

Universidade de Lisboa
Faculdade de Ciências
Departamento de Biologia Animal



CETACEANS' OCCURRENCE AND BEHAVIORAL PATTERNS
OFF THE WEST PORTUGUESE COAST

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Mestrado em Ecologia Marinha

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Dedicado a

Gonçalo, Rodrigo, Diogo, Tomás, Mariana e Afonso
porque movem o futuro.

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RESUMO

O estudo dos cetáceos na costa continental portuguesa tem sido objecto de atenção de alguns investigadores portugueses durante o séc. XX, através da realização de diversas teses académicas, análise de dados de arrojamentos que focaram a ocorrência de espécies ao longo da costa e alguns aspectos de ecologia alimentar, e ainda projectos sobre interacção com artes de pesca. Tem sido também, e de forma continuada, estudada e monitorizada a população residente de golfinhos-roazes (*Tursiops truncatus*) do Estuário do Sado, actualmente constituída por 24 indivíduos identificados. Na última década, estudos no Norte do País apontam para a possibilidade de uma população residente de botos (*Phocoena phocoena*) na Figueira da Foz e no centro possivelmente ocorrem duas populações residentes na Arrábida e na Costa da Galé.

Actualmente, o estudo de populações costeiras de golfinhos e baleias na costa Oeste de Portugal está a ser levado a cabo por algumas equipas de investigação que começam a publicar os resultados em conferências nacionais e internacionais e em algumas revistas da especialidade. No entanto, pouco se sabe ainda sobre as principais zonas de distribuição das espécies, de que forma utilizam os seus habitats e sobre estimativas de abundâncias para a costa continental portuguesa de Norte a Sul.

No presente estudo, o principal objectivo foi compreender quais as espécies com maior ocorrência numa área de estudo composta por três zonas geográficas distintas (Póvoa de Varzim, Nazaré/Peniche e Sesimbra), e analisou-se a sua distribuição nessas mesmas áreas tendo em conta parâmetros ambientais como a temperatura do mar à superfície, a profundidade do local do avistamento e a distância à costa. Focando apenas golfinho-comum, descrito por vários autores como a espécie

de maior ocorrência em Portugal continental, foi ainda feita uma descrição das principais actividades comportamentais nas zonas amostradas.

A metodologia aplicada a este estudo baseou-se em saídas de mar para observação de cetáceos, tendo sido aproveitadas saídas de oportunidade (que aconteceram independentemente de projectos direccionados ao estudo de cetáceos) e saídas de investigação (inseridas em projectos da Escola de Mar e do Centro de Oceanografia). Em cada saída foi registada a espécie, a data e hora, a posição GPS, o tamanho do grupo, a presença de crias e as principais actividades comportamentais, bem como factores ambientais como a temperatura, a profundidade e a distância à costa. Apesar de não terem sido integrados na análise, dados como o estado do vento e do mar e a presença de aves marinhas foram também registados.

No total foram realizadas 100 saídas de mar que perfizeram um total de 18 647 minutos de esforço e das quais resultaram 81 avistamentos independentes de cetáceos, nas três regiões amostradas. Tal como esperado, a espécie com maior ocorrência foi golfinho-comum (*Delphinus delphis*), observado durante todo o ano em grupos de 1 a uma centena de indivíduos embora na maior parte dos casos em grupos de 1 a 10 animais, com a presença de crias. A esta espécie seguiram-se golfinho-roaz, golfinho-riscado (*Stenella coeruleoalba*), boto e baleia-anã (*Balaenoptera acutorostrata*). Em Sesimbra, golfinho-comum e golfinho-roaz distribuem-se de forma distinta, podendo ser considerada a existência de uma partição do habitat segundo características ecológicas distintas de ambas as espécies. Foram encontradas diferenças em relação a aspectos de dinâmica de grupos, como por exemplo na presença de crias ($p < 0,05$), frequente em grupos de golfinho-comum (59%) e pouco frequente para golfinho-roaz (17%), bem como nas principais actividades comportamentais registadas. Golfinho-comum utiliza a área de estudo, principalmente a zona de Sesimbra, para todas as suas actividades diárias como deslocação (54%), alimentação (29%), socialização (15%) e repouso (2%). Golfinho-roaz foi apenas

observado em deslocação, embora deva ser considerada uma possível sobrevalorização desta actividade, já que a deslocação é inerente à alimentação e os indivíduos têm obrigatoriamente de se deslocar entre zonas de alimentação, dada a distribuição irregular dos cardumes de que se alimentam.

Foram também observadas diferenças significativas em relação às zonas de distribuição de ambas as espécies, nomeadamente na análise dos parâmetros profundidade ($p < 0,05$) e distância à costa ($p < 0,05$). Os grupos de golfinho-comum observados distribuíram-se em zonas de maior profundidade (min.=25m, máx.=400m, $x=96,15$ m, d.p.=67,23, $n=50$) e mais afastadas de costa (mín.=409m, máx.=19.491m, $x=6.308$ m, d.p.=5.313, $n=59$) enquanto os grupos de golfinho-roaz se distribuíram em zonas pouco profundas (min.=5m, máx.=180m, $x=50,78$ m, d.p.=73,48, $n=9$) e mais próximo de costa (min.=232 m, máx.=12.700 m, $x=3.162$ m, d.p.=3.728, $n=13$). Uma preferência por diferentes presas pode contribuir para estes resultados, evitando assim competição directa por recursos entre ambas as espécies. Por outro lado, é também colocada a hipótese dos grupos de golfinho-roaz utilizarem a área de Sesimbra como um corredor de deslocação entre as suas principais áreas de ocorrência. Esta zona geográfica tem características especiais à ocorrência de cetáceos, não só pelo seu carácter de protecção relativamente a algumas actividades humanas dado pelo Parque Marinho Luiz Saldanha, mas também pela existência dos canhões de Setúbal e de Lisboa que lhe garantem uma produtividade elevada e consequentemente uma importante riqueza marinha.

Também em Sesimbra, golfinho-comum foi avistado em associação a golfinho-riscado. Esta última espécie de hábitos oceânicos pode aproximar-se de costa seguindo presas pelágicas e assim formar grupos mistos que eventualmente lhe permitem um maior sucesso na captura de alimento. Golfinho-comum foi também observado numa área muito próxima a baleia-anã e, fora do nosso esforço de amostragem, a acompanhar a deslocação de uma baleia-corcunda. Apesar de não ser

nosso objecto de estudo, é de interesse revelar que foram observados vários golfinhos-comum com cortes na barbatana dorsal na Nazaré e em Sesimbra, bem como uma baleia-anã enredada e ferida por um cabo.

A maior limitação deste estudo foi a utilização de saídas de mar nem sempre direccionadas à observação de cetáceos, dificultando por vezes a recolha dos dados, bem como o número distinto de amostras recolhidas em cada zona da área de estudo, não possibilitando uma comparação geográfica. Outra falha que deverá ser colmatada nas próximas campanhas relaciona-se com a metodologia aplicada ao estudo do comportamento a qual deverá ser dedicada. No caso de golfinho-comum, a análise dos seus padrões comportamentais é ainda pouco estudada a nível global e a aposta nessa área de estudo tem bastante interesse.

De futuro prevê-se o desenvolvimento do estudo de cetáceos na zona centro, que se pretende continuado e cada vez mais consistente, através da utilização de transectos os quais já estão delineados para a área de Sesimbra. Só através desta metodologia será possível estimar a abundância das espécies e calcular o tamanho das populações. Será também organizado um catálogo de foto-identificação para as espécies golfinho-comum e golfinho-roaz, de forma a compreender possíveis padrões de residência sazonais ou permanentes. Por outro lado, é essencial que as fotografias de golfinho-roaz sejam comparadas com as das barbatanas já identificadas dos indivíduos do Estuário do Sado. Dada a proximidade entre a população residente e golfinhos oceânicos é de extrema relevância que se verifique através, deste método, se estará a ocorrer algum nível de interacção entre grupos. Sugere-se ainda, como projecto futuro, uma análise das interacções com artes de pesca na zona centro de Portugal continental.

Estudos sobre populações costeiras de cetáceos devem ser alvo de maior atenção na costa continental portuguesa. É sabido que um número significativo de espécies utiliza águas continentais portuguesas mas não estão identificados os

parâmetros ecológicos que definem esse uso. Abundância, padrões de residência, uso de habitat, actividades comportamentais, estatuto de conservação, entre outros temas, devem ser a base para as questões futuras que devem ser colocadas, estudadas e respondidas.

Palavras-chave: Cetáceos, Ocorrência, Distribuição, Habitat, Comportamento, Golfinho-Comum, Golfinho-roaz, Portugal.

