

**UNIVERSIDADE DE LISBOA**  
**FACULDADE DE CIÊNCIAS**  
**DEPARTAMENTO DE BIOLOGIA ANIMAL**



*Characterization of Cetaceans in the South coast of  
Portugal between Lagos and Cape São Vicente*

Joana Madeira Cardoso de Castro

Mestrado em Ecologia Marinha

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Dissertação orientada por:

Professor Doutor Carlos A. Assis

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# Acknowledgments

This thesis could not have been done without the help of several people.

First of all, a big “THANK YOU” to my dear adviser and friend Carlos A. Assis. For always be there for me, at any time! For the support, help, trust and consideration. There are no words to express how grateful I am. In the past 5 years of my life You were a truly adviser, in all the aspects.

To Renaud de Stephanis, as adviser and friend. For being responsible for an enormous change in my life, that I will never forget.

To the company “Mar Ilimitado” for all the help and for all the data, that allowed the realization of this project!! A very special “thanks”.

To Dave and Lesley Lundquist, for everything! A special thanks to Dave for being the best “boss” ever, for all the teaching, and most of all for being a true friend.

To Aude Pacini, for being amazing!! For all the skype conversation that help so much during this process! Thanks for always being present in my life.

To Mithriel MacKay, another big friend in the adventure that is to study cetaceans! Thanks for all the English corrections and all the support. Also to Arnold B-Nagy, for all the corrections in the GIS analyze.

To Patrícia Malico....There are no words!!! Absolutely tireless in all this process. I couldn't have make it without you.... There are really no words!

To all the CIRCÉ team, Portuguese and Spanish, for the enormous support and help in the data analyse. A special thanks to João Gonçalves, Gonçalo Prista e Marina Laborde.

To André Cid, for never judging me. Always present, always comprehensive and always there.

Finally to my family!!! This thesis is dedicated to them. Thanks for always believing in me. Thanks for always deal with my bad moods, thanks for everything..... to my mom, for making me laugh when I really just wanted to cry; to my dad, for the giving me all the serenity and guidelines in my life; to my sister Teresa, that at this point is sick of hearing about dolphins, but always supportive; to my sister Rita, for always telling me not to worry; and to my grandfather João, for reminding me that “Joana és a fera da casa, tu safaste bem”. Thanks to all of you!

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## RESUMO

A Costa Sul de Portugal Continental é uma das regiões do país mais populares para observação de cetáceos na natureza, contando actualmente com a presença de 14 empresas licenciadas para a actividade. No entanto, os conhecimentos e os estudos realizados sobre cetáceos nesta região são muito limitados. De facto, grande parte da informação sobre a ocorrência de cetáceos na Costa Algarvia é proveniente de dados de arrojamentos, que indicam a possível presença de 11 espécies de cetáceos diferentes.

Para uma melhor compreensão da utilização das águas a Sul da Península Ibérica pelas diferentes espécies de cetáceos que aí ocorrem, é necessária uma caracterização das espécies ou populações existentes ao largo da costa algarvia. Neste sentido, pretende-se com este projecto levar a cabo uma caracterização da área entre Lagos e o Cabo de São Vicente no que se refere às espécies de cetáceos que aí possam ocorrer e comparar os resultados obtidos com dados disponíveis referentes às populações estudadas até ao Estreito de Gibraltar.

Para este estudo utilizar-se-ão dados recolhidos em cooperação com uma empresa de Whale watching “Mar Ilimitado”, tomada como plataforma de oportunidade para recolha de dados no campo. A recolha dos dados está limitada à área abrangida pela empresa (Sagres-Lagos), bem como pelo limite de distância à costa a que a embarcação está sujeita, no caso em questão 5 milhas. Para o presente estudo serão recolhidos e analisados dados correspondentes à época de 2009, complementados com dados anteriormente recolhidos pelos técnicos da empresa, correspondentes a uma série temporal com início no ano de 2005. Pretende-se também complementar estes dados com informações fornecidas por outras empresas existentes ao longo da costa algarvia.

Com este projecto espera-se obter os conhecimentos necessários para a caracterização das populações de cetáceos ocorrentes na costa Sudoeste de Portugal e contribuir para o alargamento desses conhecimentos à costa Sudoeste da Península Ibérica. Especificamente, espera-se obter uma listagem das espécies de cetáceos que ocorrem entre Lagos e o Cabo de São Vicente; uma base de dados de ocorrência, distribuição e abundância de cetáceos na área de estudo; catálogos destinados a permitir a foto-identificação dos cetáceos ocorrentes na área de estudo, em particular os golfinhos comuns, a espécie consistentemente mais observada na região; mapas com a distribuição das espécies, grupos ou indivíduos observados ao longo do período coberto pelo estudo; mapas de possíveis *hotspots* para as espécies presentes; distribuição das espécies em relação à batimetria e declive da área de estudo; análise da coesão e estrutura dos grupos; presença ou ausência de crias para as espécies mais

frequentemente avistadas, nomeadamente o golfinho comum e o golfinho roaz; comparar o catálogo de foto-identificação de golfinho comum, elaborados no âmbito deste projecto, com documentos equivalentes abrangendo ocorrências no Golfo de Cádiz.

Entre os anos de 2005 a 2009, inclusive, foram avistados na área de estudo 556 grupos de golfinhos comuns, resultando numa taxa de avistamento (ER) de 2.01 avistamentos.100 km<sup>-1</sup>.

Apenas durante o ano de 2009, foram avistados 228 grupos de cetáceos, correspondendo ao encontro de 6 espécies diferentes na área. Entre estes, a espécie mais avistada foi o Golfinho Comum (182 avistamentos; ER = 1,9 avistamentos.100km<sup>-1</sup>), o Boto (22 avistamentos; ER = 0,2 avistamentos.100km<sup>-1</sup>) e Golfinho Roaz (20 avistamentos; ER = 0,2 avistamentos.100km<sup>-1</sup>). As restantes espécies foram observadas ocasionalmente resultando em, 2 avistamentos de Grampos, um avistamento de Baleia anã e um avistamento de Baleia de bossa. Em relação à batimetria, 99,3% dos avistamentos de golfinhos comuns ocorreram entre 50-200 m de profundidade. Em relação ao Boto e ao Golfinho Roaz, 100% dos avistamentos ocorreram entre 50-200 m de profundidade. O declive da área de estudo não é muito acentuado, sendo que no caso do Golfinho Roaz e do Boto, 100% dos avistamentos ocorreram na classe de declive de 0 – 80 m.km<sup>-1</sup>. Quanto ao golfinho comum 98,6% dos avistamentos ocorreram na classe de declive de 0 – 80 m.km<sup>-1</sup>.

A presença de crias de golfinhos comuns e roazes, foi uma constante durante o período amostrado. Em mais de 50% dos avistamentos de golfinhos roazes, durante o ano de 2009, crias estavam presentes no grupo; em relação ao Golfinho comum, usou-se o teste não paramétrico Kruskal-Wallis, com um intervalo de confiança de 95%, para comparar as diferenças entre os anos de 2005 a 2009 em relação à presença/ausência de crias. Verificou-se que existem diferenças significativas em relação ao esforço, de ano para ano, para encontrar pelo menos um grupo com crias (H=91,6; p << 0,05).

O catálogo de foto-identificação de Golfinhos Comuns, iniciado no verão de 2009, permitiu o registo de 342 indivíduos. Ao comparar-se este catálogo com o já existente para o Golfo de Cádiz, com 223 indivíduos (catálogo pertencente à CIRCÉ), não foi registada qualquer coincidência de indivíduos. No entanto este resultado não significa que não possa existir fluxo de indivíduos entre as regiões. A época de amostragem é limitada, bem como o número de fotografias recolhidas e passíveis de usar para fins de foto-identificação. Desta forma é necessário manter ambos os catálogos em constante actualização e comparação. O uso de plataformas de oportunidade, barcos de *Whale watching*, para a recolha de fotografias destinadas a foto-identificação deve continuar e ser incentivado.

Apesar destes resultados apresentarem várias limitações tal como o facto de a amostragem ser referente a uma pequena área geográfica da costa algarvia e à região costeira, bem como a períodos sazonais, neste caso à época de verão, sugerem que esta área pode ser particularmente interessante em termos de abundância e diversidade de cetáceos. De acordo com os mapas de distribuição, existe um enorme potencial de zonas de *hotspot* principalmente para o golfinho comum, no entanto estes resultados também revelam a presença de espécies ameaçadas tal como o Golfinho Roaz e o Boto. A determinação de *hotspots* para estas espécies, no presente estudo, é no entanto muito limitada uma vez que apenas se estão a analisar dados referentes a um curto espaço temporal.

É necessário continuar o trabalho desenvolvido, e expandi-lo a áreas mais abrangentes, quer ao longo e ao largo da costa algarvia, bem como para zonas fora da plataforma continental. Os cetáceos são animais com enorme mobilidade e grande distribuição. Medidas efectivas de conservação e estudo devem ter em conta a relação entre as populações e o seu habitat. Desta forma é necessário perceber quais são os habitats usados com maior frequência. O uso do habitat por parte destas espécies, está relacionado com factores ambientais (bióticos e abióticos), tais como a disponibilidade de alimento, épocas de reprodução e acasalamento e, por exemplo, a temperatura da água. É necessário recolher mais informação, não só no Sul de Portugal, mas também em todo o restante Golfo de Cádiz, para se conseguir obter informações de uma forma realista, robusta e global das espécies e populações que ocorrem nesta região.

É ainda necessário ter em conta que as populações de cetáceos são bastante afectadas por acções humanas, que, sobre elas causaram ou podem causar, efeitos negativos, interferindo ou não com seus estatutos de conservação. A falta de estudos e conhecimento sobre o uso de habitat por parte das espécies de cetáceos na costa Algarvia, representa um impedimento para a implementação de medidas efectivas de conservação.

Contudo, os resultados deste trabalho sugerem que costa Sul-Oeste do Algarve é uma importante area para diferentes espécies de cetáceos e apresenta o potencial para o estabelecimento de areas marinhas protegidas.

**Palavras chave:** Sul de Portugal; Cetáceos; Hotspots; Foto-identificação; Whale watching; Golfo de Cádiz

# ABSTRACT

The South of Portugal is one of the most popular regions in the country to observe cetaceans, although until now no studies have ever been carried out in the area. The present work provides a first approach on the species occurring in the area between Lagos and Cape São Vicente.

Until present, the only existing information was based on technical reports from stranding records, indicating the possible presence of 11 cetacean species.

This study, based on data collected on board a whale watching platform, has the propose to investigate the species present in the area, their occurrence and spatial distribution, and the creation of a photo-id catalogue to Common dolphins.

Between 2005 and 2009, a total of 556 Common dolphin sightings was analysed resulting in an encounter rate (ER) of 2.01 sightings.100 km<sup>-1</sup>. During 2009, a total of 228 sightings corresponding to 6 different species of cetaceans were made in the area. Among these, the most frequent species sighted were the Short-Beaked Common dolphin (182 sightings; ER = 1.9 sightings.100km<sup>-1</sup>); the Harbour porpoise (22 sightings; ER = 0.2 sightings.100km<sup>-1</sup>), and the Atlantic Bottlenose dolphin (20 sightings; ER = 0.2 sightings.100km<sup>-1</sup>). The rest of the species, only occasionally seen, were the Risso's dolphin (2 sightings), the Minke whale and the Humpback whale (1 sighting both). The Common dolphin photo-id catalogue started in 2009 and allows the identification of 342 individuals.

The results obtained enable the identification of potential cetacean 'hotspots' in the study area, particularly concerning the Common dolphin, but also reveal the presence of endangered species, such as the Atlantic Bottlenose dolphin and the Harbour porpoise. Finally, they strongly suggest that the Southwest coast of Algarve is an important area for different species of cetaceans and has the potential for the establishment of marine protected areas.

**Keywords:** South of Portugal; Cetaceans; Hotspots; Photo-identification; Whale watching; Gulf of Cadiz

# 1. INTRODUCTION

The wide diversity of cetaceans that occurs in the South Coast of the Iberia Peninsula has been the target of many studies (Verborgh *et al.*, 2009; Stephanis *et al.*, 2008; Cañadas, 2006). Notwithstanding, the knowledge about the distribution and abundance of cetaceans in the Atlantic coast of the Iberia Peninsula remains very scarce, and often limited to specific areas (Brito *et al.*, 2009; Stephanis *et al.*, 2008; Cañadas, 2006). In Southern Portugal, this type of research, specifically directed, has not been extensively done. In fact, apart from opportunistic platforms, a systematic scientific survey was never been conducted to quantify the occurrence of cetaceans along the coastline of mainland Portugal (Brito *et al.*, 2009). In last instance, most of the information about cetaceans' occurrence in Portugal has been collected through strandings' records (Silva and Sequeira, 2003).

In the Southern region of Portugal, the stranding information indicates the presence of 12 different cetacean species (Sequeira *et al.*, 1992; Sequeira *et al.*, 1996): the Harbour porpoise, *Phocoena phocoena* (Linnaeus, 1758); the Short-beaked Common Dolphin, *Delphinus delphis* Linnaeus, 1758; the Atlantic Bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821); the Striped Dolphin, *Stenella coeruleoalba* (Meyen, 1833); the False Killer Whale, *Pseudorca crassidens* (Owen, 1846); the Risso's dolphin, *Grampus griseus* (Cuvier, 1812); the Long-finned Pilot Whale, *Globicephala melaena* (Traill, 1809); the Cuvier's Beaked Whale, *Ziphius cavirostris* Cuvier, 1823; the Gervais' Beaked Whale, *Mesoplodon europaeus* (Gervais, 1855); the Fin Whale, *Balaenoptera physalus* (Linnaeus, 1758); the Minke Whale, *Balaenoptera acutorostrata* Lacépède, 1804; and the Sei Whale, *Balaenoptera borealis* Lesson, 1828. There is also a report on a land sighting of a Northern Right Whale, *Eubalaena glacialis* (Müller, 1776) with a calf, 400 m from Cape St. Vicent, Portugal (Martin and Walker 1997).

The smallest and the most frequent dolphin along the coast of Portugal is the Short-beaked Common Dolphin (*Delphinus delphis*), while the most frequent whale is the Fin Whale (*Balaenoptera physalus*) (Brito *et al.*, 2009).

Another important source of information comes from the whale watching companies. According to the tour operators established in the coast of Algarve the most commonly encountered species are the Short-beaked Common Dolphin (*Delphinus delphis*), the Atlantic Bottlenose dolphin (*Tursiops truncatus*), the Harbour porpoise (*Phocoena phocoena*), the Risso's dolphin (*Grampus griseus*), the Killer Whale, *Orcinus Orca* (Linnaeus, 1758), and the Minke Whale (*Balaenoptera acutorostrata*) (Mar Ilimitado, Golfinho Mar and Dolphins Driven, *personal communication*). The different companies consider that the Short-beaked Common Dolphin is the most frequent species in the area,

which, although usually found in smaller pods, can form groups that can reach hundreds of animals. The remaining species being only occasionally seen.

The South Coast of Portugal is a popular area for ecotourism. In recent years, several companies dedicated to whale watching were created to meet the demand, and the industry keeps expanding every year. Currently 14 companies are licensed to operate whale watching vessels off the South Coast of Portugal (Sequeira, *personal communication*) and it is estimated that as many as 10 companies are operating without licensure. Each company has three boats in operation and averages three trips per boat per day.

The deficient control by the national organs responsible for the control of the activity justifies the high number of companies operating without licensure. Also, the large number of entities that regulate the activity, such as the Instituto de Conservação da Natureza e Biodiversidade, the Turismo de Portugal, the Turismo de Natureza and the Instituto Português e dos Transportes, leads to doubts between the operators, due to the differences in information provided by each entity. Apart from that, the poor control may also be due to the fact that, in this area, there is a considerable paucity of data.

Besides that, most of the companies do not have staff with specific formation in order to be able to provide the public with proper information about the species and the operators lack the resources needed to provide the public with current scientific information regarding cetaceans. Ecotourism must include education, environmental awareness, and conservation components to provide a meaningful bridge between the public and the science.

The fact that whale-watching boats are nowadays regularly used as “platforms of opportunity” by scientists for mark-recapture studies has contributed to diminish this problem.

