $n$=259, $P$>0.5; western group: KW=0.00, $n$=54, $P$>0.5). Species diversity also was higher within the central group, with 11 different species identified, whereas in the eastern and western groups only six cetacean species were recorded.

Differences among groups of islands in the relative abundance of the five most common species were examined using the species mean sighting rate. Sighting rates of common dolphins were higher for coastal areas in all the groups of islands, reaching its maximum value in the western group (Kruskal–Wallis ANOVA, KW=12.07, $n$=430, $P$<0.05). On the contrary, spotted dolphins were more abundant

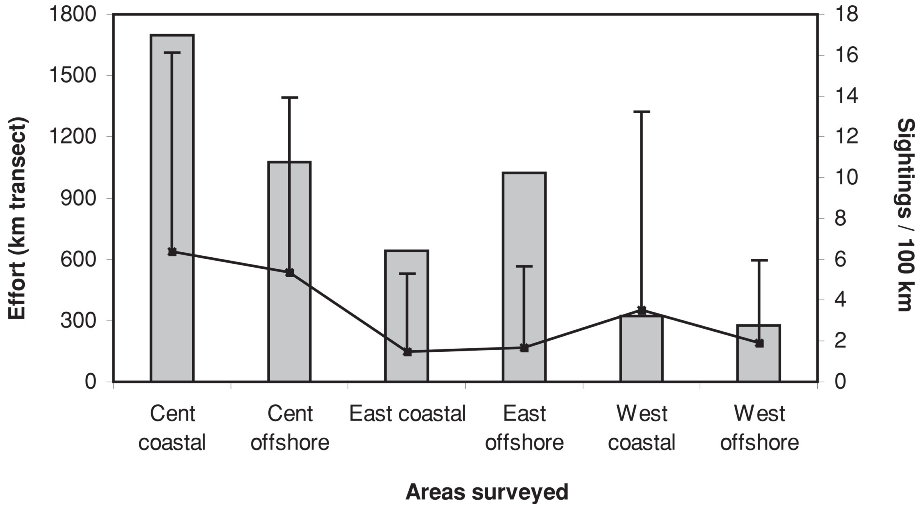


**Figure 3.** Survey effort (measured in km of transect-line), sighting rate (mean number of cetaceans sighted per 100 km surveyed), and respective standard deviation, within the study areas (Cent = central group; East = eastern group; West = western group; coastal = coastal zone; offshore = offshore zone).

in offshore zones, with the highest sighting rate being also registered in the western group (Kruskal–Wallis ANOVA, KW = 1.08, $n$ = 430, $P$<0.05). The comparison of the bottlenose dolphin mean sighting rate between coastal and offshore zones did not reveal any clear pattern. However, the mean sighting rate was significantly higher in the coastal zone of the central group (Kruskal–Wallis ANOVA, KW = 18.25, $n$ = 430, $P$<0.005). No significant differences were found among the islands and zones in the relative abundance of Risso's dolphins (Kruskal–Wallis ANOVA, KW = 3.34, $n$ = 430, $P$>0.5) and sperm whales (Kruskal–Wallis ANOVA, KW = 2.09, $n$ = 430, $P$>0.5).

Mean cetacean sighting rate varied significantly among months (Kruskal–Wallis ANOVA, KW = 25.83, $n$ = 444, $P$<0.0005). Duncan's Multiple Range Test showed that September's mean sighting rate was significantly lower than the ones recorded in May ($P$<0.05) and August ($P$<0.05). However, because of the obvious relationship among months and group of islands surveyed, it is difficult to determine if the observed value of the sighting rate is indeed the result of the monthly variation in cetacean relative abundance, or if it is caused by differences in abundance among geographic areas. To investigate this, we compared monthly values of the mean sighting rate within the central group of islands, which was the only one surveyed in every month. Differences in mean sighting rate by month were no longer significant (Kruskal–Wallis ANOVA, KW = 3.85, $n$ = 258, $P$>0.5), and December recorded the lowest sighting rate (3.5). May and August still recorded the highest values (7.1 and 6.7, respectively).

The number of cetaceans sighted by time of day was not significantly different from the hourly distribution of effort (Kolmogorov–Smirnov, D = 0.06, $n$ = 814, $P$>0.10).

We investigated differences in distribution in relation to water depth among the five species most frequently encountered during the surveys. The number of sightings per 500–m depth interval varied significantly among species (G test, G = 57.30, $df$ = 20, $P$>0.0005). About 80% of the sightings of common dolphins and bottlenose dolphins were made at depths <1000 m. However, common dolphins showed a narrower range of water depths (97–1618 m) than bottlenose dolphins (143–2170 m). Spotted dolphins exhibited the greatest range of water depths (341–2800 m), but 64% of the sightings occurred between 1000 and 2000 m. Risso's dolphins were distributed evenly among depth intervals, with the greatest depth at 1935 m. Although sperm whales inhabited a wide range of water depths, a large percentage (64%) of the sightings were concentrated in the 1000–1500 m depth interval.

Group size was not significantly correlated with water depth for any of the most frequently sighted species (Spearman Rank Correlation, common dolphin: r = 0.02, $df$ = 31; Atlantic spotted dolphin: r = − 0.18, $df$ = 46; bottlenose dolphin: r = 0.31, $df$ = 6; Risso's dolphin: r = − 0.10, $df$ = 15; sperm whale: r = 0.01, $df$ = 14; $P$>0.5 for all the species).