ABSTRACT

The present study analyzes the occurrence of cetaceans off the West Portuguese Coast between 2007 and 2009. A total of 100 boat-based surveys were conducted in a study area composed by three locations (Póvoa de Varzim (41°N), Nazaré/Peniche (39°N) and Sesimbra (38°N)), from which resulted 81 independent sightings of cetaceans. Five species were observed: common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), striped dolphin (*Stenella coeruleoalba*), harbour porpoise (*Phocoena phocoena*) and minke whale (*Balaenoptera acutorostrata*). Common dolphin was the most frequent species followed by bottlenose dolphin and the distribution of these two species was analyzed within the same geographic area where habitat partitioning seems to be occurring. Group dynamics (including group size, presence of calves and behavioural activities) and habitat parameters (including SST, depth and distance from shore) were compared. Differences were found for the presence of calves, behavioural activities, depth and distance from shore, possibly due to ecological differences between species. A description of behavioural activities of common dolphin was also promoted in order to understand the behavioural patterns of the species. Travelling was the most observed activity, followed by feeding, socializing and resting, namely in Sesimbra where the species seems to conduct all its daily life activities. Mixed groups of common dolphin and striped dolphin were registered three times in the same location and can be considered an advantage for striped dolphin, an oceanic species that approach to coast sporadically. During our campaign, several common dolphins presented injuries in its dorsal fins and one minke whale was entangled in cables and fishing nets. Cetaceans' research along the Portuguese coast has a lot of topics that should be

studied in the near future, namely abundance, patterns of residency, habitat use, behavioural patterns and conservation status.

Keywords: Cetaceans, Occurrence, Distribution, Habitat, Behaviour, Common dolphin, Bottlenose dolphin, Portugal.

CHAPTER 1: GENERAL INTRODUCTION

1.1. An introduction to cetaceans' ecology

Cetaceans occupy a large proportion of the ocean's habitats from coastal waters to neritic waters over continental shelves and estuarine systems or even rivers, using the water column, being confined to relatively shallow depths or diving to thousand of meters. In different habitats cetaceans show differential development of adaptations which reflect selective pressures of the environments in which they function. The relation between a species and its habitat form the basis to define a species' ecological niche and to allow a prediction of distribution and abundance, as also the identification of core requirements, critical knowledge for effective management and conservation. Furthermore, cetaceans are apex predators and they affect the life history strategies and population biology of their prey as well as of organisms at other trophic levels in the ecosystem to which they belong (Ballance, 2009).

Like many animals, cetaceans form aggregations for feeding and for protection. Being gregarious, cetaceans can bring the fishing school together and easily capture their prey, as also the coordinated effort reduces the time devoted to foraging, which means a gain of energy for other activities. On the other hand, cooperation makes the group stronger and ensures the protection of vulnerable individuals, reducing the probability of predation on any one individual and increasing the chance of detection of a predator (Gowans *et al.*, 2008; Balance, 2009). Groups of cetaceans are considered as mutualists since their relations are based on exchange of mutual benefits and only mutualist groups allow the formation of social bonds between individuals (Connor, 2000). The interactions between elements of a group include mating and sexual

activities, play and game, interactions of dominance and also maternal behaviours (Evans, 1987), which can be secondary benefits of schooling (Ballance, 2009).

There seems to be a correlation between school size and feeding habitats. Species that form large schools are almost all shallow-diving species that feed mainly on schooling prey, whereas those which occur in smaller school size (25 animals or less) tend to be deep-diving species or coastal species feeding on dispersed prey. This is due to predation pressure and resource availability (Norris and Dahl, 1980; Ballance, 2009). There is also a tendency for small populations of cetaceans, particularly dolphins, to become temporarily or permanently resident in small areas, forming a network of fluid associations (fusion/fission) between individuals. In these small groups, individuals hunt alone, also with a preference for solitary prey (Gowans *et al.*, 2008).

Finally, although most schools are monospecific, several species can occur in mixed-species groups. These associations appear to be opportunistic, for example in cases of food concentrations, between species of coastal and oceanic species (Ballance, 2009; Connor, 2000).

1.2. Review of cetaceans' occurrence in coastal waters of the Northeast Atlantic

Although coastal waters are primarily occurrence zones of small cetaceans, they are included in migrations routes, between feeding and reproduction areas of baleen whales off European coast. Fin whale (*Balaenoptera physalus*) and sei whale (*Balaenoptera borealis*) are frequent species, followed by blue whale (*Balaenoptera musculus*) and humpback whale (*Megaptera novaengliae*), this one with a more coastal distribution. Minke whale (*Balaenoptera acutorostrata*) is the commonest of all the rorquals (Evans, 1987). This species is amongst the most widely distributed of all baleen whales, ranging from tropical to polar waters, frequently observed in coastal or shelf waters (Reeves *et al.*, 2008). Sperm whale (*Physeter macrocephalus*) is also

reported to this area when moving northwards probably following deep ocean basins west of the Iberian Peninsula and British Isles (Evans, 1987).

In the last decade, several projects were developed as an attempt to estimate the abundance of cetaceans in European waters, namely SCANS I, SCANS II (Small Cetaceans in the European Atlantic and North Sea) and CODA (Cetacean Offshore Distribution and Abundance in the European Atlantic). For CODA an area of 968 000 km² was surveyed off the continental shelves of Britain, Ireland, France and Spain in July 2007. The aims of the project were to estimate the abundance and investigate the habitat use of cetacean species in waters beyond the continental shelf. The best estimates were 116 709 common dolphins (*Delphinus delphis*), 67 414 striped dolphins (*Stenella coeruleoalba*), 19 295 bottlenose dolphins (*Tursiops truncatus*), 25 101 long-finned pilot whales (*Globicephala melas*), 2 077 sperm whales, 6 765 minke whales, 9 019 fin whales, and 6 992 beaked whales. The results were intended to inform assessments of conservation status of all cetacean species, inform assessments of the impact of bycatch of common dolphin, and inform assessments of the impact of anthropogenic sound on deep-diving whales (Hammond *et al.*, 2009).

Concerning just the common dolphin, which is the most abundant species in Europe, recent regional and local projects have been developed approaching subjects such as distribution and abundance (Macleod *et al.*, 2003; Certain *et al.*, 2008; De Boer *et al.*, 2008; Robinson *et al.*, 2010) and feeding ecology (Pusineri *et al.*, 2007). Regarding behaviour ecology, no studies have been conducted in Europe, so far. New Zealand waters (Neumann, 2001; Stockin *et al.*, 2009) and Mediterranean (Bearzi *et al.*, 2003; Cañadas and Hammond, 2008) are the most well documented regions for this subject.

1.3. Review of cetaceans' occurrence off Portugal mainland coast

1.3.1. Coastal populations

The information about the occurrence of cetaceans in Portuguese mainland coastal waters has always been very sparse and fragmented. Along the years, whaling data, historical and strandings as well as opportunistic observations have given information about the occurrence of an extensive list of mysticetes and odontocetes. For these integrated studies, the results vary according to the geographic location but all point common dolphin as the more frequent species, followed by bottlenose dolphins or striped dolphins and harbour porpoises (e.g. Teixeira, 1979; Sequeira, 1988; Brito *et al.*, 2009). Other odontocetes as Risso's dolphins (*Grampus griseus*), pilot whales (*Globicephala* sp.), killer whales (*Orcinus orca*) and sperm whales have been referred. Regarding baleen whales, blue whales, fin whales, sei whales, humpback whales and minke whales, these are included in the "observed at sea" or "captured" lists (e.g. Teixeira, 1978; Sequeira, 1988; Brito *et al.*, 2009).

Considering that common dolphin is the most observed species off Portugal mainland, studies about its feeding ecology (Silva, 1999) and interactions with fisheries were also promoted (Wise, 2007). Nevertheless, the majority of the studies conducted consist in academic theses and presentations at scientific meetings, indicating that a complete and continuous field-based study about distribution and abundance of cetaceans is still missing. There are currently some research teams trying to promote field-based research in the northern and central areas off the west coast, whose results are starting to be analysed.

1.3.2. Resident population of bottlenose dolphins of the Sado estuary

Known since the 19th century (Bocage, 1863), the existence of a resident population of bottlenose dolphins in the Sado estuary has always been the primary focus of cetaceans study in Portugal mainland. With some references along the 20th century, from the 1980's this population has been constantly monitored (Teixeira and Duguay, 1981; dos Santos, 1985; dos Santos and Lacerda, 1987) and a photo-identification study was started. A continuous approach along the years enabled an estimative for the size of the population and has confirmed the decrease of the "Sado dolphins". Firstly, in 1982, estimated as forty animals (dos Santos and Lacerda, 1987), seven years later as thirty (Gaspar, 1994), twenty later as 26 (Augusto, 2007) and nowadays the entire group is identified and is composed by 23 individuals: 5 juveniles and 18 adults (www.projectodelfim.com visited in 11.06.2010).