The proposed scheme will utilize the whale-watching boats and crew to collect the data (Photo-ID) combining whale-watch tours with scientific research (Verborgh *et al.*, 2009; Wittich, 2009).

Further, systematically planned studies are critical to better understand the distribution, abundance and occurrence of cetaceans in this area. New guidelines for whale watching in the South of Portugal are also critical for effective long term management. When thinking about conservation measures for cetaceans, it is necessary to identify the species, the various populations and estimate their abundance, habitat use and spatial distribution. It is also important, whenever possible, to have information on their diet and natural history (Cañadas, 2006).

Marine mammals are often referred to as charismatic mega fauna: people care about them more than other species or groups, and that contributes to the conservation of

entire ecosystems (Reynolds *et al.*, 2009). In fact, several efforts have been made in order to protect marine mammals and their habitats, as shown by the considerable number of international conventions, laws and organizations devoted to the subject. Portugal, both as an independent country and as member of the European Union, is a party of most of these conventions and agreements, and therefore has the duty to follow the guidelines suggested.

The present study intends to characterize the cetacean's fauna occurring in the area between Cape São Vicente and Lagos, a region chosen because of the lack of studies on the subject.

The study will attempt to answer the following questions:

- a) Which species occur in the area?
- b) What is the encounter rate and abundance index for each species?
- c) What is the spatial distribution of the different species with relation to the bathymetric features of the Cape São Vicente area?

And to create a Photo-Id catalogue for common dolphins.

Despite having obtained data for several species of cetaceans during the time of this study, this work will focus especially, on the common dolphin, the Bottlenose dolphin and the Harbour porpoise, and intends to be an initial step into the cetaceans' investigation in the area, and serve as a baseline for future works.

## **2. STUDY AREA**

The south coast of Portugal belongs to the Algarve region. It includes approximately 160 km, from Sagres to the Guadiana river mouth (Alveirinho Dias, 1988). The continental platform is very short, varying between 7 km and 28 km wide (Magalhães, 2001 and Marques, 1982), with 17 km as the average value (Lopes & Cunha, 2010). The slope is soft and well defined, located at an average depth of 110 m to 150 m. It has 2500 km<sup>2</sup> inside the bathymetric depth of 200 m. The morphology reflects a geological evolution controlled by tectonic and sedimentary dynamics similar to other regions of the Gulf of Cadiz (Lopes & Cunha, 2010).

The currents on the Algarve platform region are generally weak. Drift currents predominate. The drift current adapt to the coastal profile, moving parallel to the coast in both directions, near the 30 m isobathymetric line. Currents reach speeds nearly 50 cm.s<sup>-1</sup> in extreme cases, although it typically flows below 25 .s<sup>-1</sup> (Magalhães, 2001).

The tides have a half-day regime and an average amplitude of 2 m (maximum: 3,5 m: minimum: 0,5 m) (Falcão *et al.*, 2003).

The average wave energy is considered low along the coast line, with seasonal variations, rising in winter following to rough weather. The result is an increase in beach erosion (Dolbeth *et al.*, 2006).

The 10 m and the 20 m isobathymetric lines follow the coast line with considerable regularity (Costa and Franca, 1982). The hydrologic characteristics, such as The salinity, the pH and the temperature are considerably uniform. The salinity is nearly constant all year, varying between 36.1 and 36.3 at surface and 36.1 to 36.4 at a depth of 50 m . The temperatures peak between July and August and reach minimum values between January and February (Ricardo, 2009).

Another characteristic of the coast of Algarve is the presence of submarine canyons and trenches, which facilitate the flow of the water masses and sedimentary load (Lopes & Cunha, 2010). The most important canyons are the Lagos canyon, the Portimão canyon, the Albufeira canyon, the Faro canyon and the São Vicente canyon. Regarding the trenches it is relevant to refer the Diogo Cão trench and the Álvares Cabral trench. This study focuses on the area between Lagos and Cabo São Vicente (Fig 1) which has the western conditions and characteristics, also part of this area is inserted in the Natural Park, Parque Natural do Sudoeste Alentejano e Costa Vicentina.

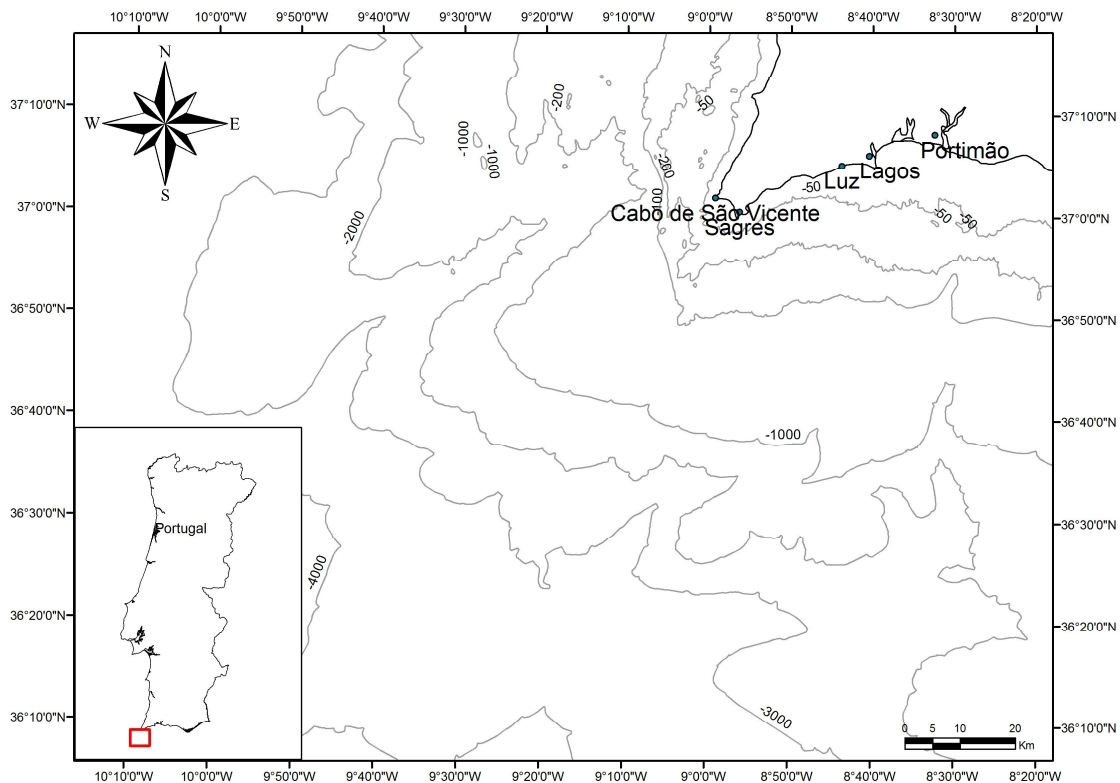


Figure 1. Location of the study area.

The São Vicente canyon has substantial influence in this area. It is located in the Gulf of Cadiz (GoC), in the Northwest Atlantic Ocean, off SW Iberia. The GoC is located between the Straits of Gibraltar (5°W) and the Gorringe Bank (12°W) between 34°N and 38°N (Valadares *et al.*, 2009). The canyon has a general staircase-like shape with the upper and lower parts trending NE-SW and the middle sector with an NNE-SSW direction (Valadares *et al.*, 2009). The São Vicente canyon head lies very close to the shore, at depths shallower than 70 m and runs towards the Horseshoe Abyssal Plain at an approximate depth of 4900 m. It extends for more than 120 km, being the larger submarine canyon on the GoC, reaching up to 20 km in width (Valadares *et al.*, 2009). Tide-topography interaction along a submarine canyon is able to enhance mixing, providing a cross shelf eddy flux of salt. Vertically forced tidal currents advect salty waters from the bottom of the canyon to its head, where mixing takes place. Differences in salinity between up and down canyon tidal currents produce an eddy flux of salt (Vargas-Yáñez *et al.*, 2002).

"Meddies" (Mediterranean eddies) are warm, salty eddies of Mediterranean water generated by instabilities in the water flowing from Gibraltar. The Cape São Vicente is a generation site for meddies by a mechanism of separation of the frictional boundary layer at these sharp corners (Serra & Ambar, 2000). Eddies are responsible for upwelling phenomenon, generating richer waters at the surface (Alan E. Burger, 2003; Lee *et al.*, 1999). Eddies also contribute to the upwelling with warmer waters generated by spring-summer winds (Baringer & Price, 1997). Because of these characteristics, the São Vicente canyon has great influence on marine life around Sagres, helping to increase the productivity of these waters and supporting a considerable biodiversity.

### 3. STUDIED SPECIES

The basic knowledge about the species that are the object of the present study will help to better understand their distribution, habitat use and dynamics.

The Short-beaked Common dolphin, *Delphinus delphis* Linnaeus, 1758:



Figure 2. Short-beaked Common dolphin in the South of Portugal (photo by Joana Castro).

Until today, two species of Common dolphin are recognised worldwide: the short-beaked (*Delphinus delphis*) and the long-beaked (*D. capensis*), with a subspecies of the long-beaked (*D. capensis tropicalis*) also acknowledged. This consideration of two species is based on the morphological difference which has been supported by genetic analysis, that shows considerable differences in the mitochondrial DNA between both forms (Rosel *et al.*, 1994), which suggests that they have been separated for a long time and probably do not interbreed, despite living in sympatry. On the other hand, some authors consider that only one species exists, *Delphinus delphis*, and that the others are geographic forms or subspecies (Cañadas, 2006).

Even though this species is very widespread in most of the European waters, there are many aspects of common dolphin biology and ecology, including abundance, distribution and taxonomy that remain unclear (ECS 2004).

The Short-beaked Common dolphin is a small cetacean with a very wide distribution (Bearzi *et al.*, 2003). This distribution it is not panmictic and can be found in series of geographically separated populations (Heyning & Perrin, 1994; Perrin & Brownell, 1994; Jefferson & Van Waerebeek, 2002). Studies on the abundance and distribution of cetaceans are not easy, particularly concerning species like common dolphins, with a world wide range, different habitat types (Hammond *et al.* 2002, Lopez

2003, Silva and Sequeira 2003) and both long term and short term movements (Northridge *et al.*, 2004; Brereton *et al.*, 2005).

The average size of an adult Common dolphin is approximately 2 m in length, with males slightly larger than females (Evans 1987). Adults' weight varies between 75 - 85 kg, with a maximum 136 kg (Evans 1987; Evans 1994). Pregnancy is estimated to be 10-11.5 months (Evans 1987; Perrin and Reilly 1984; Murphy 2004) and the calves are born with 80 cm to 90 cm in length (Evans 1987; Evans 1994).

In relation to predators, it is known that cetaceans have very few of them, although the main predators are sharks, Killer whales, False Killer whales and Man (Perrin *et al.*, 2002). In the South of Portugal, there is an anecdotal evidence showing that the presence of Killer Whales (*Orcinus orca*) and False Killer (*Pseudorca crassidens*) is very rare, which is why the predators of dolphins here can be reduced to sharks and the Man (direct or accidental death).

Harbour porpoise, *Phocoena phocoena* (Linnaeus, 1758)



Figure 3. Harbour porpoise in the South of Portugal (photo by Joana Castro).

The Harbour or Common porpoise, *Phocoena phocoena* (Linnaeus 1758), is one of six species recognised in the family Phocoenidae (Read 1999). It is the smallest cetacean that occurs in the Atlantic Ocean (Sequeira, 1988) and in European waters (Watson, 1985). On average, the size of an adult is around 150 cm to 160 cm and the weight 45 kg to 60 kg (Gaskin *et al.*, 1974). In the North Sea the maximum size for males and females was 170 cm (55 kg) and 171 cm (55.5 kg), respectively (Lockyer 1995; Santos *et al.*, 2001a; Santos and Pierce, 2003). Nevertheless, the information from strandings in the northwest Spain and Portugal shows that Harbour porpoises in these areas seem to be larger, around 200 cm (Donovan & Bjørge 1995; Sequeira 1996).

Harbour porpoises are widespread in coastal waters of the Northern Hemisphere and in temperate and subarctic waters in the North Atlantic and North Pacific (Santos and Pierce, 2003). Although this was once the most common of the cetaceans in European waters, it has suffered a serious decline, between 53,000 and 89,000 animals, in the last century (Reijnders, 1992). The species is listed in the Appendix II of CITES and The Red List Category and Criteria for Harbour porpoise is “*Least Concern*” ([www.iucnredlist.org](http://www.iucnredlist.org)).

In continental Portugal, the first records of Harbour porpoises were made in the 19<sup>th</sup> century, and indicate that this species was very abundant (Bocage in Sequeira 1988; Nobre in Sequeira 1988). In late 1970s the records indicate a decrease in the amount of animals, only seen occasionally and moving alone or in small groups (Teixeira in Sequeira 1988). Nowadays most of the information about this species in mainland Portugal comes from stranding records along the coastline, and that is how the abundance and occurrence have been estimated.

Atlantic Bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821)



Figure 4. Atlantic Bottlenose dolphin in the South of Portugal (photo by Joana Castro).

The Bottlenose dolphin is distributed worldwide, showing such an extraordinary adaptation to the diverse conditions in different regions that it is difficult to define fixed characteristics for the species' feeding habits, behaviour or social structure (Cañadas 2004).

*Tursiops* is a polytypic genus (Hershkovitz 1966). There are a lot of different morphotypes that differ in coloration pattern, body measures and cranial structure (Walter 1981; Ross and Cockcroft 1990). These differences arise controversy among scientists, and some consider there are more than 20 different species belonging to the genus *Tursiops* (Hershkovitz 1966; Ross 1977; Walter 1981; Ross and Cockcroft 1990). As most

of the distribution of these characters generally overlaps (Walter 1981; Ross and Cockcroft 1990), *Tursiops truncatus* was considered as a single species by many experts (Ross and Cockcroft 1990; Wilson and Reeder 1993) until molecular data supported the separation of *Tursiops aduncus* as a different species (LeDuc *et al.*, 1999; Wang *et al.*, 1999).

Studies done in different areas of distribution revealed two distinct morphotypes: the coastal morphotype and the offshore morphotype (Ross 1977, 1984; Walter 1981; Perrin, 1982; Leatherwood and Reeves, 1983; Duffield *et al.*, 1983; Ross and Cockcroft 1990; Van Waerebeek *et al.*, 1990; Mead and Potter 1995; Torres *et al.*, 2003). According to Perrin (1982) this distinction is related to and based on morphologic aspects, such as number of teeth and the robustness of the jaw, which might be connected with the type of diet and habitat. Mean adult length ranges between 2.5 m and 3.8 m (Mead and Potter, 1990; Read *et al.*, 1993). These sizes have great variability, especially when both morphotypes described are compared, the coastal being rather smaller than the offshore one (Perrin *et al.*, 2002). Coloration is a more or less uniform dark grey body with white belly. In general *Tursiops truncatus* is more robust than the other small delphinids, the common dolphin or the striped dolphin for example (Cañadas 2004). Bottlenose dolphins reach sexual maturity at the age of 8-12 years in males and 5-10 years in females (Reynolds *et al.*, 2000). The gestation period is about 12 months and the lactation period goes from 12 to 20 months (Perrin *et al.*, 2002; Reynolds *et al.*, 2000).

*Tursiops truncatus* is an opportunistic species, feeding on the most abundant prey (Sequeira, 1988), and feeds mainly on demersal species (Gunter 1942; Tomilin 1957; Evans 1987; Barros and Odell 1990; Gannier 1995). In the Atlantic waters of Portugal and Galicia, the analysis of stomach contents indicates that 99% of the diet is composed by fish, with the Gadidae, and especially the blue whiting, as main prey items, (Santos *et al.*, 1996; Silva and Sequeira 1997).

Bottlenose dolphins have a very cosmopolitan distribution. The species is widespread in the world's temperate and tropical oceans, occupying most marine habitats except the polar zones (Leatherwood and Reeves, 1983; Klinowska, 1991; Wilson *et al.*, 1999). In continental Portugal, several studies were made on a resident population at the Sado Estuary (dos Santos, M. E. and Lacerda, 1987; Gaspar, R. 1994; Freitas, A. 1995; Brito, C. 2001), but there is a lack of knowledge about this species in relation to the distribution, population, and habitat use in other areas of continental Portugal. The only information found related to the south of Portugal belongs to SEC (Sociedad Espanola de Cetáceos), which conducted an expedition in the Gulf of Cadiz and Portuguese waters in 2004, and only sighted one Bottlenose dolphin in Portuguese waters.