## Discussion

Eleven different species of cetaceans were seen during the surveys conducted around the islands of the Azorean Archipelago, in the summer and autumn seasons of 1999 and 2000. This represents less than half the number of species already confirmed for this area (Reiner *et al.*, 1993; Gonçalves *et al.*, 1996). Atlantic spotted dolphins, common dolphins, and bottlenose dolphins were the most abundant species, comprising almost half of the sightings and accounting for a large percentage of the individuals seen. Together with Risso's dolphins, these were the only species encountered in all the groups of islands surveyed. Baleen whales were only seen twice during the surveys. This is not totally unexpected since baleen whales are known to be more abundant in the Azores early in the year (Gordon *et al.*, 1995; unpublished data) and this was the time when the least survey effort was made during this study. Beaked whales of the genus *Mesoplodon* and northern bottlenose whales were among the most frequently sighted cetacean species. The particular bottom topography of the Azores, with abundant submarine canyons, conforms to the known deep-water preferences of beaked whales. On the other hand, the lack of continental shelf implies the existence of deep waters very nearshore, making it possible to sight species that usually inhabit more offshore waters.

Our results of mean group sizes and group ranges for small dolphins generally are lower than the ones recorded for the same species in other geographic areas. In this study, we estimated a mean group size of 14.9 individuals for the common dolphin, which contrasts with the 64.4 animals found in the Mediterranean (Forcada *et al.*, 1994), 125 in the Galápagos (Smith & Whitehead, 1999) or 254.3 in the northern Gulf of California (Silber *et al.*, 1994). Similarly, the mean group size for Atlantic spotted dolphins (14.6 animals) is much lower than the one recorded in the Gulf of Mexico (26.6) (Mullin *et al.*, 1994). Risso's dolphins were found in groups averaging 5.9 animals, comparing to the mean groups of 12.8 reported for the Gulf of Mexico (Mullin *et al.*, 1994), 13 for the Galápagos (Smith & Whitehead, 1999) and 7.2 for the Mediterranean (Forcada *et al.*, 1994). Mean group size found for bottlenose dolphins (11.3), on the other hand, lies within the range of average groups reported elsewhere (see Shane *et al.*, 1986).

Distribution and abundance of food resources, predation risk, and some of the physical characteristics of the habitat are known to influence group size of cetacean populations (Norris & Døhl, 1980; Wells *et al.*, 1980). Group sizes are expected to be higher in open water habitats or with increased water depth. In this study, not only did we find lower mean group sizes in three dolphin species, but we also did not find a relationship between group size and water depth for any of the species analyzed. Although larger groups would probably increase foraging efficiency in an oceanic environment, such as the Azores, perhaps the fact that these waters are relatively poor in food resources will tend to counterbalance this tendency. Furthermore, because the risk of predation can be relatively low due to the absence of top predators, there is no great advantage in forming very large groups.

Cetaceans were seen in all the groups of islands and zones surveyed, although they appeared to be more frequent and/or abundant in certain areas. Thus, the central group recorded both the greatest species diversity and the highest sighting rates. Differences in cetacean abundance among the three groups of islands could be related to differences in the abundance or diversity of food resources, although the absence of data on prey species or on primary productivity in the waters around the Azores prevented confirmation of this hypothesis. Alternatively, results could be biased due to the large differences in sighting effort among groups of islands. In general, relative abundance of cetaceans tended to be higher in the coastal zones around the islands, than in more offshore waters. Apparently, cetacean abundance was more homogeneous within, than among the groups of islands.

There were considerable differences in spatial distribution between some species, whereas common dolphins occurred preferentially in coastal areas, Atlantic spotted dolphins exhibited the reverse tendency, with greater relative abundances recorded in the offshore zones. This spatial segregation also was evident in the range of water depths inhabited by each species. Although bottlenose dolphins were sighted throughout the study area, a large percentage of sightings were concentrated in the coastal area around the central group of islands. Bottlenose dolphins occupied a slightly wider range of water depths than common dolphins, but these two species seemed to share the same habitat. Risso's dolphin presented a mean water depth intermediate between bottlenose and spotted dolphins. In general, results reported here regarding habitat preferences are in agreement with findings from other areas (Mullin *et al.*, 1994; Silber *et al.*, 1994; Smith & Whitehead, 1999). Differences in habitat selection among these species likely reflect distinct feeding habits and foraging strategies, and also could contribute to reduce ecological competition among species that occur in the same geographic area.

We detected a monthly variation in the mean cetacean sighting rate, with the highest values registered in May and August and the lowest in September. Yet, when we compared monthly values of the mean sighting rate within the central group of islands, differences were no longer significant, and December recorded the lowest sighting rate. May and August still had the highest values. These results suggest that May and August values really could reflect seasonal variations in the relative abundance of cetaceans, but the minimum detected in September was mainly the result of the lower cetacean abundance in the area being surveyed—the eastern group of islands. At present; however, there is insufficient information to detect monthly or seasonal changes in cetacean abundance in the Azores.

Some of the findings of this study could have important consequences in the management of the whale-watching activity. For instance, the fact that we did not find any significant differences in the relative abundance of cetaceans within each group of islands could be crucial in convincing managers and operators to decentralize the activity.

This study represents the first attempt to document occurrence, distribution, and relative abundance of cetaceans in all the islands of the Archipelago of the Azores. Care should be taken; however, because results presented here only pertain to some months of the year, and may not reflect accurately what happens in the area during the remaining period. Thus, new cetacean survey studies are necessary to clarify seasonality, maybe using other methods such as aerial surveys.

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