The long term study of this population, unique in Portugal and one of the smallest in Europe, has allowed an increasing information about this nucleus in particular and the species *Tursiops truncatus* in general, in themes such as acoustic (dos Santos *et al.* 1990; Couchinho, 1999; Brito, 2001; Picanço, 2003) and behaviour and feeding ecology (Harzen, 1995; dos Santos, 1998; Carvalho, 2003; dos Santos *et al.*, 2007). Moreover, patterns of residency and movements have been studied and the occupancy of the estuary as of the adjacent coastal waters are well documented (e.g. Cândido, 2003; Augusto, 2007).

1.3.3. Resident populations of harbour porpoises

Along the continental shore, predominantly in the north, this species is observed in Aveiro/Figueira da Foz, Arrábida and Costa da Galé (Martins, 1998; Cabral *et al.*, 2005). It has also been reported to an area between Porto and S. Pedro de Moel

(Ferreira, 2008). The patterns of residency of harbour porpoises are believed (Cabral *et al.*, 2005) but are not yet understood since its study is not facilitated. The animals are seen only briefly and partially as they break the surface to breathe, they are comparatively small and are usually alone or in small groups of two to five individuals (Reeves *et al.*, 2002).

There is a current need of information about this species in European waters, since one of its primary threat is by-catch and incidental mortality in fisheries (Parsons *et al.*, 2010).

1.4. Objectives

The main aim of this study was to analyse the occurrence, diversity and habitat use of cetaceans off the West Portuguese coast.

More specifically, two questions were addressed:

- Are common dolphins and bottlenose dolphins partitioning the same habitat?
- Which are the most frequent behavioural activities of common dolphins in Portuguese waters?

1.5. References

Augusto, J. (2007). Análise da estrutura social, da composição dos grupos e associações nos golfinhos-roazes (*Tursiops truncatus*) residentes na região do Sado. Dissertação para obtenção do grau de mestre. Faculdade de Ciências da Universidade de Lisboa.

Ballance, L. (2009). Cetacean Ecology. In 'Encyclopedia of Marine Mammals'. (Eds Perrin, W.F., Würsig, B. and Thewissen, J.G.M.). pp.196-201. (Elsevier: San Diego, California.)

Bearzi, G., Reeves, R.R., Notarbartolo-di-Sciara, G., Politi, E., Cañadas, A., Frantzi, A. and Mussi, B. (2003). Ecology, status and conservation of short-beaked common dolphins *Delphinus delphis* in the Mediterranean Sea. *Mammal Review* **33**, 224-252.

Brito, C. (2001). Estudo da possível influência de factores ecológicos e comportamentais nas emissões acústicas dos golfinhos-roazes *Tursiops truncatus* no estuário do Sado. Dissertação para obtenção do grau de mestre. Instituto Superior de Psicologia Aplicada, Lisboa.

Brito, C. Vieira, N., Sá, E. and Carvalho, I. (2009). Cetaceans' occurrence off the west central Portugal coast: a compilation of data from whaling, observations of opportunity and boat-based surveys. *Journal of Marine Animals and Their Ecology* **2**, 4pp.

Bocage, M.B. du. (1863). Liste de mammifères et reptiles observés en Portugal. *Rev. Mag. Zool. Puré appliquée* **15**, 329-333.

Cabral, M.J. (coord.), Almeida, J., Almeida, P.R., Dellinger, T., Ferrand de Almeida, N., Oliveira, M.E., Palmeirim, J.M., Queiroz, A.I., Rogado L. and Santos-Reis, M. (2005). 'Livro Vermelho dos Vertebrados de Portugal.' (Instituto da Conservação da Natureza: Lisboa.)

Cañadas, A. and Hammond, P.S. (2008). Abundance and habitat preferences of the short-beaked common dolphin *Delphinus delphis* in the southwestern Mediterranean: implications for conservation. *Endangered Species Research* **4**, 309-331.

Cândido, A.T. (2003). Utilização de um sistema de informação geográfica (SIG) para análise da distribuição e padrões de movimento da população de golfinhos-roazes (*Tursiops truncatus*) do estuário do Sado. Dissertação para obtenção do grau de mestre. Instituto Superior de Psicologia Aplicada, Lisboa.

Carvalho, I. (2000). Observação e análise dos padrões de comportamento dos golfinhos-roazes, *Tursiops truncatus* (Montagu, 1821), no estuário do Sado. Relatório de estágio de licenciatura. Faculdade de Ciências da Universidade de Lisboa.

Certain, G., Ridoux, V., van Canneyt, O. and Bretagnolle, V. (2008). Delphinid spatial distribution and abundance estimates over the shelf of the Bay of Biscay. *ICES Journal of Marine Science* **65**, 656–666.

Connor, R.C. (2000). Group living in whales and dolphins. In 'Cetaceans Societies: Field Studies of Dolphins and Whales.' (Eds Mann, J., Connor, R.C., Tyack, P.L., and Whitehead, H.) pp.199-218 (The University of Chicago Press, Chicago.)

Coucinho, M.N. (1999). Padrões de emissão de assobios por golfinhos-roazes (*Tursiops truncatus*) na região do Sado. Dissertação para obtenção do grau de mestre. Instituto Superior de Psicologia Aplicada, Lisboa.

De Boer, M.N., Leaper, R., Keith, S. and Simmonds, M.P. (2008). Winter abundance estimates for the common dolphin (*Delphinus delphis*) in the western approaches of the English Channel and the effect of responsive movement. *Journal of Marine Animals and Their Ecology* **1**, 14-20.

dos Santos, M.E. and Lacerda, M. (1987). Preliminary observations of the bottlenose dolphin (*Tursiops truncatus*) in the Sado estuary (Portugal). *Aquatic Mammals* **13**, 85-80.

dos Santos, M.E., Caporin, G., Moreira, H.O., Ferreira, A.J. and Coelho, J.L.B. (1990). Acoustic behaviour in a local population of bottlenose dolphins. In 'Sensory Abilities of Cetaceans, Laboratory and Field Evidence'. (Eds Jeanette, E., Thomas A. and Kastelein, R.A.) pp.585-598. (Plenum Press: New York.)

dos Santos, M.E. (1998). 'Golfinhos-roazes do Sado: Estudos de Sons e Comportamento.' (Instituto Superior de Psicologia Aplicada: Lisboa.)

dos Santos, M. E., Coniglione, C. and Louro, S. (2007). Feeding behaviour of the bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821) in the Sado estuary, Portugal, and a review of its prey species. *Revista Brasileira de Zoociências* **9**, 31-39.

Evans, P. G. H. (1987). 'The Natural History of Whales and Dolphins.' (Cristopher Helm: London.)

Ferreira, M. Monteiro, S., Rodrigues, P., Mendes, P., López, A. and Vingada, J. V. (2008). Summer distribution and abundance of cetaceans in northern/center Portugal. In 'Proceedings of the 22nd Annual Conference of the European Cetacean Society, Egmond aan Zee 10-12 March'. (Eds. Philips E.) p.294

Gaspar, R. (1994). Estudo dos movimentos, da sociabilidade e dos padrões de frequência dos roazes *Tursiops truncatus* na região do estuário do Sado, utilizando a foto-identificação. Relatório de estágio de licenciatura. Faculdade de Ciências da Universidade de Lisboa.

Gowans, S., Würsig, B. and Karczmarski, L. (2008). The Social Structure and Strategies of Delphinids. *Advances in Marine Biology* **53**, 195-294.

Hammond, P.S., Macleod, K., Gillespie, D. Swift, R., Winship, A., Burt, M.L., Cañadas, A., Vázquez, J.A., Ridoux, V., Certain, G., Van Canneyt, O., Lens, S., Santos, B., Rogan, E., Uriarte, A., Hernandez, C. and Castro, R. (2009). Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA), Final Report.

Harzen, S. (1995). Behaviour and social ecology of the bottlenose dolphin, *Tursiops truncatus*, in the Sado estuary. In 'Análise da estrutura social, da composição dos grupos e associações nos golfinhos-roazes (*Tursiops truncatus*) residentes na região do Sado'. (Augusto, 2007). (Dissertação para obtenção do grau de mestre. Faculdade de Ciências da Universidade de Lisboa.)

Macleod, K., Simmonds, M.P. and Murray, E. (2003). Summer distribution and relative abundance of cetacean populations off north-west Scotland. *Journal of the Marine Biological Association of the United Kingdom* **83**, 1187-1192.

Martins, A.I.D. (1998). Padrão de ocorrência dos botos (*Phocoena phocoena*) na região marinha adjacente ao estuário do Sado, Portugal. Relatório de estágio de licenciatura. Faculdade de Ciência da Universidade de Lisboa.

Mougenot, D. (1989). 'Geologia da Margem Portuguesa.' (Instituto Hidrográfico: Lisboa.)

Neumann, D.R. (2001). The activity budget of free-ranging common dolphins (*Delphinus delphis*) in the northwestern Bay of Plenty, New Zealand. *Aquatic Mammals* **27**, 121-136.

Norris, K.S. and Dahl, T.P. (1980). The Structure and Function of Cetacean Schools. In 'Cetacean Behaviour.' (Eds Herman, L.H) pp.211-261. (John Wiley & Sons: New York.)