## Other Species

Minke whales, *Balaenoptera acutorostrata* Lacépède, 1804, are the smallest and most abundant of the roquals. The species can be found in all the world's oceans, having a large and cosmopolitan distribution (Perrin *et al.*, 2002). Minke whales are considered more frequently distributed near shore than in open ocean (Tetley 2004), often associated with coastal habitats or ice edge areas (Kasamatsu *et al.*, 2002). Most of the information about the occurrence of this species in Portugal comes from strandings (Sequeira *et al.*, 1992; Sequeira *et al.*, 1996).

Humpback whales, *Megaptera novaeangliae* (Borowski, 1781) are known for their wide distribution and long migrations, with several instances of 8000 km migration reported (e.g. Stone *et al.*, 1990; Darling *et al.*, 1996; Stevick *et al.*, 1999), though details of these migrations are poorly known. (Stevick *et al.*, 2003). In the Mediterranean Sea this species has always been considered extremely rare (Aguilar, 1989; Notarbartolo di Sciara and Demma, 1997), but since 1990 the number of sightings has increased (Frantzis *et al.*, 2004). In mainland Portugal, most information on the occurrence of humpback whales comes from the strandings (Sequeira *et al.*, 1992; Sequeira *et al.*, 1996).

Risso's dolphin, *Grampus griseus* (Cuvier, 1812), is a species with a large distribution. It can be found in all the oceans: in the Pacific, from the Kuril Islands and the Southeast of Alaska, to New Zealand and Chile; in the Atlantic, from the Newfoundland and the Scottish Shetland Islands to Argentina and South Africa; in the Indian, from the south of South Africa to the South of Australia, Tasmania and New Zealand. It is also found in the Red Sea (Evans, 1987). Usually individuals of this species occur in offshore areas, although in the Atlantic it is frequent to observe small groups close to shore on the West coast of Africa, Atlantic islands (Cape Verde, Canarias and Azores) and on the European coast (Mainland Portugal, Golf of Biscay, West coast of Ireland and Scotland) (Evans, 1987).

There are records of the occurrence of this species near mainland Portugal since 1924 (Chaves, 1924). Nowadays, in the Azores it is considered a very common species (Silva *et al.*, 2003), though in mainland Portugal there are few records.

## 4. METHODOLOGY

### 4.1. Data Collection – Survey and Sightings

#### 4.1.1. Field data collection

A whale watching boat from the company, Mar Ilimitado, operating in Sagres was used as an opportunistic platform in this study. This company conducts three trips a day, with a single vessel boat. Carrying capacity includes 12 passengers, one skipper and one guide. The average duration of each trip is 90 minutes.

Data from sightings of common dolphins (between 2005 and 2009) and Bottlenose dolphins and Harbour porpoises (during 2009), were analysed.

The transects made by the company were random tracks, with any pre-defined path.

Since a platform of opportunity was used in this work, several limitations are to be considered with this kind of survey: time spent with the animals, the approach of the boat, the velocity during effort, and the duration of each trip.

All trips used in this study were approximately 1h 30 min, but the number of trips per day was variable according to the availability of tourists and meteorological conditions. During the surveys a continuous effort was made at all times, only stopping when a group of cetaceans were approached. In most of the trips two observers searched for the animals covering an 180° angle ahead of the vessel.

The sighting effort was measured as the number of kilometres travelled searching for cetaceans. The position of the boat was recorded during all trips by a GPS (Global Position System), creating the track for each trip.

Data between 2005 and 2009 were collected by the employees of the whale-watching company and, although the company's database included different data parameters, depending on the observer responsible for collecting the data, several of them, such as the GPS track, the GPS position of the animals, date, species sighted, number of individuals, presence or absence of calves, group cohesion and environmental data (sea state, wind speed, visibility) were consistent across all years. From 15<sup>th</sup> of June to 30<sup>th</sup> of September 2009 the following data were systematically collected: GPS track, date, species, GPS position, distance from the boat, angle, the initial cue, initial behaviour, contact behaviour, final behaviour, response of the animal to the boat, cohesion of the group, number of individuals, number of adults, juveniles, calves and newborns, direction of travel of the animal, and information on the number of boats present in a circle of 300m. Environmental data, such as depth, water temperature, visibility, wind direction, Beaufort, sea state and swell were also collected. Although all these information were collected,

only the GPS track, the GPS position, date, species, number of individuals, presence or absence of calves, and group cohesion will be analysed in the present work.

For purposes of data analysis, the study area was divided into quadrats using a grid with a cell resolution of 2 min latitude (3704 m) by 2 min longitude (3006 m), using ArcGIS 9.3. This scale was used in order to make the results comparable to those of previous studies and with future research programs carried out by CIRCÉ (Conservation, Information & Research on Cetaceans). Following de Stephanis *et al.*, (2008), only the cells with a sighting effort of at least 3 km were used in the analyses.

For each cell the total of km (effort for each cell), the total number of sightings, and the total number of animals sighted was calculated.

#### **4.1.2. Presence and relative abundance of cetaceans**

To quantify the cetaceans' relative abundance three parameters were used:

1 – The Encounter Rate (ER) (sightings km<sup>-1</sup>), the number of sightings of a given species per 100 km of effort: **ER = (Sightings/Effort) x 100.**

2 – The abundance rate (AR) (ind. km<sup>-1</sup>) defined as the number of individuals of a given species over the effort in the research area in km: **AI = (Individuals/Effort) x 100.**

3 - Density Estimation (using “Kernel Density Estimation”, a statistical tool from ArcGIS (Hawth's Tools)) (Beyer, H. L. 2004), a non-parametric way of estimating the probability density function of a random variable. For example, given some data about a sample of a population, this analysis extrapolates the data to the entire population. Kernel Density Estimation was calculated for *Delphinus delphis* between the years of 2005 - 2009. For *Tursiops truncatus* and *Phocoena phocoena* only the year of 2009 was used.

The Kernel tool was run using both ER and AI per cell as a weighting factor. If a sighting fell inside a cell with less than 3 km effort, a weight of 1 was attributed, making the point neutral to the analysis (Beyer, H. L. 2004).

#### **4.1.3. Spatial distribution and bathymetry**

Two bathymetric features were used, the depth and slope. The mean depth and slope were calculated for each quadrat. Depth data were obtained from the Portuguese hydrographic institute (Instituto Hidrográfico - <http://www.hidrografico.pt/download-gratuito.php>). From this data we created a TIN (Triangulated irregular network) in order to get the slope (a raster with a resolution of 100x100 m) and then, each cell assumed as bathymetric gradient the maximum slope and the mean depth.

The distribution of cetaceans according to depth and slope was made based on a continuous depth and slope data set, the mean values of quadrats. Depth and slope were ranked into subjective categories to provide a pertinent ecological context for the interpretation of the results (Figs. 19, 20 and 21; Table V).

Depth was categorised according to the diving capabilities of the observed cetaceans and the minimum and maximum depths in the study area: 50–100 m, 100–150 m, 150–200 m and  $\geq 200$  m.

The slope was categorised as follows: 0 –80  $\text{m.km}^{-1}$ , 80–160  $\text{m.km}^{-1}$ , 160–240  $\text{m.km}^{-1}$  and  $\geq 240$   $\text{m.km}^{-1}$ .

#### **4.1.4. Social organization: group size, group cohesion and presence or absence of calves**

The group size was obtained by the minimum and maximum values of the encountered groups per species. In 2009 the group cohesion was calculated to all species (Table I).

Table I - Classifications of group cohesion

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	<b>D</b> = dispersed (> 5 bodies)
	<b>C</b> = compact (1-5 bodies)
<b>Group Cohesion</b>	<b>VC</b> = very compact (< 1 body)
	<b>L</b> = lone individual
	<b>NI</b> = not identifiable

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The presence or absence of calves was analysed based on the data for two species: *Delphinus delphis* and *Tursiops truncatus*.

For *Tursiops truncatus*, the total number of sightings was considered, and the presence (Pr), absence (Ab) or the incapacity to identify the presence or absence of calves (not identifiable - NI) in each sighting, during 2009, were analysed.

Concerning *Delphinus delphis*, the data was tested for normality and homoscedasticity and, given the results, the non parametric Kruskal-Wallis test, with a 95% confidence interval, was used to compare the differences in the presence of calves among different years (2005-2009) using the groups in which it was possible to determine this variable. The Dunn test was used for pairwise testing.

## 4.2. Data Collection - Photo-ID

Photo-identification (Photo-ID) is a methodology that uses photographs of long-term natural marks, such as nicks and notches on the dolphins' dorsal fins (Würsig and Jefferson 1990; Bearzi *et al.*, 2005) as well as scars and pigmentation patterns (Hammond *et al.*, 1990; Auger-Méthé and Whitehead 2007) to identify individuals. Photo-ID methodology has several advantages, such as the fact that it is a non-invasive and inexpensive technique, allowing extensive use in cetacean studies (Hammond *et al.*, 1990; Auger-Méthé and Whitehead 2007).

During the present study photos were taken with a Nikon D200 camera using 18-200mm and 70-300mm lenses, between 15<sup>th</sup> June and 30<sup>th</sup> September 2009, on board a whale watching boat belonging to the company Mar Ilimitado.

All species encountered were photographed, but Common dolphins (*Delphinus delphis*) were the only ones included in the catalogue, which is the first catalogue developed for common dolphins in the south coast of continental Portugal.

All pictures were catalogued and each individual was attributed a code of the form DD\_ALG\_XXXX, where DD stands for *Delphinus delphis*, ALG for Algarve (the region of the study) and XXXX the number assigned to the particular individual in the catalogue (ex: DD\_ALG\_0001). The catalogue was handmade, with no Photo-ID program used. In the identification nicks and notches in the dorsal fin were used (Würsig and Jefferson 1990), as well as body scars and pigmentation patterns (Lockyer and Morris 1990).

Each picture was analyzed and the data information was organized in a Microsoft EXCEL datasheet. The data consisted of basic information such as: sighting number, picture number, number of individuals in the picture, number of the individual analysed in the picture (starting from the closest individual to the furthest and from left to right when two animals were at the same distance), date of the picture, angle, individual quality, and code name of the individual.

The angle of the picture starts in 0° when the animal is photographed directly from the front and goes around the animal clockwise every 30° (Fig. 5).

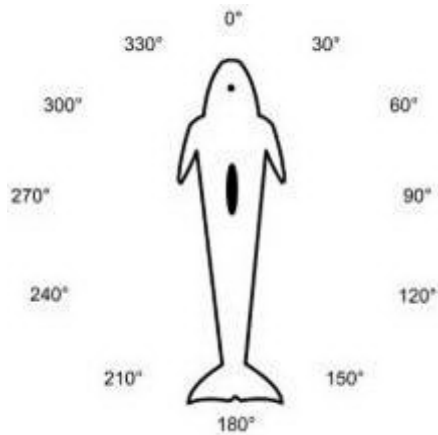


Figure 5. Photo-id angles.

In each picture, each individual was attributed a quality rating (Q) on a scale from 0 to 2 (poor to excellent) based on five characteristics: focus, size, orientation, exposure, and the percentage of the fin visible in the frame (Table II).

For the purpose of the catalogue only the best quality pictures (Q1 and Q2) (Table II) were used.

Table II - Quality rating for photos used in photo-id process

Quality rating (Q)	Description
Q0	Unusable individual dorsal fin: blurred, too far away or if the angle is between 330° and 30° or 150° and 210° (Fig. 6)
Q1	Medium quality representation of part of the fin or the entire dorsal fin (Fig.7)
Q2	High quality representation of the entire dorsal fin (Fig.8)



Figure 6. Photo Q0



Figure 7. Photo Q1



Figure 8. Photo Q2

Following the conditions stated above, a catalogue of the dorsal fins from both the left and the right side was created.

This catalogue was compared with that of the Gulf of Cadiz (belonging to CIRCÉ), the closest population to the study area, to see if there were any matches. Only the left side catalogue was considered in this process because there is only a left side catalogue for the Gulf of Cadiz.

## 5. RESULTS

### 5.1. Surveys and Sightings

#### 5.1.1. Presence of cetaceans and relative abundance

From 2005 to 2009 a total of 27610.44 km of transects were covered in the study area, with a total of 556 sightings of Common dolphins (*Delphinus delphis*). The year with higher ER was 2008 and the one with the lowest was 2006. On the other hand, 2006 was the year with higher AI and 2007 the one with the lowest (Table III).

Table III - Number of sightings of Common dolphins (*Delphinus delphis*), mean group size, standard deviation (SD), encounter rate (ER) and abundance index (AI) calculated in relation to the observation effort in 2005-2009

Year	Effort (Km)	Number of groups seen	Mean group size	Range	SD	ER	AI
2005	2412,82	39	37.18	2 - 135	33.80	1,62	60,10
2006	3693,60	77	45.55	1 - 301	64.86	2,08	94,95
2007	5423,09	100	20.84	1 - 101	18.68	1,84	38,43
2008	6481,71	158	17.60	1 - 101	21.11	2,44	42,91
2009	9599,22	182	25.24	1 - 500	41.05	1,90	47,85
Totals	27610,44	556	10.87	1 - 500	28.62	2,01	52,21

Between February 14<sup>th</sup> and October 26<sup>th</sup> 2009, the effort was 9599,22 km in 233 different trips, corresponding to approximately 412 hours, carried out from one vessel. A total of 228 cetacean sightings comprising 6 different species were made (Table IV). Effort and spatial distribution for each species is shown in Figs. 9, 12, 15 and 18.

Table IV - Number of sightings per species, mean group size, standard deviation (SD), encounter rate (ER) and abundance index (AI) for 2009

Species	Number of groups seen	Mean group size	Range	SD	ER	AI
Common dolphin <i>Delphinus delphis</i>	182	25,24	1 - 500	41,05	1,90	47,85
Harbor porpoise <i>Phocoena phocoena</i>	22	2,86	1 - 6	1,58	0,23	0,66
Bottlenose dolphins <i>Tursiops truncatus</i>	20	17,1	1 - 50	11,8	0,21	3,56
Risso's dolphin <i>Grampus griseus</i>	2	5	1 - 5	-	0,02	0,10
Minke whale <i>Balaenoptera acutorostrata</i>	1	1	-	-	0,01	0,01
Humpback whale <i>Megaptera novaeangliae</i>	1	1	-	-	0,01	0,01
Totals	228	-	-	-	-	-

### **5.1.2. Spatial distribution of the different species of cetaceans**

#### **Common Dolphins (*Delphinus delphis*)**

##### Spatial distribution - Results for 2005-2009

The results of the analysis of the spatial distribution of Common dolphins are based in all the data pooled among the years 2005 to 2009.

The area covered and the respective trackings and sightings of Common dolphins during the study period are represented in Fig.9.

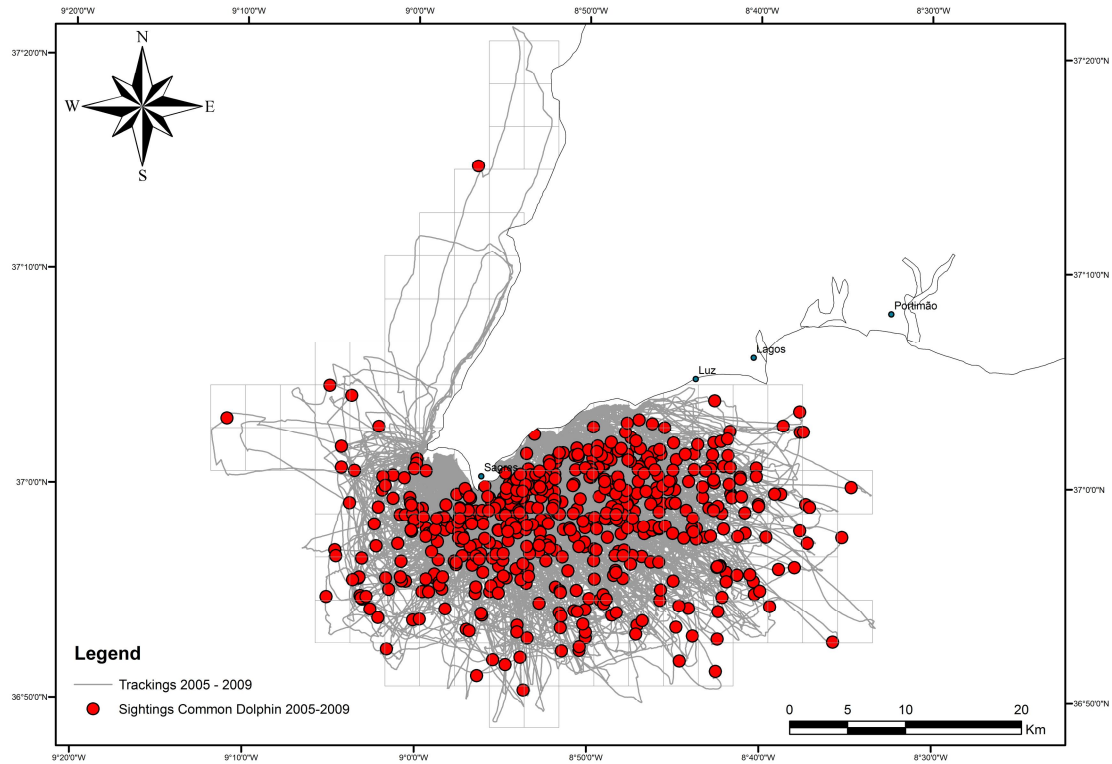


Figure 9. Observation effort (km) during 2005-2009 (grey lines) and the sightings of Common dolphins (red dots).

The range in distance from the coast line varies between 313,98 m and 23919,62 m. In Average common dolphins were found 7438,01 m away from shore.

Figs. 10 and 11, show the areas of higher probability density distribution of Common dolphins, according to the Kernel analyses and using the ER and AI as weight factor.

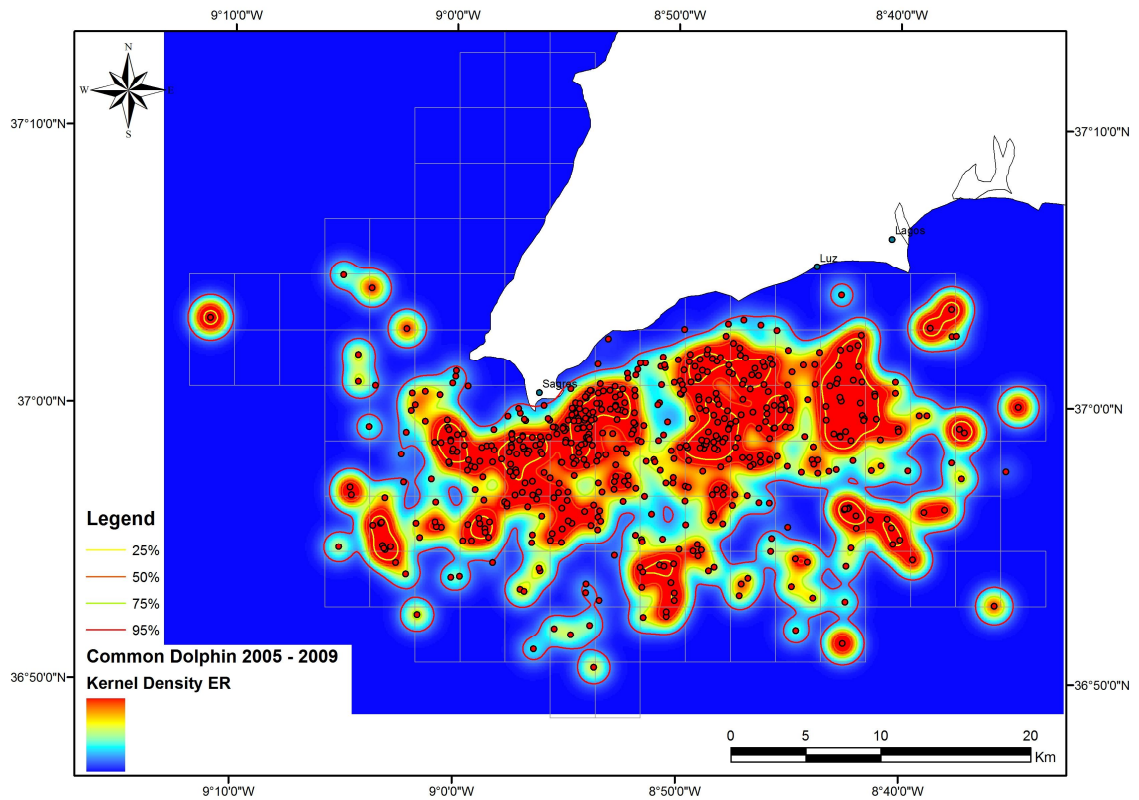


Figure 10. Kernel density spatial distribution of Common dolphins weighted by the encounter rate (ER) during 2005-2009, representing areas of higher probability of hotspots.

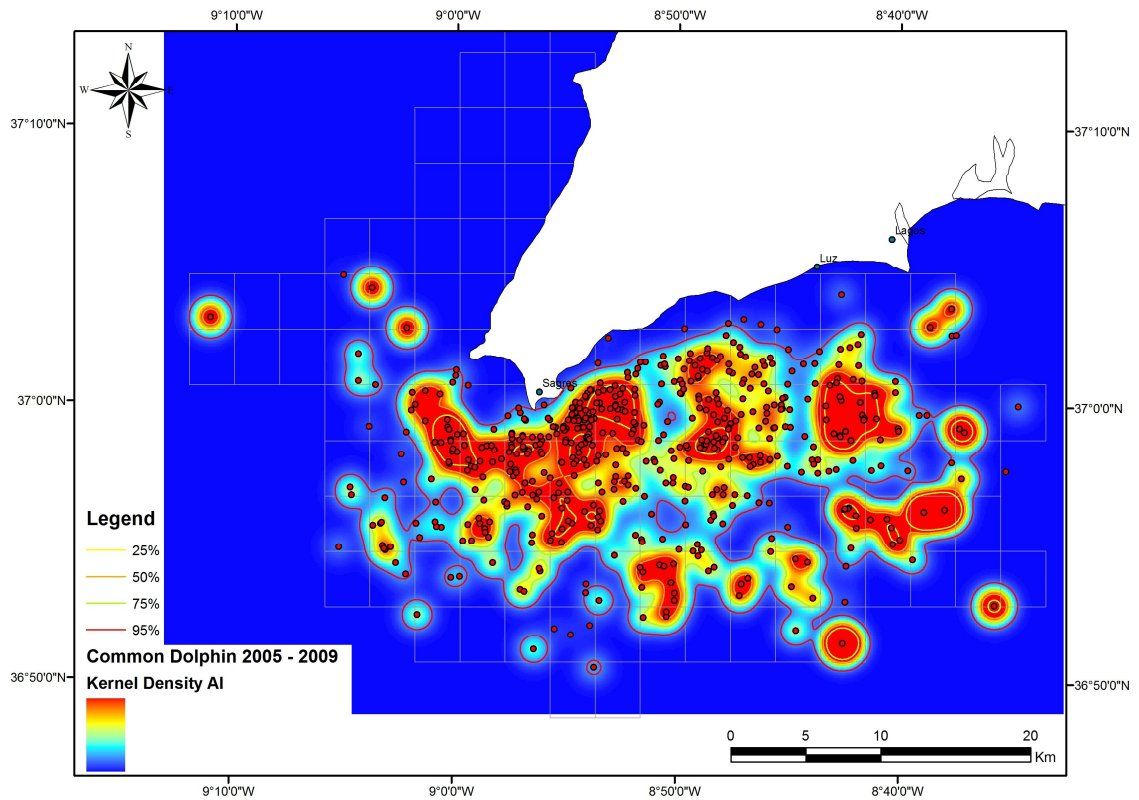


Figure 11. Kernel density spatial distribution of Common dolphins weighted by the abundance index (AI) during 2005-2009, representing areas of higher probability of hotspots.

## Harbour porpoise (*Phocoena phocoena*)

### Spatial distribution - Results for 2009

The area covered and the respective tracks and sightings of Harbour porpoises during 2009 are represented in Fig.12

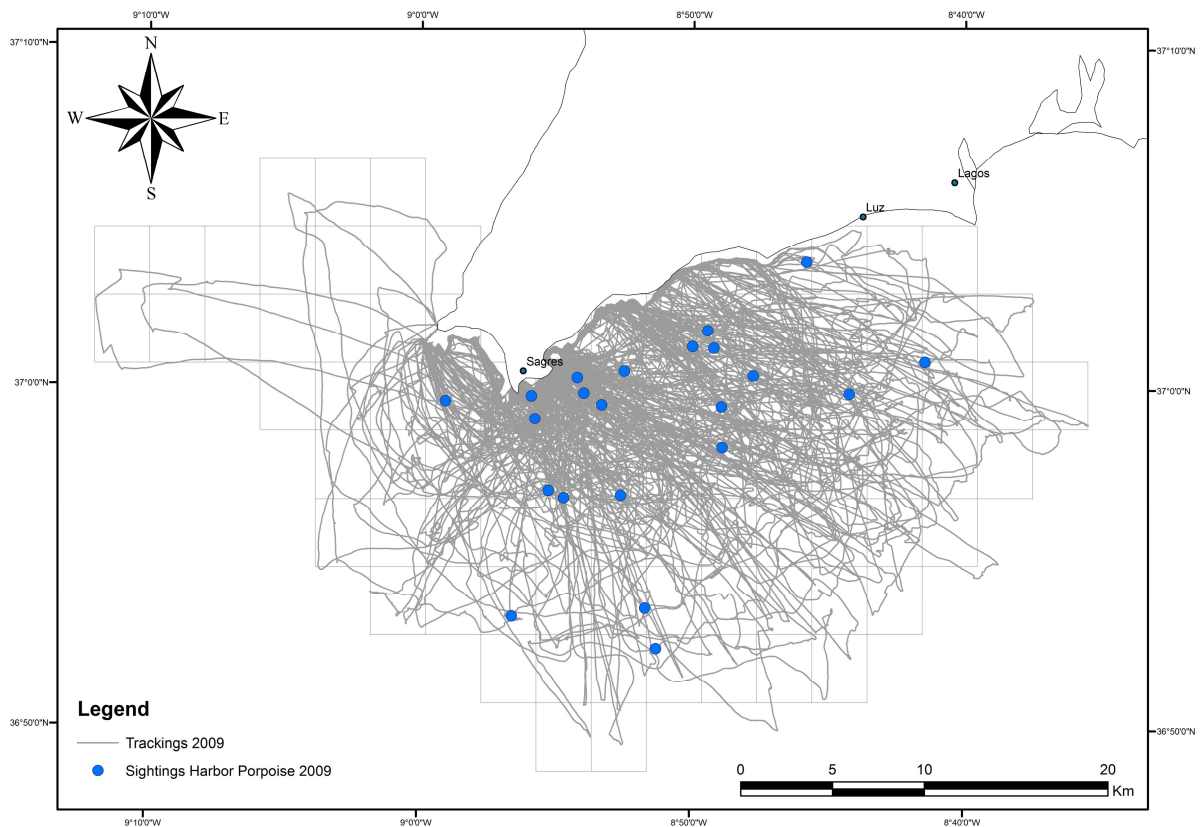


Figure 12. Observation effort (km) during 2009 (grey lines) and the sightings of Harbour porpoises (blue dots).

The range in distance from the coast line varied between 738.92 m and 15768.48 m. Harbour porpoises were found at a mean distance of 5873.91 m from shore.

Figures 13 and 14, show the areas of higher probability density distribution of Harbour porpoises in 2009 according to the Kernel analysis using the ER and AI as weight factors.

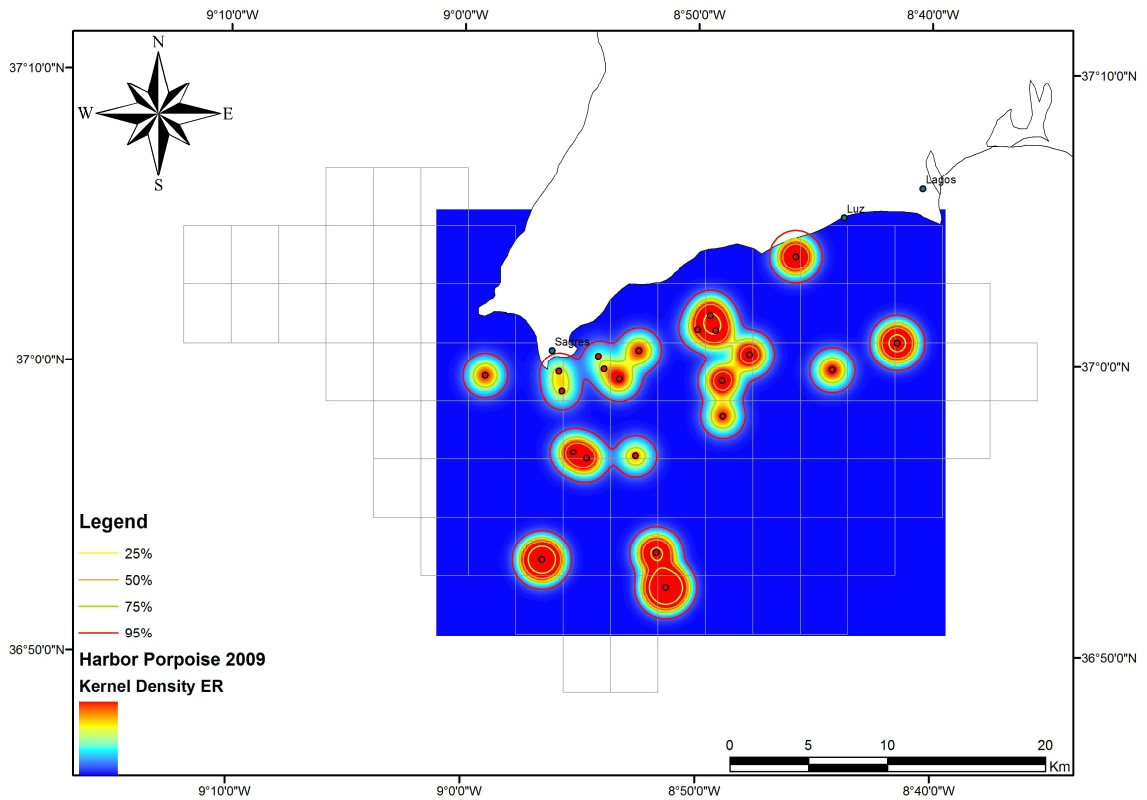


Figure 13. Kernel density spatial distribution of Harbour porpoise weighted by the encounter rate (ER) during 2009, representing areas of higher probability of hotspots.

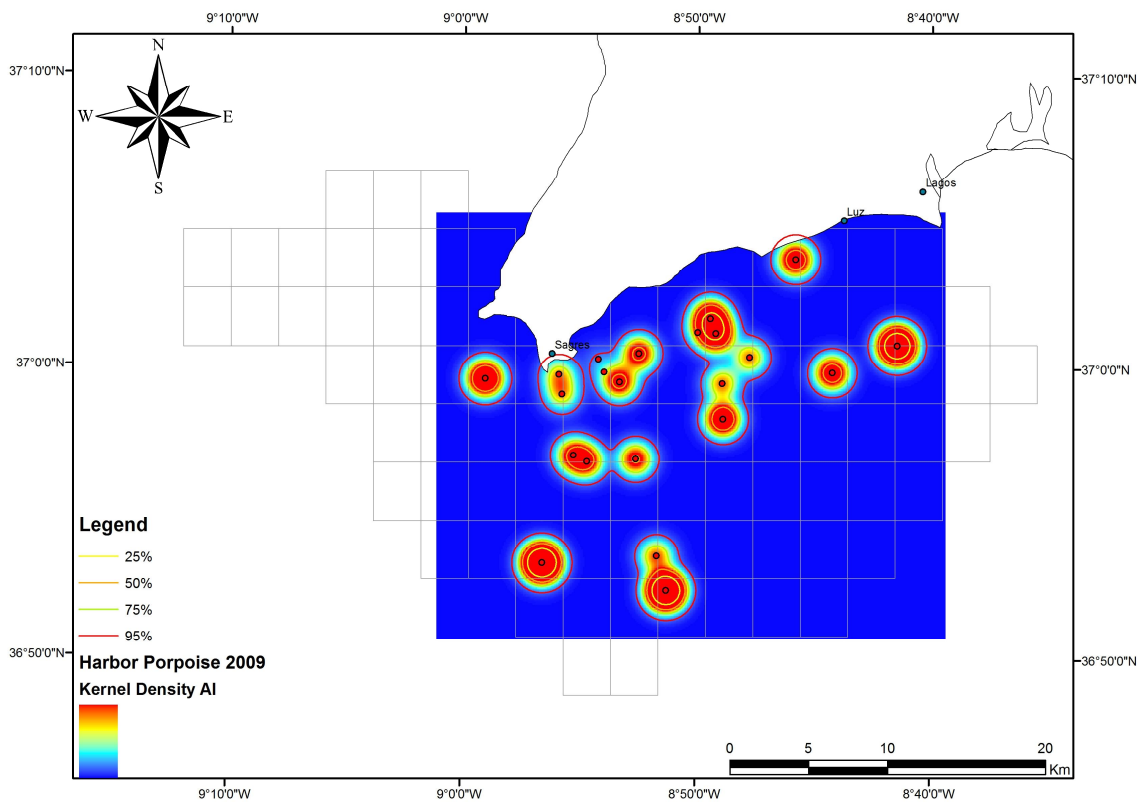


Figure 14. Kernel density spatial distribution of Harbour porpoises weighted by the abundance index (AI) during 2009, representing areas of higher probability of hotspots.