Parsons, E.C.M.; Clark, J.; Warkham, J. and Simmonds, M.P. (2010). The Conservation of British Cetaceans: a review of the treats and protection afforded to whales, dolphins and porpoises in UK waters, Part 1. *Journal of International Wildlife Law & Policy* **13**, 1-62.

Picanço, C.I.C. (2003). Produção de assobios pelos golfinhos-roazes, *Tursiops truncatus* (Montagu, 1821) no estuário do Sado e estudo das associações entre indivíduos. Relatório de estágio de licenciatura. Universidade de Évora.

Pusineri, C., Magnin, V., Meynier, L., Spitz, J., Hassani, S. and Ridoux, V. (2007). Food and feeding ecology of the common dolphin (*Delphinus delphis*) in the oceanic northeast Atlantic and comparison with its diet in neritic areas. *Marine Mammal Science* **23**, 30–47.

Reeves, R. R., Stewart, B. S., Clapham, P.J. and Powell, J.A. (Eds) (2002). 'National Audobon Society Guide to Marine Mammals of the World.' (Alfred A. Knopf: New York.)

Robinson, K.P., Einfeld, S.M., Costa, M. and Simmonds, M.P. (2010). Short-beaked common dolphin (*Delphinus delphis*) occurrence in the Moray Firth, north-east Scotland. *Marine Biodiversity Records* **3**, 1-4.

Sequeira, M.L. (1988). Mamíferos marinhos da costa portuguesa: Padrões de distribuição e ocorrência das principais espécies. Relatório de Estágio. Faculdade de Ciências, Universidade de Lisboa.

Silva, M.A. (1999). Diet of common dolphins, *Delphinus delphis*, off the Portuguese continental coast. *Journal of the Marine Biological Association of the United Kingdom* **79**, 531-540.

Stockin, K.A., Binedell, V., Wiseman, N., Brunton, D.H., Orams, M.B. (2009). Behavior of free-ranging common dolphins (*Delphinus* sp.) in the Hauraki Gulf, New Zealand. *Marine Mammal Science* **25**, 283-301.

Teixeira, A.M.A.P. (1978). Contribuição para o estudo dos mamíferos marinhos da costa Portuguesa. Relatório de Estágio. Faculdade de Ciência, Universidade de Lisboa.

Teixeira, A. M. A. P. (1979). Marine mammals of the Portuguese coast. *Sonderdruck aus Z. f. Säugetierkunde* **44**, 221-238.

Teixeira, A.M. and Duguy, R. (1981). Observations de Delphinudés dans les eaux côtières portugaises. *Relatórios de Actividades do Aquário Vasco da Gama* **9**, 1-9

Wise, L., Ferreira, M., Silva, M., Sequeira, M., Silva, A. (2005) Estudo das interações entre mamíferos marinhos e a pesca de cerco na costa oeste portuguesa. *Relat. Cient. Téc. IPIMAR, Série digital* (<http://ipimar-iniap.ipimar.pt>), nº 25.

**CHAPTER 2: COMPARISON OF HABITAT USE OF COMMON DOLPHIN
(*DELPHINUS DELPHIS*) AND BOTTLENOSE DOLPHIN (*TURSIOPS TRUNCATUS*)
IN PORTUGAL MAINLAND**

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Abstract

The co-occurrence of two or more species of the family *Delphinidae* in the same geographical area is frequent and has been reported elsewhere for common dolphins

(*Delphinus delphis*) and bottlenose dolphins (*Tursiops truncatus*). Between January 2007 and October 2009, we observed occurrence and distribution of both species in three locations off Portugal mainland coast and analysed differences between species considering group dynamics (group size, presence/absence of calves and behaviour) and habitat parameters (sea surface temperature, depth and distance to coast). From a total of 81 independent sightings of cetaceans, 60 were of common dolphins and 13 of bottlenose dolphins. Both species were observed mostly in small groups (45% and 50% respectively). 59% of common dolphins' groups included calves in opposite of groups of bottlenose dolphins, composed predominantly by adults (17% sightings with calves). Common dolphins were observed travelling, feeding, socializing and resting, while bottlenose dolphins were only observed travelling. Differences were also found when comparing habitat preferences, with common dolphins occurring preferentially in deepest waters and more distant to coast and bottlenose dolphins in shallower waters near shore. The results suggest that habitat partitioning is occurring due to differences in these species' ecological niches.

Keywords: ecology, habitat partitioning, common dolphin, bottlenose dolphin, Portugal

Introduction

Cetacean distribution data along the Portuguese coast is limited to a few sources and more detailed information about habitat use and patterns of residency is missing. It is known that short-beaked common dolphin, (*Delphinus delphis* Linnaeus, 1758); hereafter common dolphin) is the more frequent species followed by common bottlenose dolphins (*Tursiops truncatus* Montagu, 1821); hereafter bottlenose dolphin)

(Teixeira, 1979; Wise *et al.*, 2005; Brito *et al.*, 2009). A better understanding of dolphins populations' ecological niches, specifically for these two species, is relevant for conservation and management decisions, designing Marine Protected Areas when needed and implementing new technologies both inshore and offshore. Plus, the knowledge of habitat use of bottlenose dolphins allows the understanding of the levels of interaction, competition or mutualism relations that they may have with resident populations.

Common dolphins have a widely distribution from continental shelf and pelagic waters of the Atlantic and Pacific Oceans along shelf edges and in areas with sharp bottom relief such as seamounts and escarpments. (Reeves *et al.*, 2002). It is the most abundant species in European Atlantic (Hammond *et al.*, 2009) and in the Mediterranean is found in groups of a few individuals to several hundred, with of calves present year-round. In this region common dolphins exhibit a relatively flexible feeding habits and have a preference for epipelagic and mesopelagic fish, occupying areas of submarine canyons (Bearzi *et al.*, 2003).

Bottlenose dolphins occur in warm temperate to tropical waters, very close to shore, in bays and mouths of rivers, as well as in the open ocean. Inshore bottlenose dolphins inhabiting shallow waters form small groups between 3 and 10 individuals but these units are not closed. Other communities of bottlenose dolphins, which occur in adjacent habitats and non-resident individuals are often observed within one community's core range area (Gowans *et al.*, 2008). The social structure of bottlenose dolphins is characterized by dynamic units varying from stable and resident groups to groups continually changing in size and membership over time and a fluid association between these two kinds of structure (Balance, 1990).

The co-occurrence of two or more species of the family *Delphinidae* in the same geographical area is very common and has been reported for *D. delphis* and *T. truncatus* in the Mediterranean (Bearzi, 2005a). This sympatry could lead to habitat

partitioning for two reasons: the species avoid each other in consequence of interspecific competition or they have ecological differences and occupy different niches (Roughgarden, 1976; Bearzi, 2005b). The present study aims to infer about the habitat use of common dolphins and bottlenose dolphins in Portuguese mainland coast. It would be expected, considering the ecological differences between the species, that they do not enter in direct competition but naturally distribute unequally.

Material and Methods

Study Area

The study area includes three locations in the west Portuguese coast: Póvoa de Varzim (41°N), Nazaré/Peniche (39°N) and Sesimbra (38°N) (Fig. 1). The oceanographic characteristics of these 3 locations are very dissimilar concerning the type of slope and oceanographic features. The northern zone is characterized by a continuous continental shelf without exuberant demographic accidents, and the central and southern zones by submarine canyons, namely Nazaré, one of the largest and deepest canyons of Europe, Lisboa and Setúbal (Mougenot, 1989). These locations are important fishing spots of the Portuguese coast and they all are in the vicinity or included in Marine Protected Areas: Parque do Litoral Norte (Póvoa de Varzim), Reserva Natural das Berlengas (Nazaré/Peniche) and Parque Marinho Prof. Luiz Saldanha (Sesimbra).

Data Collection and Analysis

Data was collected from January 2007 to October 2009 and two different survey methods were utilized: platforms of opportunity and research dedicated boat-based surveys. Both surveys consisted in non systematic surveys in which the vessel route was determined at the start of each day, based on prevailing weather conditions and aiming to acquire greatest spatial coverage. All the boat trips were conducted during

day-light period, between 8am and 18pm. Whenever cetaceans were sighted the vessel position, species, group size, group composition and predominant behavioural activity were recorded. Depth in the moment of sighting was registered from vessel sonar and distance from shore was afterwards calculated for each sighting using ArcView 9.1 GIS software.