## ***Bottlenose dolphin (Tursiops truncatus)***

### Spatial distribution - Results for 2009

The area covered and the respective tracks and sightings of Bottlenose dolphins during 2009 are represented in Fig. 15.

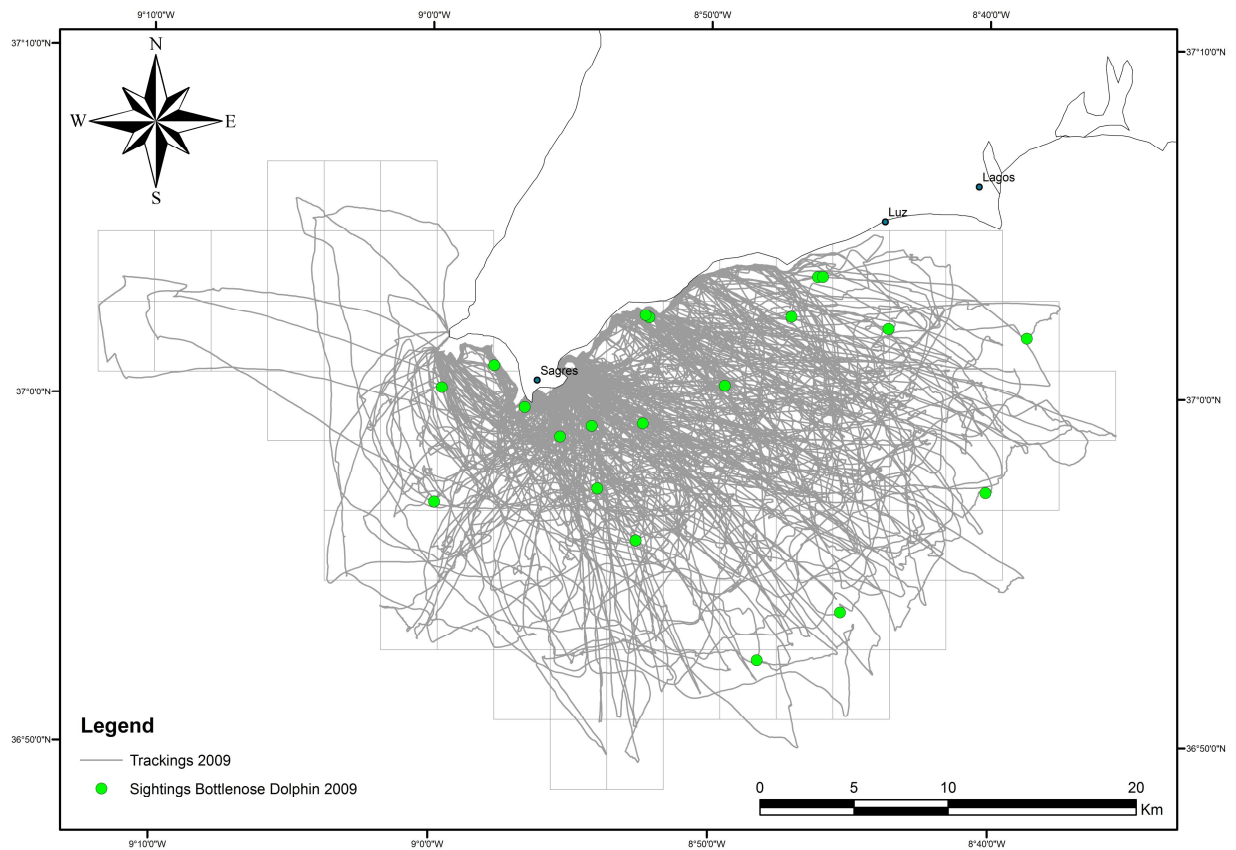


Figure 15. Observation effort (km) during 2009 (grey lines) and the sightings of Bottlenose dolphins (green dots).

The range in distance from the coast line varied between 419,74 m and 18650,40 m. In average Bottlenose dolphins were found 5519,34 m away from shore.

Figures 16 and 17 show the areas of higher probability density distribution of Bottlenose dolphins in 2009 according to the Kernel analysis using the ER and AI as weight factors.

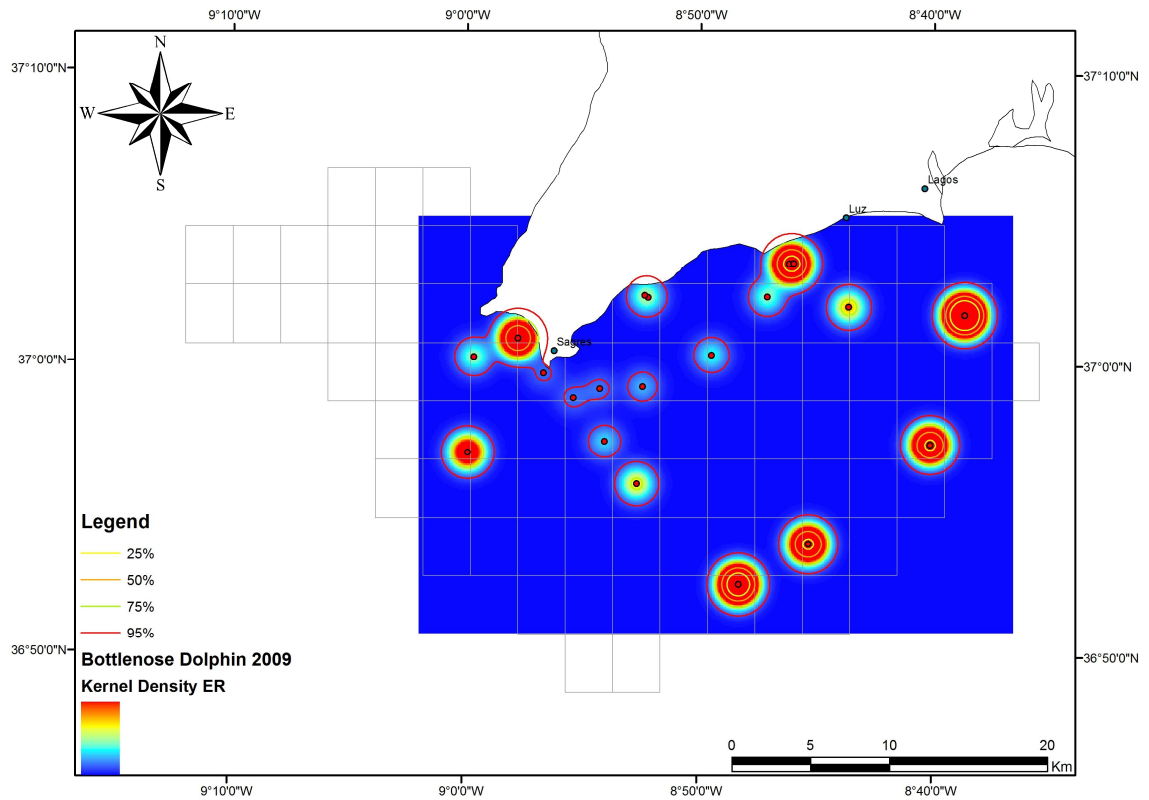


Figure 16. Kernel density spatial distribution of Bottlenose dolphins weighted by the encounter rate (ER) during 2009, representing areas of higher probability of hotspots.

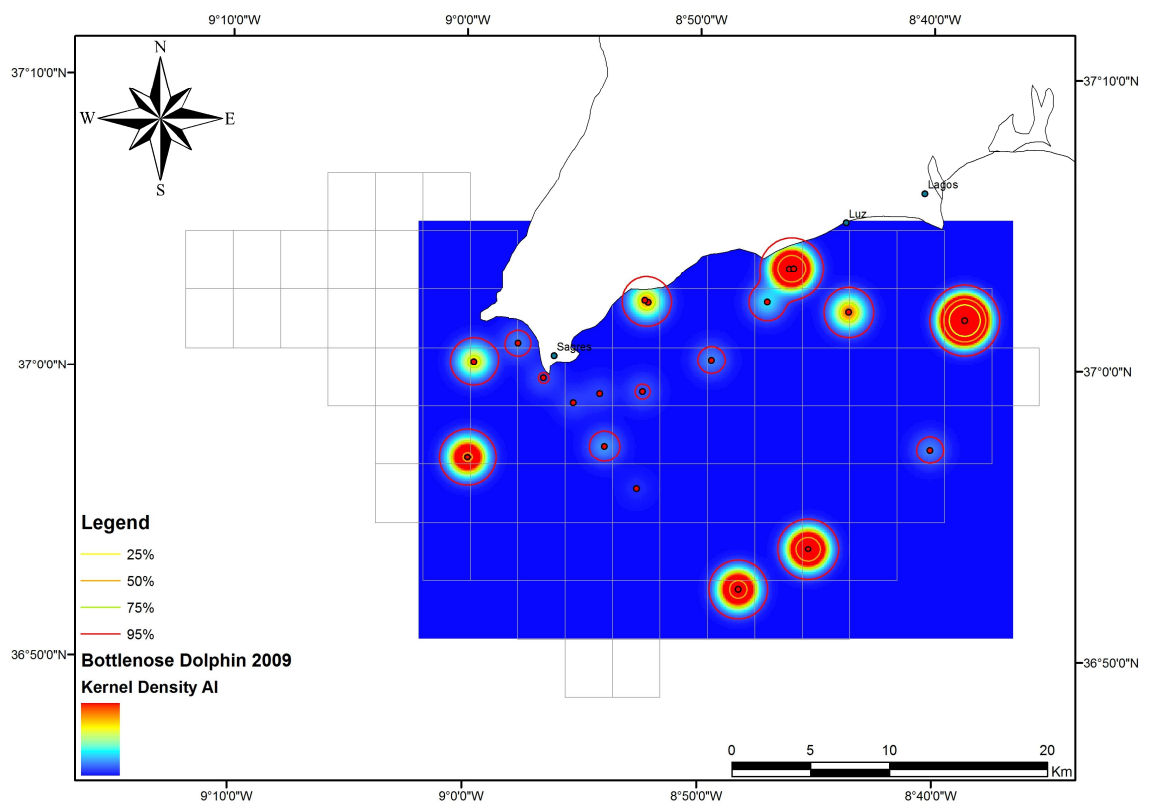


Figure 17. Kernel density spatial distribution of Bottlenose dolphins weighted by the abundance index (AI) during 2009, representing areas of higher probability of hotspots.

## Other Species

### Spatial distribution - Results for 2009

The area covered and the respective tracks and sightings of Minke whales, Risso's dolphins and Humpback whales, during 2009 are represented in Fig. 18.

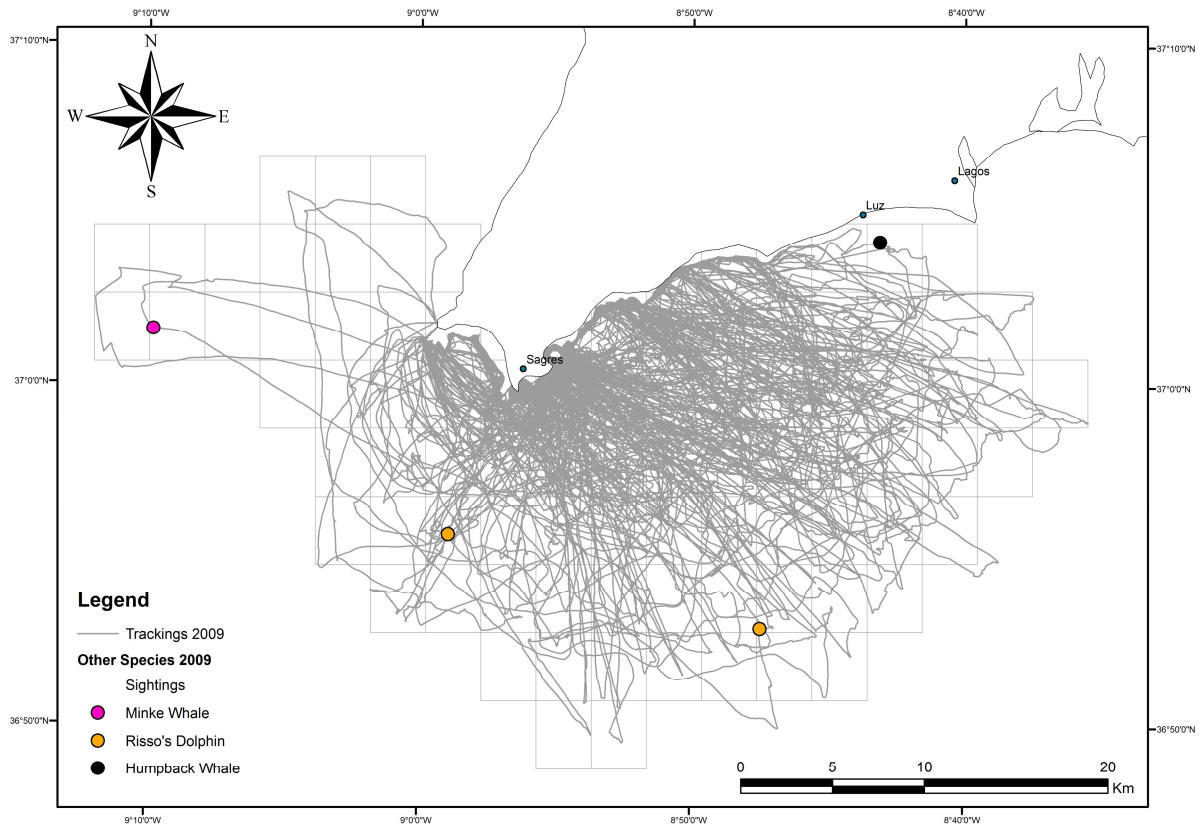


Figure 18. Observation effort (Km) during 2009 (grey lines); sightings of Minke whale (pink dots); sightings of Risso's dolphin (yellow dots); sightings of Humpback whale (black dots).

The Minke whale sighting was made approximately 15469,5 m from shore and in a region 1000 m deep. Risso's dolphins were found at 18062,6 m and 8652,9 m from shore, at a region 179,23 m and 100 m deep respectively, The Humpback whale was found very close to shore, 1774,39 m away in a region 50 m deep.

### 5.1.3. Bathymetry and Slope

The number of sightings per 100 km of effort was considered relative to depth and slope.

Concerning depth, and since there are no sightings in zones shallower than 50 m deep, the class between 50 m and 100 m was considered as the first class. It was in this class that most of sightings were made for all species found. In the last class,  $\geq 200$  m, the number of sightings was very small.

The slope was characterised adopting the categories of Piatt *et al.*, (2006) from 0 to 80  $\text{m.km}^{-1}$ , 80 to 160  $\text{m.km}^{-1}$ , 160 to 240  $\text{m.km}^{-1}$  and  $\geq 240 \text{ m.km}^{-1}$ . The slope in the study area is not very marked and most of the sightings were made between 0  $\text{m.km}^{-1}$  and 80  $\text{m.km}^{-1}$ .