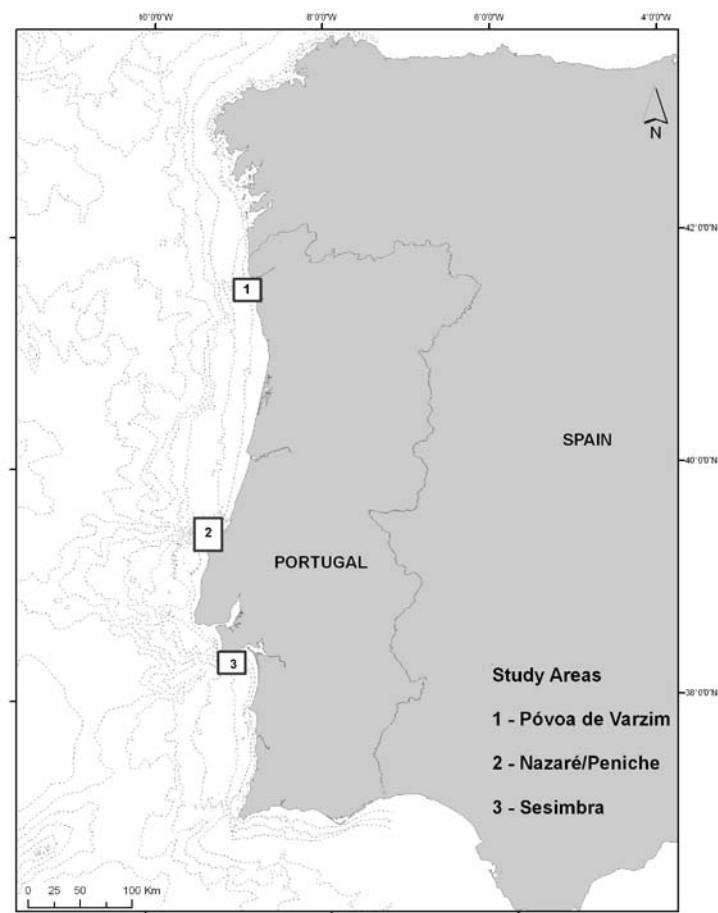


Fig. 1. Study area including the three different locations off Portugal mainland and showing batimetric lines.

Sea surface temperature (SST) was obtained from <http://www.medspiration.org/> and the values are the mean temperature of an area of 4 km² (2 km from shore to ocean x 2

km parallel to shore). A group was defined as any number of animals observed in association, moving in the same direction and engaging in the same activity (Shane, 1990). Group size was classified as 1-10; 11-20; 21-50; 51-100 and group composition included presence of calve/juvenile (one-half and one-third the length of an adult) and adult (any animal > 1,80m) (Stockin *et al.*, 2009). Behaviour was recorded in four categories (adapted from Shanne, 1990; Stockin *et al.*, 2009): traveling (dolphins engage in persistent, directional movement, making noticeable headway), feeding (dolphins exhibit nondirectional movement, frequent changes in heading prevent animals from making headway in any specific direction), socializing (dolphins chasing, copulating or engage in any other physical contact with other dolphins) and resting (dolphins stay close to the surface in a tight group, engaged in slow maneuvers with little evidence of predictable than observed in other behavioural states).

To analyse differences in the habitat use between common dolphins and bottlenose dolphins a qui-square test was used to infer group dynamics (group size, group composition and behaviour) and Mann–Whitney U-test (Statistica v.9) were used for habitat parameters (SST, water depth and distance from shore).

Results

Species occurrence

A total of 99 boat-based surveys were conducted (20 in Póvoa de Varzim, 21 in Nazaré/Peniche and 58 in Sesimbra). A total of 18 647 minutes of survey data were collected resulting in 81 independent sightings of cetaceans. Including the three geographic locations, 5 species were detected during the survey period and in just one occasion was not possible to identify the Delphinidae species. Common dolphin was the most observed species (n=60), followed by bottlenose dolphins (n=13), striped dolphins (n=4), harbour porpoises (*Phocoena phocoena*) (n=2) and minke whales

(*Balaenoptera acutorostrata*) (n=2). Common dolphins were sighted at the three surveyed locations and bottlenose dolphins in Nazaré/Peniche and Sesimbra (Fig. 2). Mixed groups of common dolphins and striped dolphins were registered (n=3). Mixed groups of common dolphins and bottlenose dolphins were never found and the two species were never observed in the same day.

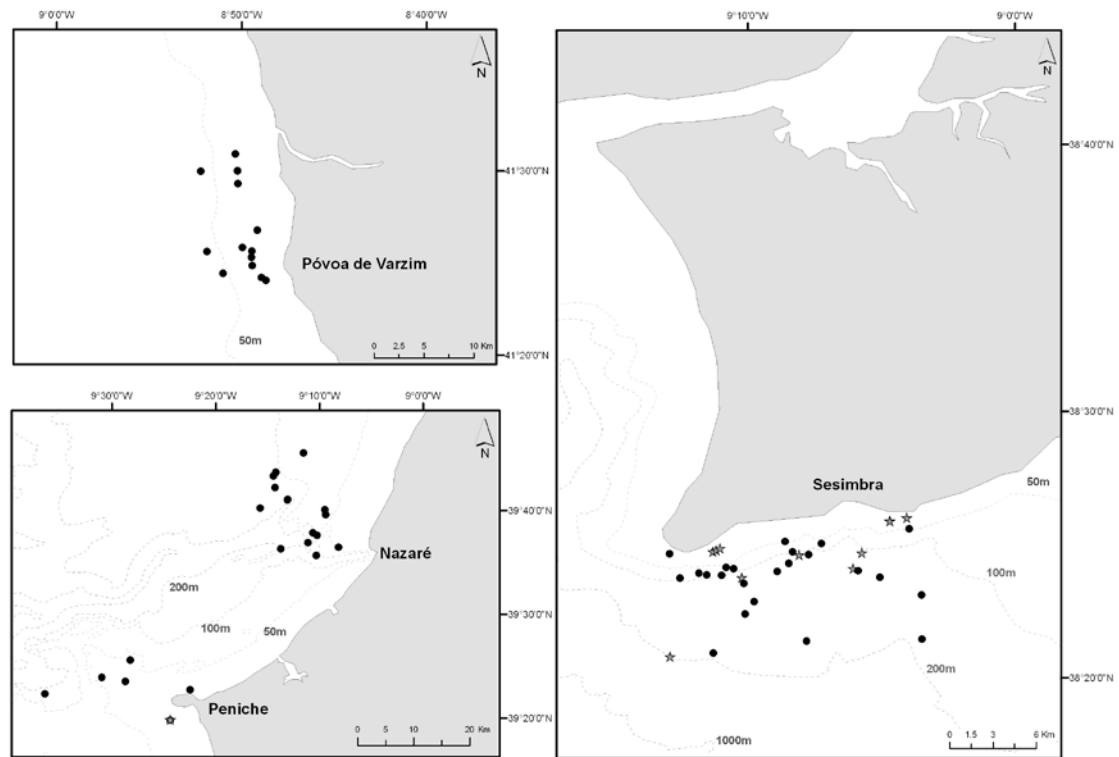


Fig. 2. Distribution of common dolphin (n=60) (black spots) and bottlenose dolphin (n=12) (grey stars) in three different locations off Portugal mainland, between January 2007 and October 2009.

Group dynamics

For both species the most recorded group size was 1-10 individuals, in 45% sightings of common dolphins (n=22) and 50% of bottlenose dolphins (n=6), followed by groups of 11-20. No significant differences were found between group sizes of common

dolphins and bottlenose dolphins. The presence of calves/juveniles was significantly higher for common dolphins (59%, n=34) than for bottlenose dolphins (17%, n=2) ($p<0,05$). Common dolphins were observed travelling (n=28), feeding (n=15), socializing (n=8) and resting (n=1) while bottlenose dolphins were observed only travelling (n=10). A summary of these results is shown in Table 1.

Table 1. Number and percentage of sightings of group sizes (1-10, 11-20, 21-50 and 51-100 individuals), presence/absence of calves and behavioural activities for *Delphinus delphis* and *Tursiops truncatus* off Portugal mainland between January 2007 and October 2009.

Group size	<i>D. delphis</i>	<i>T. truncatus</i>
1-10	22	6
11-20	12	3
21-50	10	1
51-100	5	2
Calves		
Presence	34	2
Absence	24	10
Activity		
Traveling	28	10
Feeding	15	0
Socializing	8	0
Resting	1	0

Habitat variables

The habitat variables measured for *D. delphis* and *T. truncatus* sightings are shown in Fig.3.

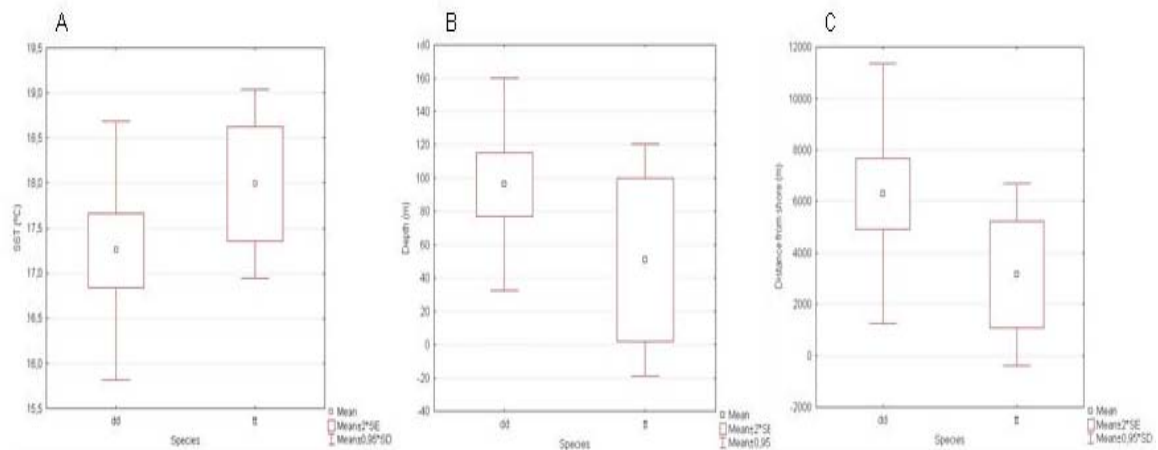


Fig.3. Habitat variables of *Delphinus delphis* and *Tursiops truncatus* sightings: (A) sea surface temperature, (B) depth and (C) distance from shore.

For SST only the months between April and October were included, because no encounters with bottlenose dolphins were registered outside this period. Common dolphins were observed at a mean SST of 17,25°C (range=14,45°C-20,35°C, s.d.=1,51, n=53) and bottlenose dolphins at a mean of 17,99°C (range=16,21°C-19,32°C, s.d.=1,10, n=12) but no significant differences were found between species.

The depth range of common dolphins sightings varied from 25 m to 400 m with a mean depth of \bar{x} =96,15 m (s.d.=67,23, n=50) and for bottlenose dolphins between 5m and 180m with a mean depth of \bar{x} =50,78 m (s.d.=73,48, n=9). This difference between deeper and shallower waters was significant between the two species ($p<0,05$) with common dolphins exhibiting a preference for deeper waters.

The mean distance from shore observed for common dolphins was 6 308 m and varied from 409 m to 19 491 m (s.d.=5 313, n=59) and for bottlenose dolphins the

mean distance was 3 162 m and varied from 232 m to 12 700 m (s.d.=3 728, n=13). Significant differences were found between the two species ($p<0,05$), showing the preference of common dolphins for deepest waters.

Discussion

Occurrence and association of species

Common dolphin was the most observed species, registered in the three surveyed locations, followed by bottlenose dolphin, as already described for Portugal mainland coast by other authors (e.g. Teixeira, 1979; Brito, 2009). Bottlenose dolphins were mostly observed in Sesimbra (n=12) and were never seen with common dolphins in the same day (even though seen in the same week and in some occasions in the day before) suggesting that habitat partitioning is occurring.

Striped dolphins were registered most of the times in mixed-groups with common dolphins as also described for other regions worldwide (Frantzis and Herzing, 2002; Cañadas and Hammond, 2008). Being an offshore species, striped dolphins can use this association as an advantage when coming to shallower waters to follow coastal preys (Quérrouil *et al.*, 2008).

Group dynamics

Common dolphins were observed year-round in small groups with calves, in travelling, feeding and socializing. The species seem to use the study area to conduct all the activities of its daily life, traveling between feeding areas, foraging and establishing relations with its co-specifics, including mating. Bottlenose dolphins were observed also in small groups, mostly without calves and traveling.

Apparently these two species are using the habitat with different purposes, since their behavioural activities were very distinctive and their distribution unequal. It

should however be noted that the behavioural activity travelling for bottlenose dolphins may be overestimated in prejudice of feeding. It is possible that our survey effort did not included the most active periods if we take into account that this species may feed mostly in the early morning and late afternoon (Shane *et al.*, 1986). On the other hand, contrary to what it was observed for common dolphin, in several occasions bottlenose dolphins not only do not approach the boat as they move away. Bottlenose dolphins have a herd structure with different formations, and the group structure seems to change, namely in fear reactions. The animals gathered together underwater and emerged in a densely packed group far away from the danger (Bel'kovich *et al.* 1991) which can drive the observer to register another behavioural activity from the original.

Being travelling the more observed activity we can expect that migration plays an important role in cetaceans' distribution (Gowans and Whitehead, 1995). Food resources are rarely uniform throughout the environment and predators need to travel between feeding areas. Also, the organization in small groups, as observed in this study, may be an improvement for more efficient foraging strategies because preys are often distributed over many small patches, as also reported for both species in the Mediterranean (Cañadas and Hammond, 2008).

Nevertheless, the social structure of bottlenose dolphins is very complex. Fluctuations on group sizes probably occur, with an influx of new individuals on closely groups (Zolman, 2002). This is an important issue since the area of Sesimbra is nearby the Sado Estuary where a population of *T. truncatus* is resident, and is actually an object of a governmental conservation plan, and it is of primary importance to understand if the different populations have some level of interaction.

Habitat variables

Considering the environmental parameters analysed, no differences were found in SST values between the two species, and depth and distance to coast were in fact the explanatory variables for habitat use and partitioning by *D. delphis* and *T. truncatus*.

Common dolphins seem to have a preference for deepest waters, with a mean depth of 96,15m and a mean distance to coast of 6 308 m. In this case, submarine canyons can have an ecological importance based on its optimal features for mixing nutrients and consequently richness in prey for cetaceans (Hui, 1979; Hooker *et al.*, 1999; de Stephanis *et al.*, 2008). This can lead common dolphins to Nazaré/Peniche and Sesimbra where submarine canyons are present. Bottlenose dolphins were observed very close to shore, with a mean depth of 50,78 m and a mean distance to coast of 3 162 m, but in Póvoa de Varzim (the northern location surveyed near shore and characterized by low depth) the species was never observed during our campaign. This can lead to a hypotheses based on a superabundance of food resources which attracts different species within a same geographic area (Selzer and Payne, 1988).

Moreover, the study area in Sesimbra includes a particularly important marine protected area (Parque Marinho Prof. Luiz Saldanha), where restrictions to fisheries are being imposed since 1998. This can be seen as a potential factor in creating an interesting spot to feed as happens in other regions (e.g. Toth *et al.*, 2010). It has been described that *D. delphis* and *T. truncatus* may differ in distribution and prey preference as a consequence of competition for resources in inshore waters (e.g. Bearzi *et al.*, 2005). The diet of common dolphins seem to change with geographical areas and according to seasonal fluctuations in prey distribution but in the study area an examination of stomach contents reported by Silva (1999) pointed sardine (*Sardina pilchardus*) as the most important prey due to the abundance of this pelagic species in our coast. Bottlenose dolphins are more opportunistic feeders adapting their diet to

prey availability and differing among seasons, habitats, age and sex (Shane *et al.*, 1986; Gannon and Waples, 2004).

It is also possible that bottlenose dolphins use the area in Sesimbra as a coastal-corridor with a certain level of fidelity as known for this species worldwide (Defran and Weller, 1999; Bearzi *et al.*, 2009). The species tends to exhibit varying degrees of residence to particular regions, ranging from small localized inshore populations, apparently resident to specific embayments, to larger numbers of migratory coastal dolphins which appear to move latitudinally on a seasonal basis (Wang *et al.*, 1994).

Although the number of sightings of bottlenose dolphins was relatively low, the present study offers new insights on the distribution and habitat use of *D. delphis* and *T. truncatus* and is a first approach about habitat partitioning of both species in Sesimbra. As expected, the species seem to have different ecological niches and it does not seem to exist a direct competition for resources. Further research and the analyses of the photo-id catalogue need to be promoted to better understand the relations between species and resident populations.

References

Ballance, L.T. (1990). Residence patterns, group organization, and surfacing associations of bottlenose dolphins in Kino Bay, Gulf of California, Mexico. In 'The Bottlenose Dolphin'. (Eds Leatherwood, S. and Reeves, R.R) pp.267-283 (Academic Press, Inc.: San Diego, California)

Bearzi, G., Reeves, R.R., Notarbartolo-di-Sciara, G., Politi, E., Cañadas, A., Frantzis, A. and Mussi, B. (2003). Ecology, status and conservation of short-beaked common dolphins *Delphinus delphis* in the Mediterranean Sea. *Mammal Review* **33**, 224-252.

Bearzi, G., Politi, E., Agazzi, S., Bruno, S., Costa M. and Bonizzoni, S. (2005). Occurrence and present status of coastal dolphins (*Delphinus delphis* and *Tursiops truncatus*) in the eastern Ionian Sea. *Aquatic Conservation: Marine and Freshwater Ecosystems* **15**, 243–257.

Bearzi, M. (2005a). Habitat partitioning by three species of dolphins in Santa Monica Bay, California. *Bulletin of the Southern California Academy of Sciences* **104**, 113–124.