For Common dolphins, data from 2005 – 2009 was considered. Analysing the data from depth, it was in the first class that most of sightings were made but it was in the last one that a higher ER was found (Fig.19). Considering the slope, most of the sightings were made between 0 to 80  $\text{m.km}^{-1}$  (Table V).

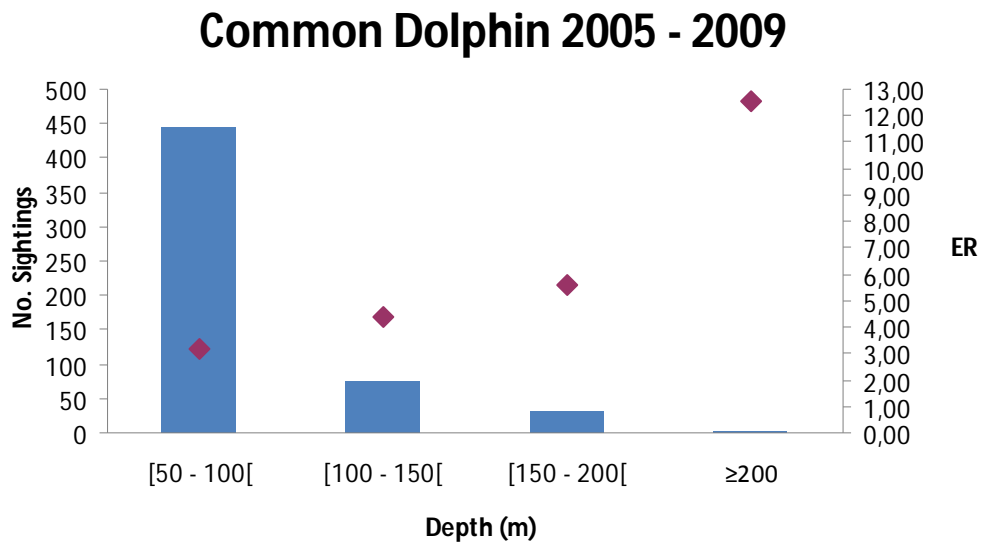


Figure 19. Distribution of number of sightings of Common dolphins (bars) and encounter rate in sightings/kilometers (♦) in relation to depth from 2005-2009.

Table V - Distribution of number of sightings of Common dolphin and encounter rate in relation to slope during 2005-2009

Slope (m.km <sup>-1</sup> )	No. Sightings	ER
[0 - 80[	548	3,49
[80 - 160[	2	4,7
[160 - 240[		
≥ 240	6	6,9

Sightings of Harbour porpoises per 100 km of effort in 2009 are shown in Figure 12. The results of the data from depth (Fig.20) show that most of the sightings were made in the class [50 – 100[, although higher encounter rates were found in the class [150 – 200[.

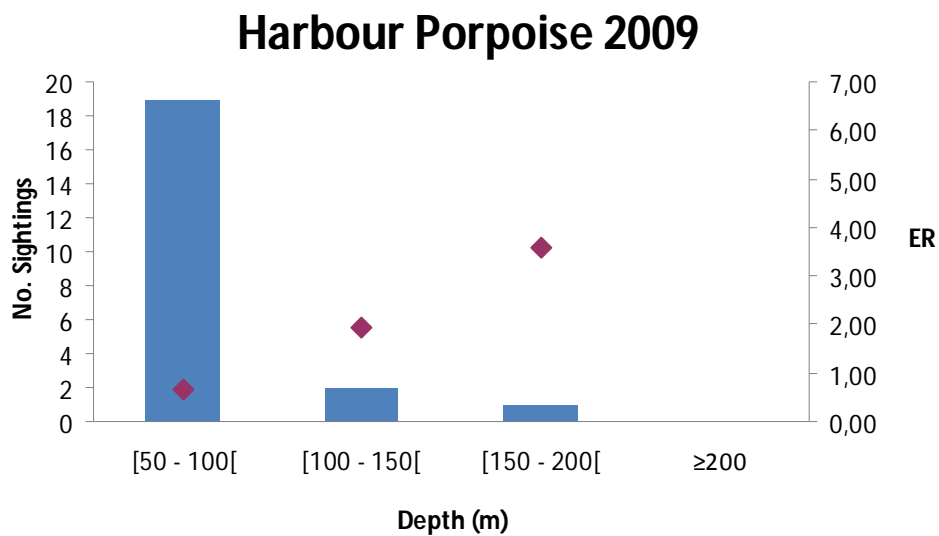


Figure 20. Distribution of number of sightings of Harbour porpoise (bars) and encounter rate in sightings/kilometers (♦) in relation to depth in 2009.

In relation to slope, all the sightings of Harbour porpoises were made between 0 to 80 m.km<sup>-1</sup>.

Sightings of Bottlenose dolphins per 100 km of effort in 2009 are shown in Figure 15. Most of the sightings were made in the class [50 – 100[, although the higher ER is found in the class [150 – 200[ (Fig.21).

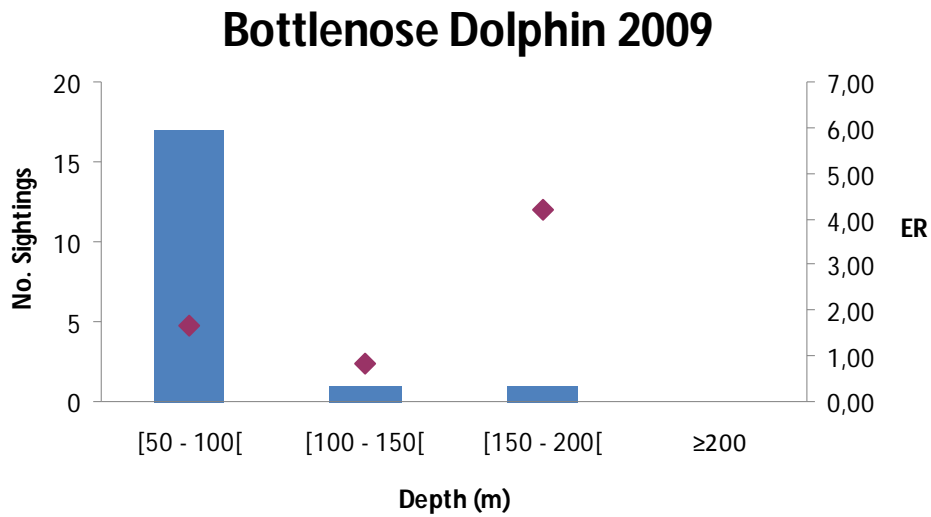


Figure 21. Distribution of number of sightings of Bottlenose dolphins (bars) and encounter rate in sightings/kilometers (♦) in relation to depth in 2009.

In relation to slope, all the sightings of Bottlenose dolphins were made between 0 to 80 m.km<sup>-1</sup>.

### 5.1.4. Social organization

#### Common dolphin

From 2005 until 2009, there were 556 sightings of Common dolphins, ranging from 1 to 500 individuals (Table III). It is consistent, in 4 years study that most of the groups found were between 1-25 individuals (Fig 22).

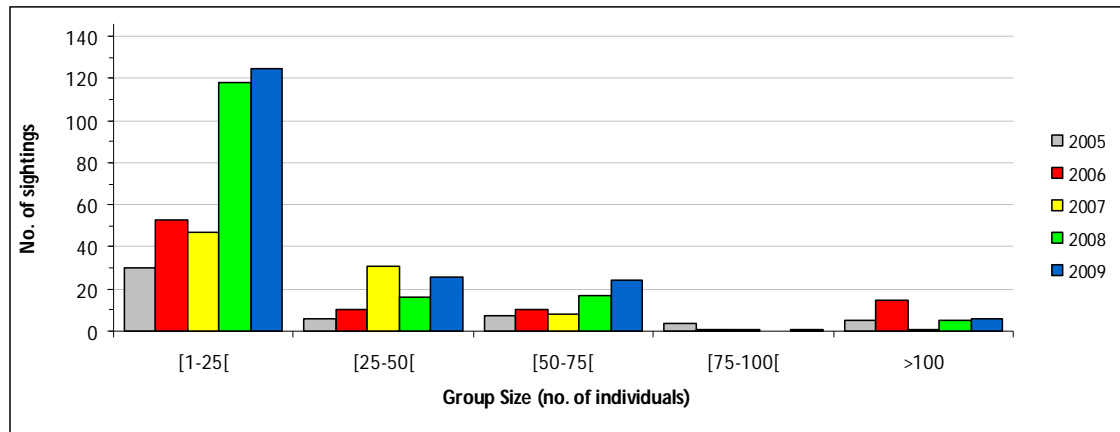


Figure 22. Number of sightings of Common dolphins in relation to group size in 2005-2009.

The group cohesion data was analysed only for 2009. In 82 sightings the groups were disperse (D), in 8 sightings the groups were compact (C), in 81 sightings they were very compact (VC). Only in one sighting was observed one lone individual (L). and in 10 sightings there is no information in relation to group cohesion (NI) (Fig.23).

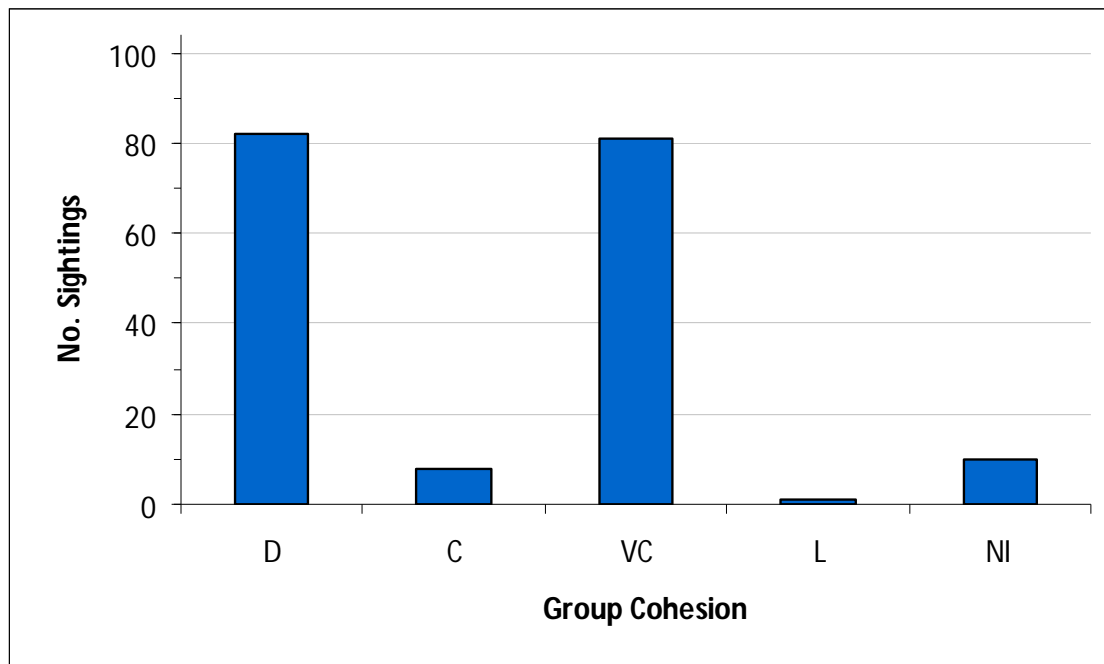


Figure 23. Number of sightings of Common dolphins in relation to group cohesion in 2009.

In this study, calves were observed in 53,53% of the groups in which the presence or absence of calves was possible to determine. A Box & Whiskers plot (Fig. 24) among the years suggested that there were considerable differences between the years. This impression was confirmed by the statistical analysis results that showed significant differences in the effort to encounter at least one group with calves ( $H=91,59606$ ;  $p < 0,05$ ).

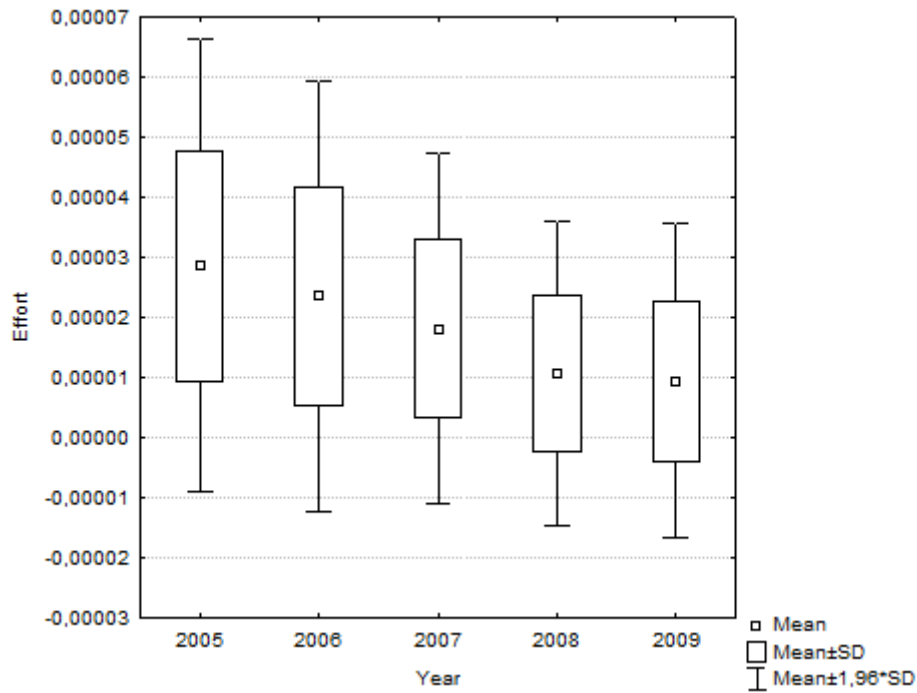


Figure 24. Box & Whiskers plot: Effort rate to sight at least a group with calves per year (presence or absence of calves/distance navigated in each track (Kilometers)).

According to post-hoc tests all the pairs are significantly different except for 2005 vs 2006, 2006 vs 2007 and 2008 vs 2009 (Table VI).

Table VI - Results from the Dunn test, showing the significance between the years (significant p values in bold)

2005		2006		2007		2008		2009	
Z	p	Z	p	Z	p	Z	p	Z	p
<b>2005</b>		1,527498	1,000000	3,403234	<b>0,006659</b>	6,369619	<b>0,000000</b>	6,927374	<b>0,000000</b>
<b>2006</b>	1,527498	1,000000		2,031051	0,422498	5,382421	<b>0,000001</b>	6,028495	<b>0,000000</b>
<b>2007</b>	3,403234	<b>0,006659</b>	2,031051	0,422498		3,501554	<b>0,004626</b>	4,174652	<b>0,000298</b>
<b>2008</b>	6,369619	<b>0,000000</b>	5,382421	<b>0,000001</b>	3,501554	<b>0,004626</b>		0,643932	1,000000
<b>2009</b>	6,927374	<b>0,000000</b>	6,028495	<b>0,000000</b>	4,174652	<b>0,000298</b>	0,643932	1,000000	

### Harbour porpoise

In 2009, there were 22 sightings of Harbour porpoise (Table IV), in which the largest group found comprised 6 animals (4 sightings). The most common group size was 2 individuals (7 sightings) followed by lone individuals with 5 sightings (Fig 25).