Bearzi, M. (2005b). Dolphin sympatric ecology. *Marine Biology Research* **1**, 165-175.

Bearzi, M. Saylan, C.H. and Hwang, A. (2009). Ecology and comparison of coastal and offshore bottlenose dolphins (*Tursiops truncatus*) in California. *Marine and Freshwater Research* **60**, 584-593

Bel'kovich, V.M., Agafonov, A.V., Yefremenkova, O.V., Kozarovitsky, L.B. and Kharitonov, S.P. (1991). In 'Dolphin Societies'. (Eds Pryor, K. and Norris, K.S.) pp.17-77 (University of California Press, Ltd: California).

Brito, C., Vieira, N., Sá, E. and Carvalho, I. (2009). Cetaceans' occurrence off the west central Portugal coast: a compilation of data from whaling, observations of opportunity and boat-based surveys. *Journal of Marine Animals and Their Ecology* **2**, 4 pp.

Cañadas, A. and Hammond, P.S. (2008). Abundance and habitat preferences of the short-beaked common dolphin *Delphinus delphis* in the southwestern Mediterranean: implications for conservation. *Endangered Species Research* **4**, 309-331.

Defran, R.H. and Weller, D.W. (1999). Occurrence, distribution, site fidelity, and school size of bottlenose dolphins (*Tursiops truncatus*) off San Diego, California. *Marine Mammal Science* **15**, 366-380.

de Stephanis, R., Cornulier, T., Verborgh; Sierra, J.S., Gimeno, N.P. and Guinet, C. (2008). Summer spatial distribution of cetaceans in the Strait of Gibraltar in relation to the oceanographic context. *Marine Ecology Progress Series* **353**, 275–288

Frantzis, A. and Herzog, D.L. (2002). Multi-species associations of striped dolphins (*Stenella coeruleoalba*), short-beaked common dolphin (*Delphinus delphis*), and Risso's dolphins (*Grampus griseus*) in the Gulf of Corinth (Greece, Mediterranean Sea). *Aquatic Mammals* **28**, 188-197.

Ganons, D.P. and Waples D.M. (2004). Diets of coastal bottlenose dolphins from the U.S. Mid-Atlantic coast differ by habitat. *Marine Mammal Science*. **20**, 527-545.

Gowans, S. and Whitehead, H. (1995). Distribution and habitat partitioning of small odontocetes in the Gully, a submarine canyon on the Scotian shelf. *Canadian Journal of Zoology* **73**, 1599-1608.

Gowans, S., Würsig, B. and Karczmarski, L. (2008). The Social Structure and Strategies of Delphinids: Predictions Based on an Ecological Framework. *Advances in Marine Biology* **53**, 195-294.

Hammond, P.S.; Macleod, K., Gillespie, D. Swift, R., Winship, A., Burt, M.L., Cañadas, A., Vázquez, J.A., Ridoux, V., Certain, G., Van Canneyt, O., Lens, S., Santos, B., Rogan, E., Uriarte, A., Hernandez, C. and Castro, R. (2009) Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA). Final Report.

Hooker, S.K., Whitehead, H. and Gowans, S. Marine protected areas design and the spatial and temporal distribution of cetaceans in a submarine Canyon. *Conservation Biology* **13**, 592-602.

Hui, C.A. (1979). Undersea topography and distribution of dolphins of the genus *Delphinus* in the Southern California Bight. *J. Mammal.* **60**, 521–527.

Mougenot, D. (1989). Geologia da Margem Portuguesa. Instituto Hidrográfico, Lisboa.

Quérrouil, S., Silva, M.S., Cascão, I., Magalhães, S., Seabra, M.I., Machete, M.A. and Santos, R.S. (2008). Why Do Dolphins Form Mixed-Species Associations in the Azores? *Ethology* **114**, 1183–1194.

Reeves, R. R., Stewart, B. S., Clapham, P.J. and Powell, J.A. (2002). 'National Audobon Society Guide to Marine Mammals of the World.' (Alfred A. Knopf: New York.)

Rougharden, J. (1976). Resource Partitioning Among Competing Species-A Coevolutionary Approach. *Theoretical Population Biology* **9**, 388-424.

Selzer, L and Payne, P.M. (1988). The distribution of white-sided (*Lagenorhynchus acutus*) and common dolphins (*Delphinus delphis*) vs. environmental features of the continental shelf of the northeastern United States. *Marine Mammal Science* **4**, 141-153.

Shane, S.H., Wells, R.S. and Würsig, B. (1986). Ecology, behavior and social organization of the bottlenose dolphin: a review. *Marine Mammal Science* **2**, 34-63

Shane, S.H. (1990). Behaviour and ecology of the bottlenose dolphin at Sanibel Island, Florida. In 'The Bottlenose Dolphin'. (Eds Leatherwood S. and Reeves, R.R.) pp. 245-265. (Academic Press: San Diego, California.)

Silva, M.A. (1999). Diet of common dolphins, *Delphinus delphis*, off the Portuguese continental coast. *Journal of the Marine Biological Association of the United Kingdom* **79**, 531-540.

Stockin, K.A., Binedell, V., Wiseman, N., Brunton, D.H., Orams, M.B. (2009). Behavior of free-ranging common dolphins (*Delphinus* sp.) in the Hauraki Gulf, New Zealand. *Marine Mammal Science* **25**, 283-301.

Teixeira, A. M. A. P. (1979) Marine mammals of the Portuguese coast. *Sonderdruck aus Z. f. Säugetierkunde* **44**, 221-238.

Toth, J.L., Hohn, A.A., Able, K.W. and Gorgone, A.M. (2010). Patterns of seasonal occurrence, distribution, and site fidelity of coastal bottlenose dolphins

(*Tursiops truncatus*) in southern New Jersey, U.S.A. *Marine Mammal Science*. pp.17
DOI: 10.1111/j.1748-7692.2010.00396.x

Wang, K.R., Payne, P.M. and Thayer, V.G. (1994). Coastal Stock(s) of Atlantic Bottlenose Dolphin: Status Review and Management. In 'Proceedings and Recommendations from a Workshop held in Beaufort, North Carolina, 13-14 September 1993'. P.126 (NOAA, USA.)

Wise, L., Ferreira, M., Silva, M., Sequeira, M., Silva, A. (2005) Estudo das interações entre mamíferos marinhos e a pesca de cerco na costa oeste portuguesa. *Relat. Cient. Téc. IPIMAR, Série digital* (<http://ipimar-iniap.ipimar.pt>), nº 25.

Zolman, E.S. (2002). Residence patterns of bottlenose dolphins (*Tursiops truncatus*) in the Stono River estuary, Charleston County, South California, U.S.A. *Marine Mammal Science* **18**, 879-892.

CHAPTER 3: A DESCRIPTION OF SHORT-BEAKED COMMON DOLPHIN'S BEHAVIOURAL ACTIVITIES IN PORTUGAL MAINLAND

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Abstract

The present study describes the behavioural activities of short-beaked common dolphins in a poorly known study area. The aim is to present information about activity budget, group size and group composition in three different locations of Portugal mainland coast. A total of 100 boat-based surveys were conducted between January 2007 and October 2009 from which resulted 60 observations of common dolphins and 52 independent observations of behavioural activities, including travelling, feeding, socializing and resting. Travelling was the most frequent activity (54%), followed by feeding (29%), socializing (15%) and resting (2%). Groups between 1-10 individual were the most frequently sighted (45%), followed by groups of 11-20 (25%), 21-50 (20%) and 51-100 (10%). One event of socializing included persecution, belly-to-belly

contact and copulation, occasionally involving the repetitive intercourse of the same female by different males. Mixed-groups of common dolphins were also recorded, namely with striped dolphins. It seems that common dolphin uses the study area to conduct all the activities of its daily life.

Keywords: activity patterns, behaviour activities, common dolphin, Portugal

Introduction

Short-beaked common dolphins (*Delphinus delphis*) have a wide distribution along the continental shelf and pelagic waters of the Atlantic and Pacific Oceans, gathering in schools of dozens, hundreds or thousands individuals, very active at surface and preferentially feeding on small schooling fish (Evans, 1994; Reeves *et al.*, 2002). The schools of common dolphins are thought to be composed of small subunits of about 20 to 30 individuals, probably closely related (Evans, 1994). There may be segregation in schools by age and sex (Perrin, 2009) and association with schools of other dolphins' species have been observed (Evans, 1994; Frantzis and Herzing, 2002).

Published information regarding common dolphins' activity budget exist for New Zealand (Neumann, 2001; Stockin *et al.*, 2009), studies on feeding behaviour exist for Mexico (Gallo Reynoso, 1991) and New Zealand (Newmann and Orams, 2003) and in the Mediterranean several studies concerning distribution, density and conservation status include data about behavioural activity (e.g. Bearzi *et al.*, 2003; Cañadas and Hammond, 2008). In spite of this, little is known about behavioural ecology of common dolphins worldwide, namely for Atlantic European waters. In Portugal mainland this species is the most frequently sighted along the coast (Teixeira, 1979; Wise *et al.*, 2005, Brito *et al.*, 2009) and although some themes as feeding ecology (e.g. Silva,

1999) and interaction with fisheries (e.g. Wise *et al.*, 2007) have been approached, a behavioural ecology study has not been promoted yet. Here we present the first data about behavioural activities, activity budget, group size and group composition of common dolphins in Portuguese mainland waters.