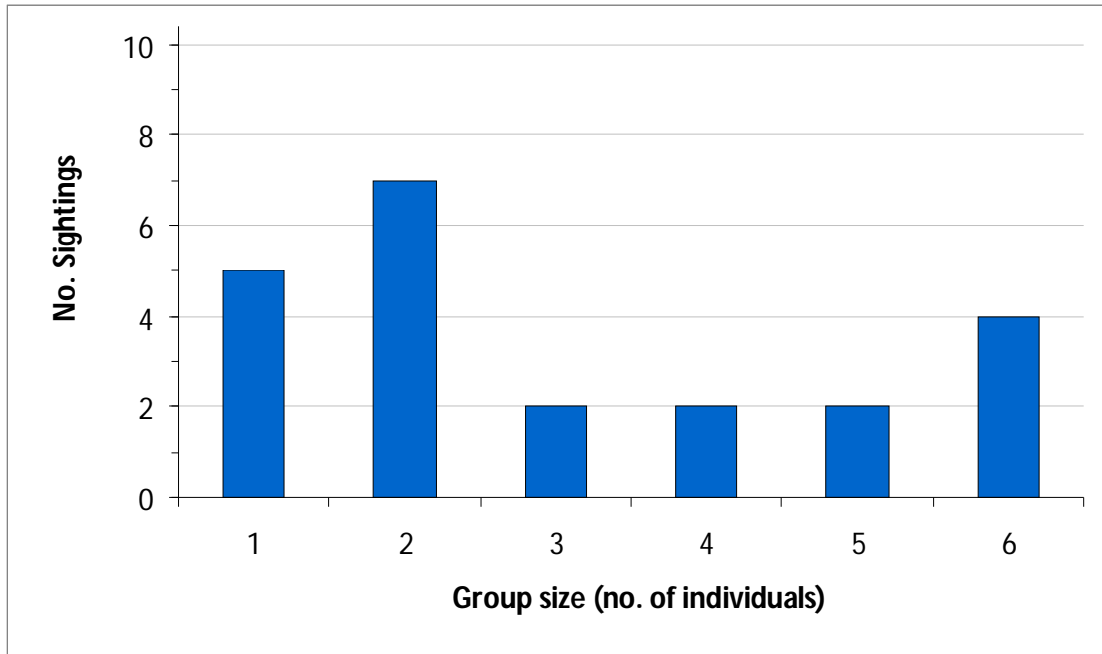


Figure 25. Number of sightings of Harbour porpoise in relation to group size in 2009.

In relation to the cohesion of the group, in 17 sightings the groups were very compact (VC) although in the rest of the sightings it was not possible to identify the level of cohesion (NI) (Fig.26).

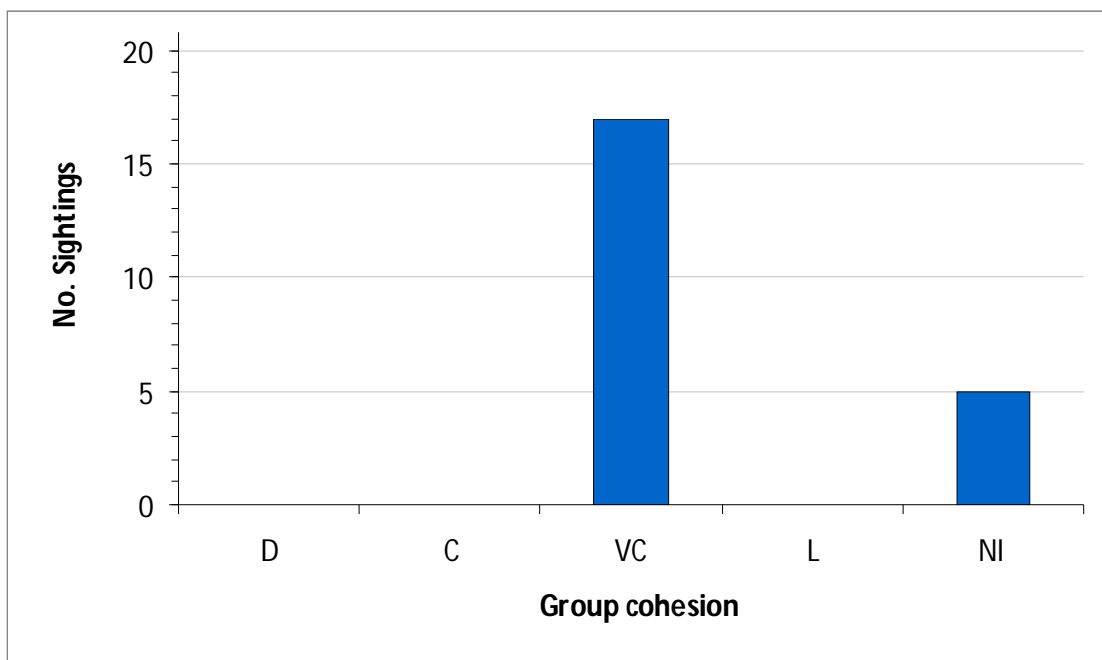


Figure 26. Number of sightings of Harbour porpoise in relation to group cohesion in 2009.

### ***Bottlenose dolphin***

In 2009, there were 20 sightings of Bottlenose dolphins (Table IV). In 15 sightings the group size ranged between the 1 and 20 individuals, while in 5 sightings groups larger than 20 individuals were observed (Fig 27).

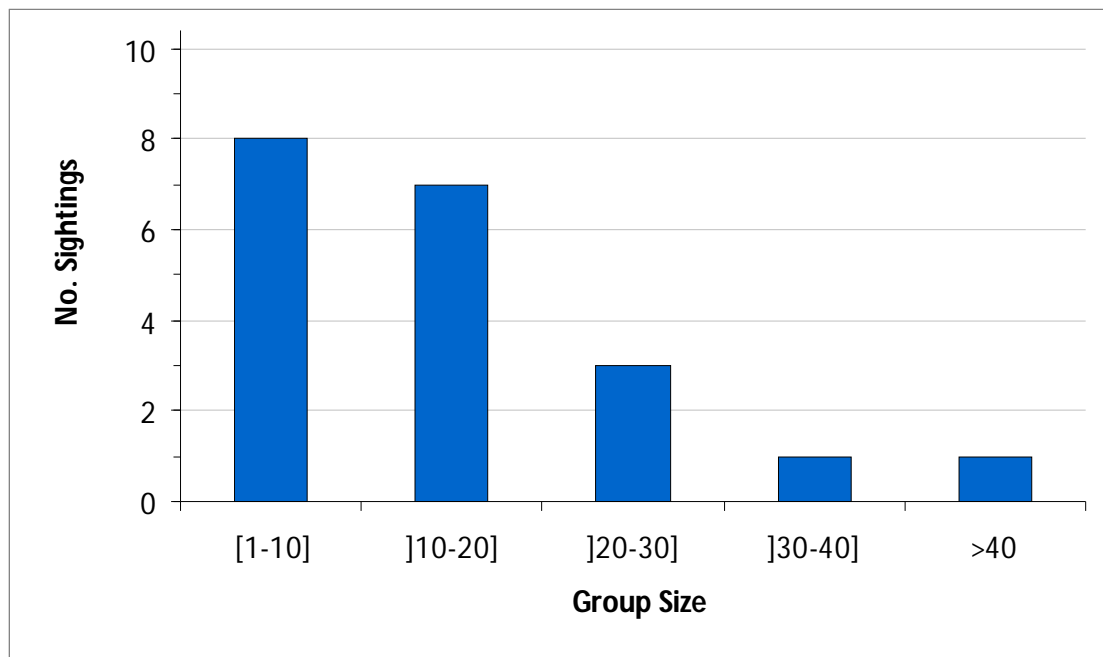


Figure 27. Number of sightings of Bottlenose dolphins in relation to group size in 2009.

In relation to group cohesion, Bottlenose dolphins were very compact (VC) in 15 sightings, corresponding to 75% of all groups. In 3 sightings the group was considered dispersed (D) and in 2 sightings it was not possible to determine the cohesion of the group (NI) (Fig.28).

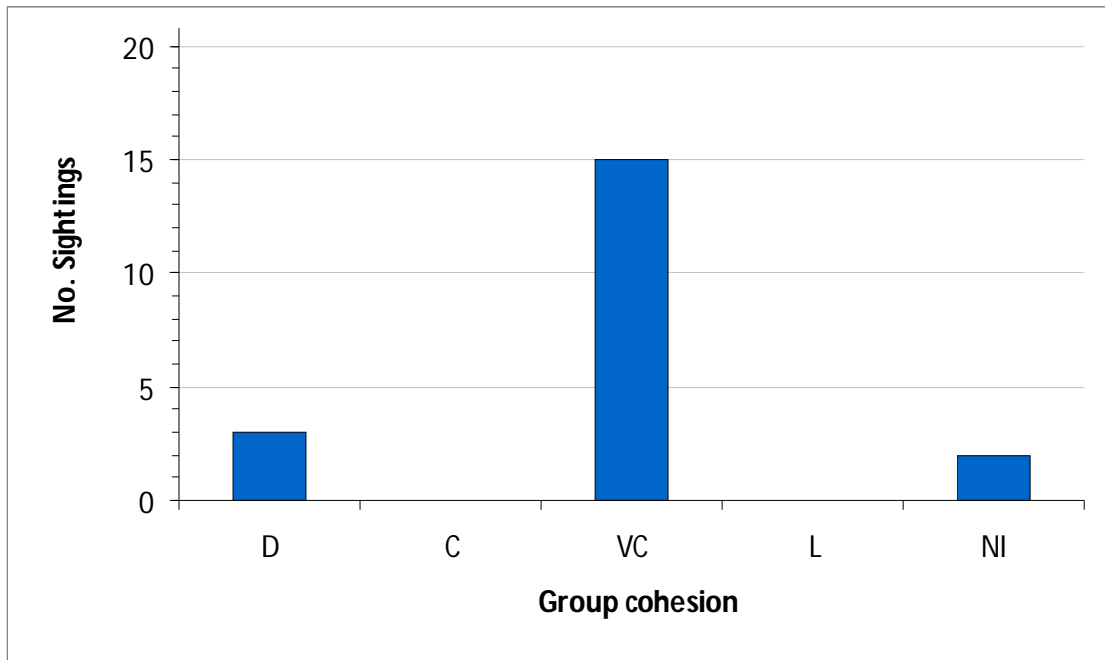


Figure 28. Number of sightings of Bottlenose dolphins in relation to group cohesion in 2009.

The presence or absence of calves in Bottlenose dolphins can be seen in Fig 29. In 11 sightings out of 20, calves were present (Pr). In 2 sightings they were absent (Ab) and in 7 sightings there was no information (NI).

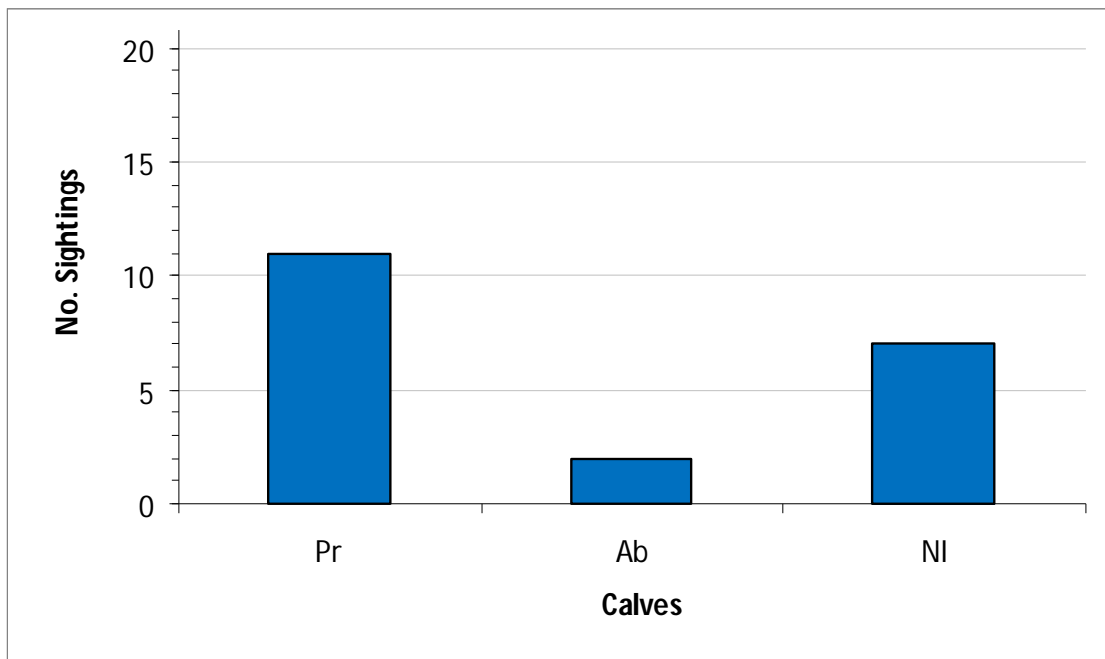


Figure 29. Number of sightings of Bottlenose dolphins in relation to present (Pr) or absence (Ab) of calves during 2009. NI stands for no information.

## 5.2. Photo identification

Photographs of common dolphins, taken between 15<sup>th</sup> June and 30<sup>th</sup> September 2009, were used for identification purposes. There were a total of 140 sightings of Common dolphins during this period.

A total of 1353 photos were analysed (Table VII), based on which 342 individuals were identified. 149 individuals were identified only on the right side of the fin, 148 only in the left side, and 45 on both sides. The left side catalogue of 193 individuals from the South of Portugal was compared with the 223 individuals in the catalogue from the Gulf of Cadiz. No match was found between the two catalogues.

Table VII - Number of pictures analyzed according to quality rating

<b>Quality</b>	<b>No. of pictures</b>
Q0	318
Q1	584
Q2	451
Total	1353

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## 6. DISCUSSION

### 6.1. Spatial distribution, abundance and social organization of cetaceans

#### *Common dolphin (Delphinus delphis)*

The maps of the density and occurrence of Common dolphins during 2005-2009 in the study area can be seen in fig 10 e 11 showing that there are no big differences between the use of the AI or the ER as factor of weight in the Kernel analysis, revealing that the areas of more encounters are also the areas where the animals are more abundant.

Most of the sampling was done during the summer time, and the animals were found very close to shore, 7438,01m in average (Fig 9).

Common dolphins occur in most coasts of the world, and mainly in the continental shelf but can be found in all depth ranges (Evans, 1994; Forcada and Hammond, 1998; Peddemors, 1999; Cañadas *et al.*, 2002). In this study, 552 sightings of common dolphins, corresponding to 99.3%, were made over the continental shelf, in a range of 50-200 m deep, although, 80.2% of the sightings were made between 50-100 m deep, in very shallow waters. Only 4 sightings occurred in areas deeper than 200 m (Fig 19). These results agree with previous studies, suggesting that this specie is more frequent in shallow waters (Cañadas *et al.*, 2002)

Although most of the sightings were made in shallow waters, we can see an increase of the ER with the increase of depth (Fig 19). In fact, the lowest ER corresponds to the region of higher number of sightings, in the most shallow waters range. This is possible, due to the fact that most of the survey effort was done in shallow waters. Therefore, and even with few sightings in deeper areas, since the survey effort (km) was smaller, this will result in higher ER. A similar situation happens with the slope results, were 98.6% of the sightings were made in the slope class of [0-80], corresponding to the lowest ER, 3,49 (Table V). To better understand how this animals use deeper waters, it would be really interesting to do surveys out of the continental shelf, and also during the winter time, since most of the data was collected during the summer time. It is known that Common dolphins have differences in distribution and density in relation to the season variations (Cañadas 2006).

The Common dolphin is considered a very opportunistic species in terms of feeding habits (Klinowska 1991; Young and Cockcroft 1994; Gannier 1995). So it is to expect that the distribution and abundance of the animals is strictly related with the abundance and distribution of prey (Cañadas 2006).

According to previous studies (Silva and Sequeira, 2003; Santos *et al.*, 2004), it seems that the main prey for common dolphins (*Delphinus delphis*) in the Portuguese waters is the sardine (*Sardina pilchardus*). In this study this covariate was not available. Therefore, further studies need to be done taking into account the presence and abundance of common dolphins with the abundance and distribution of their main prey, in this case the sardine.

In relation to social organization, common dolphin is described as a very gregarious species, which can form groups of several hundreds or even thousands of animals (Evans 1994; Evans 1994; Leatherwood *et al.*, 1988). Nevertheless, published data show a basic social unit between 20 to 30 animals (Evans 1994). Our results agree with this, since in most of the sightings, between the years 2005-2009, the size of the groups observed varied between 1 and 25 individuals (Fig 22). As in most highly gregarious species with very little sexual dimorphism, almost nothing is known about the sex/age composition of the groups and their social organisation (Cañadas 2006).

The presence or absence of calves interferes with the preference of habitats. For example groups with calves are known to prefer costal waters than deeper waters (Cañadas 2006). In our results calves were present in more than 50% of the groups in which they were possible to be determined. It is important to emphasize, that most of the data was collected during summer season (June – October), when supposedly the birth season takes place, and thus it was expected to register a high percentage of groups with calves.

Although some authors mentioned that even if the reproduction season of this species is not well defined, it seems that according to the area there might be more than one peak of maximum conception (Cañadas 2006). These peaks are usually extrapolated from the months of maximum proportion of births (Cañadas 2006). In the North Atlantic the maximum peak is estimated in summer (July to October) (Cañadas 2006; Evans 1987). According to Gannier (1995) in the Mediterranean, it is also estimated the summer, to be the season with maximum conception.

Although the effort necessary to encounter groups with calves continuously decreased along the years, suggesting an increase in the number of calves (Fig.24), we believe that other reasons are influencing these results. The data from 2005 until 2008 was collected by the guides of the whale watching company which started the activity in 2005. Therefore along these years the methodology has been improved and the data collected getting more consistent. In 2009 the data was collected by a conducted marine mammal observer (MMO). This could explain why the clear decrease in the effort rate may not really be related with the fact that are more calves every year, but instead with the fact that the data was collected in a more consisted away. It is possible to observe that

the differences between 2008 and 2009 are not significant, which corresponds to 4 years of improving the data collected by the company and one year with a directed MMO.

Nevertheless these results strongly suggest the presence of calves during the summer season, indicating that this could be an important area for the reproduction of common dolphins. Notwithstanding, more conducted studies are needed, to better confirm this hypothesis.

From 2005 until 2009 there was a large increase in the number of sightings of common dolphins, from 39 to 182 (Table III). This situation is related to the fact that the company increases the number of trips per year, which brings an increase in the survey effort (Table III). These results are extremely interesting, since a total ER of 2,01 was obtained, specially when comparing this result with the one estimated for the closest studied population, occurring in the Strait of Gibraltar (ER = 2,29), where common dolphins are known to be very abundant (de Stephanis *et al.*, 2008). Therefore we can assume that the study area can be an important zone for distribution and abundance of common dolphins in the South of Portugal.

### **Harbour porpoise (*Phocena phocena*)**

The results concerning this species provide a new insight into the abundance and occurrence of the Harbour porpoise in the study area. According to the 2005 SCANS – II project, which had the goal of estimating small cetacean abundance in the North Sea and European Atlantic continental shelf waters, there were no sightings of Harbour porpoises in the South part of Portugal, and only a few sightings in the North of the country. This fact makes these results extremely interesting, suggesting that this area might be more used by this species than what was expected and known (Table IV). Also, this area is probably one of the few, where whale watching occurs and Harbour porpoises are present. The maps of the density and occurrence seen in figures 13 and 14 show that there are no large differences between using the AI or the ER as weight factors in the Kernel analysis, revealing that the areas of more encounters are also the areas where the animals are more abundant.

Most sampling was done during summertime, and the animals were found reasonably close to the shore, 5873.91 m on average (Fig. 12).

Harbour porpoises are known to have seasonal variation in which near-shore sightings are more common during the summer and infrequent in wintertime (Gaskin & Watson, 1985; Barlow, 1988; Sekiguchi, 1995). During the winter, the coastal occurrence is considerably reduced, since the species supposedly move offshore to the border of the continental shelf (DETR *et al.*, 2000)

This seasonal variation could be a response to a change in oceanographic conditions (Lockyer, 1995; Bräger *et al.*, 2003) or changes in the availability and distribution of prey (DETR *et al.*, 2000). Other factors could be the depth, current velocity and sub-surface topography and gradient (Whaley, 2004). In this case, 100% of the sightings were made in areas where the slope varies between 0 – 80 m.km<sup>-1</sup>, corresponding to a ER of 0.9. Also 19 sightings were made in the [50-100[ depth (m), 2 sightings in [100-150[ depth (m) and only one sighting was made in more than 150m depth (Fig. 20). Although most sightings were in shallow waters, an increase of the ER as depth increased could be noticed (Fig. 20). This is possible because most of the survey effort was in shallow waters. Therefore it would be really interesting to survey in deeper areas in order to have a better understanding of how this animals use those areas.

According to Taylor & Dawson (1984), the Harbour porpoise is typically found alone or in small groups. This fact was noticed in the present study area, where in 22 sightings, 100% of them involved groups of 6 individual or less (Fig.25 & 26).

The studies made by Sequeira and Ferreira (1994), show that 50% of the cause of mortality of Harbour porpoises is related to fishery activities. Most of the stranding

information is also focused more in the centre and north of the country (Sequeira *et al.*, 1992; Sequeira and Ferreira, 1994; Sequeira, 1996), and there is little information about strandings in the South part of the mainland Portugal (Sequeira *et al.*, 1992; Sequeira *et al.*, 1996). The work done by the Portuguese Stranding Network in mainland Portugal, coordinated by the Nature Conservation Institute in collaboration with the Portuguese Wild Life Society (Ferreira, *personal communication*), provides most of the stranding information, mainly for the Harbour porpoises, and it should be expanded in a more active way to the South. There is a need for basic information on the biology of *P. phocoena* and other small cetaceans, including their current abundance (Hammond *et al.*, 2002). It is extremely important to better survey the South part of Portugal to get a better and more complete picture of the abundance and occurrence of *P. phocoena* in the area and also of how the abundance of this species can be estimated in European waters.

These results are very limited, and only provide a baseline on the abundance and occurrence of this species in the study area, but gives no information concerning the increase, decrease or stable number of the population.

### ***Atlantic Bottlenose dolphin (Tursiops truncatus)***

In the present study, a total of 20 sightings associated to 9599.22 km of effort resulted in an ER of 0.21 and an AI of 3.56, (Table IV) revealing that this area could be an important zone for Bottlenose dolphins. The maps corresponding to the density and distribution can be seen in figures 16 and 17, showing the high probability of abundance and occurrence of Bottlenose dolphin in study area. Comparing the maps of the ER and AI using the Kernel analysis it is evident that in few areas the probability of occurrence differ from the areas of abundance. However, in this analysis it was found that there are more common areas where there is a higher probability of occurrence than abundance. Bottlenose dolphins have an extensive distribution and are found in a wide range of habitats, although our understanding of habitat preference is limited and most of the studies were conducted in tropical coastal waters (Wilson *et al.*, 1997). In the study area, Bottlenose dolphins were found in average very close to shore, 5519.34 m (Fig.15). In relation to slope, 100% of the sightings were made in areas where the slope varies between 0 m.km<sup>-1</sup> and 80 m.km<sup>-1</sup>, corresponding to an ER of 1.74.

Concerning the depth, 17 sightings were made in the bathymetry class of [50-100[ depth (m), one sighting was observed in the bathymetry of [100-150[ depth (m) and one sighting in more than 150 m depth (Fig.21). When comparing the ER with the bathymetry (Fig.21), is possible to see that in shallow waters where most of the sightings occurred, the ER is lower than in deeper waters. This can be explained because most of the survey effort was done in shallow waters. To better understand how these animals use deeper waters, it is necessary to increase the survey effort in deeper zones.

The social organization of Bottlenose dolphins it is very variable, but in general it is considered that larger groups are found more offshore and smaller groups more inshore. A typical group varies between 2 and 25 animals, although there are reports of groups from 100 to 1000 individual (Evans 1987; Perrin *et al.*, 2002). In the present study, most of the groups found were between 1 and 30 individuals (18 sightings); only two sightings were made for groups larger than 30 individuals; and the mean group size was 17 animals (Fig.27). Bottlenose dolphins are a species with a social organization that is both variable and complex (Quintana-Rizzo and Wells, 2001). This species has a fission–fusion social organization, exhibiting associations that change frequently in composition and size over small spatial and temporal scales and with others that are remarkably stable over many years (Wells *et al.*, 1987; Wells 1991; Connor *et al.*, 1992; Smolker *et al.*, 1992).

The birth period changes per area and it has been described in Florida during Autumn and in Europe around mid-summer (Reynolds *et al.*, 2000; Perrin *et al.*, 2002). In

the present study, most of the data was collect during summertime, and in 11 sightings out of 20, calves or newborns were present (Fig 29).

The Bottlenose dolphin is an important species for conservation. The species is listed in the Annex II of the EU Habitats Directive, which considers it a priority species for conservation, and requires the creation of SACs (Special Areas of Conservation) in European waters. The conservation status of the species, according to the Red Book of the IUCN, is “Data Deficient” ([www.redlist.org](http://www.redlist.org)), although there is evidence of declines in populations in Northern Europe, the Mediterranean and in the Black Sea (Evans 1987; [www.redlist.org](http://www.redlist.org)). Historical catches, accidental captures and environmental degradation are linked to declines in these populations (IWC 1992). In the Portuguese Red List the conservation status of Bottlenose dolphins is “Least Concern”.

Results from this study, although very limited, clearly indicate that Bottlenose dolphins are an important and present species in the south of Portugal. More studies are necessary to better understand how this species use the southern region of Portugal. Such data could provide the key to improving the conservation status of this species in Portugal and in European waters, and to establish strong conservation plans and management.

## ***Other Species***

### ***Minke whale***

In the study area there was only one sighting of a Minke whale (Fig 18), corresponding to only one individual, associated to an ER and to an AI of 0.01 (Table IV). The animal was 15469,50 m away from shore, in a 1000 m deep area. Although there was just one sighting of this species during the study period, fishermen from the local community report relatively frequent observations of these animals. It is relatively well-understood the way these animals occurs at higher latitudes in the North Atlantic (Stewart & Leatherwood, 1985), but in lower latitudes the species is poorly known and understood. Some are believed to be present in the Caribbean in the west and around the Strait of Gibraltar in the east (Christensen *et al.*, 1990). More studies and information are necessary to see how Minke whales use the habitat in the south of Portugal, and where they occur.

### ***Humpback whale***

During the study period, a single humpback whale was observed (Fig 18), corresponding to an ER and an AI of 0.01 (Table IV). The animal was a juvenile and it was extremely close to shore only 1774,4 m away, corresponding to a depth of 50 m. This individual had a “peanut-shaped” head, which is associated with an emaciated and underweight body condition (Fair *et al.*, 2006). This suggests that this animal was not in the most healthy condition.

### ***Risso's Dolphin***

During this work there were 2 sightings of Risso's dolphin (Fig 18), corresponding to an ER of 0.02 and an AI of 0.10 (table IV). One of the sightings was made at 18062,6 m from shore, at a depth of 179,32 m, and the other one, was made at 8652,9 m from shore and 100 m deep. The groups range between 1 and 5 (Table IV). The group size varies between 1 and 5 individuals (Table IV). According to Evans (1987) inshore groups are always smaller than offshore ones. It would be interesting to collect more information about how these animals occurred in the area, and Photo-ID studies should be made.

## 6.2. Photo-identification

The possibility of identifying individuals in the field allows scientists to better estimate population parameters and model their social structure (Hammond *et al.*, 1990; Auger-Méthé and Whitehead 2007).

In this study, a whale watching platform was used to collect the Photo-ID data. Several problems occurred during the process of photographing the groups. The boat used was a small RHIB with a capacity for 12 tourists and had very limited space on board. It was difficult to move on the boat in order to take high quality photos. Most of the pictures were taken from the back of the boat so as not to disturb the tourists. Also, the main interest of the company and the skippers is to allow tourists to view the animals; they are not concerned with positioning the boat to allow the perfect conditions for Photo-ID. Therefore, in several sightings, the relative position of the boat and the dolphins was poor and it was not possible to take photos at angles of 90° or 270°. In Photo-ID work the sun should be behind the photographer so that the sunlight lights up the features of the dorsal fin and the back of the animals. When the sun is behind the subject in relation to the photographer, the dorsal fin will appear as a silhouette, not showing markings, such as coloration patterns, identifying scratches or lesions, on the fin or back of the animal (Culloch 2004). These are probably the reasons for the small number of photos analysed, 1353, and also the higher number of photos with Q0 and Q1 in relation to Q2 (Table VII). Common dolphins are also very difficult to photograph. They move quickly and are active when coming to the surface, resulting in a lot of water in front of the dorsal fin and thus reducing the possibility of identifying the individual.

It has been suggested that the tissue of the dorsal fin does not regenerate (Würsig and Würsig 1977; Bigg 1982; Auger-Méthé and Whitehead 2007), however notches can elongate on growing fins or can become shallower with time (Auger-Méthé and Whitehead 2007). Also, natural marks can change with time and the individuals who are recognized by those marks can become unidentifiable (Hammond 1986; Auger-Méthé and Whitehead 2007).

In the case of Photo-ID analysis for common dolphins, the identification is based on a combination of natural marks and dorsal fin pigmentation patterns (Neumann *et al.*, 2002; Bearzi *et al.*, 2005). Therefore, in this study, only individuals having obvious long-term marks on their dorsal fins were included in the catalogue, resulting in 342 individuals identified.

Another important fact to consider in this study was the limitation in time spent with the group of animals which reduced the chance to properly photograph most of the individuals of the group. Also, when encountering large groups, the boat would only stay

with the animals that come close to the boat, again reducing the possibility of covering most of the individuals in the full group. This can result in a considerable bias in the estimation of the population size favouring the underestimation, a reason why this topic was not included in the present work.

Also the fact that only highly marked animals were catalogued may lead to underestimation, since the marks can be unevenly distributed within a population, allowing the identification of only some of its individuals (Gowans and Whitehead 2001; Auger-Méthé and Whitehead 2007).

When comparing the created catalogue with the already existent catalogue from the Gulf of Cadiz, no matches were found. This result does not mean that there is no mixing between the individuals in the two areas. It is necessary to increase the effort in the Photo-ID process and keep both catalogues active and in constant comparison.

The distribution, habitat use and the understanding of the dynamics of a dolphin population can be obtained when individuals are followed for a number of years during long-term mark-recapture studies utilising photo-identification (Wilson *et al.*, 1999; Rogan *et al.*, 2000; Culloch 2004). It would be extremely interesting to continue working on the Photo-ID of Common dolphins in order to estimate the population size using mark capture-recapture models. With a long-term study, it would be possible to define if the same individuals are present year after year, and create a discovery curve for Common dolphins, allowing the estimation of an increase or decrease in the population size as well as immigration and emigration rates. For that, more photos are necessary from different years and also from different times of the year.

## 7. FINAL CONSIDERATIONS

This work provides the first information on the summer distribution of cetaceans in near shore areas between Cape São Vicente and Lagos. The contribution of this study is highly relevant since cetacean surveys, had never been conducted before in most of the research area. The study area, during the summer, is characterized by the constant presence of the Common dolphin, *Delphinus delphis*, the Atlantic Bottlenose dolphin, *Tursiops truncatus*, and the Harbour porpoise, *Phocoena phocoena*.

The Common dolphin is definitely the species that most occurs in the area and also the most abundant, with higher values of both ER and AI.

The geographic area covered was limited to near shore waters of the Algarve, over the continental shelf, and during the summer time. Thus, it is necessary to carry on with it, in more distant areas and during other seasons, in order to properly understand how the studied species use the region. Also, given the high mobility and broad distribution of cetaceans, it is necessary to collect information from the whole Gulf of Cadiz to obtain a more complete overview of the population(s) that occurs in the area.

In accordance with the constraints that characterize the present study, the Common dolphin Photo-ID study is also rather limited, providing only a rough idea of the number of individuals that were possible to identify in the area. In order to make the Photo-ID album a more efficient tool, it is necessary carry on with the photo recording process and expand it to the other species present. The use of whale watching platforms to collect Photo-ID data should be continued and encouraged.

Concerning the spatial distribution of cetaceans in the area, habitat preference models, such as GLM and GAM models, using the physiographical features of the area and considering the cetacean occurrence and abundance should be applied.

The lack of knowledge in the habitat use of cetaceans in the South of Portugal represents and drawback for effective cetacean's conservation.

This study reveals the presence of two protected species, the Bottlenose dolphin and the Harbour porpoise. The Habitats Directive only allows the creation of marine protected areas (MPAs) for these 2 species, therefore, it is important to consider the creation of MPAs that cover identified hotspots for cetaceans, supported by the development and implementation of an effective management strategy.

Concerning the Bottlenose dolphins and the Harbour porpoises, the data analysed represents a short-term survey, in 2009, so it is necessary to consider that it may have led to biased conclusions about the habitat use of these species in this area.

In spite of that fact, the results obtained strongly suggest that the South coast of Portugal is an important area for several species of cetaceans.

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