Material and Methods

Boat-based surveys were conducted in three different locations of Portuguese mainland coast, Póvoa de Varzim (n=20), Nazaré/Peniche (n=21) and Sesimbra (n=58) (Fig.1).

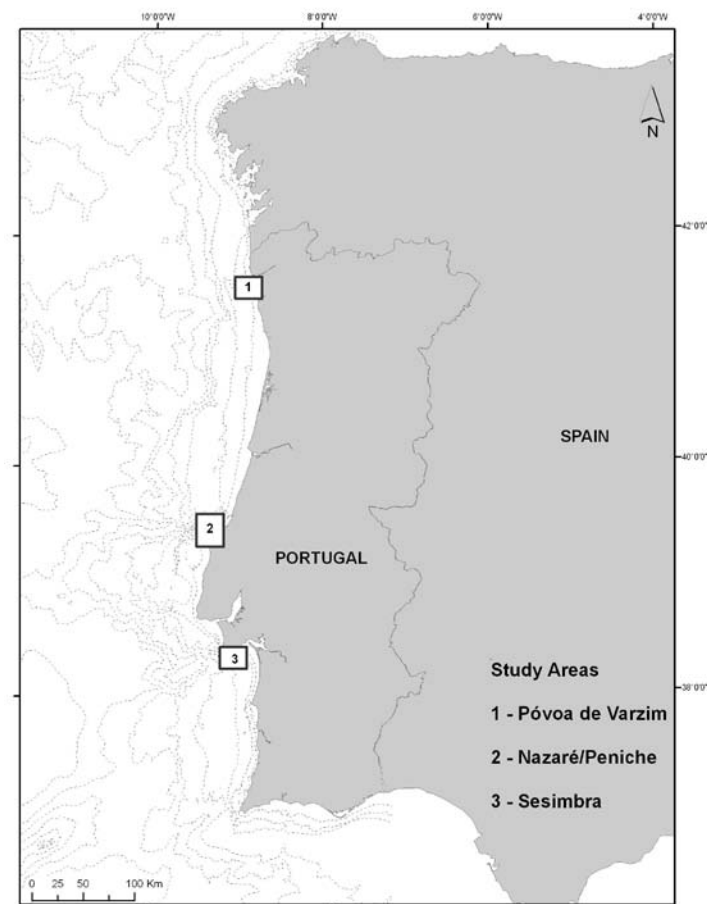


Fig. 1. Study area including three different locations along Portugal mainland coast, from January 2007 to October 2009.

A total of 99 surveys were conducted between January 2007 and October 2009, with a total of 18 647 minutes at sea. Two independent observers were scanning for sightings. For each encounter a field-sheet was completed with species identification, GPS position, group size and composition and behavioural activity in the first moment of the sighting. Environmental conditions, as SST and depth, were also recorded. Individuals and groups were colour photographed with Nikon D50 and D70 equipped with 75-300 mm and 75-400 mm lens in order to register the behavioural activity, and when possible video taped. During the encounters a group's focal approach was used (Mann, 1999). A focal individual-follow was not conducted due to the difficulty to identify always the same individual in the group; firstly, its dorsal fins are not as marked and recognizable as, for example, the dorsal fin of bottlenose dolphins (*Tursiops truncatus*), and secondly, groups are very fluid and its elements frequently changed their position.

A group was defined as any number of animals observed in association, moving in the same direction and engaging in the same activity (Shane, 1990). For each encounter four categories were used to characterize group behavioural activities observed and were defined (adapted from Shanne, 1990; Stockin *et al.*, 2009) as *Travelling*: dolphins engage in persistent, directional movement, making noticeable headway; *Feeding*: dolphins exhibit nondirectional movement, frequent changes in heading prevent animals from making headway in any specific direction; *Socializing*: dolphins are chasing, copulating or engage in any other physical contact with other dolphins, and *Resting*: dolphins stay close to the surface in a tight group engaging in slow maneuvers.

The group size was classified as 1-10; 11-20; 21-50; 51-100 and group composition included presence of calve/juvenile (one-half and one-third the length of an adult) and adult (any animal > 1,80m) (Stockin *et al.*, 2009). Any event of other

cetaceans' species observed near (<100m) the focal group was considered as a mixed-group (Stockin *et al.*, 2009).

Results and Discussion

A total of 60 independent encounters with common dolphins and 52 independent observations of behavioural activities were recorded. The most observed activity was traveling (54%, n=28), followed by feeding (29%, n=15), socializing (15%, n=8) and resting (2%, n=1) (Figs. 2 and 3).

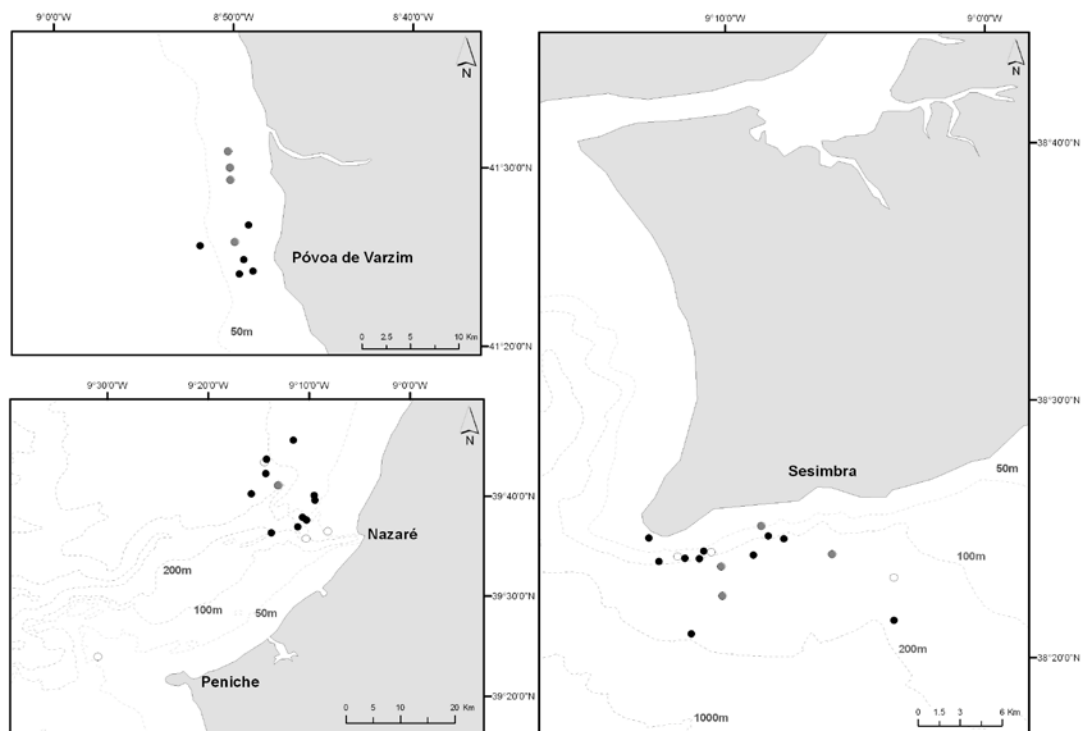


Fig. 2. Sightings of behavioural activities, traveling (black spots), feeding (grey spots) and socializing (white spots) of common dolphins (*Delphinus delphis*) in three different locations of Portugal mainland coast, between January 2007 and October 2009.

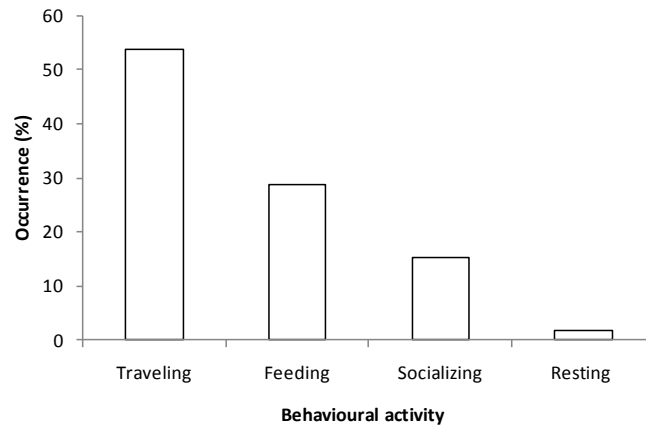


Fig. 3. Percentage of occurrence of behavioural activities of common dolphins off Portugal mainland, between January 2007 and October 2009 (n=52).

Resting was recorded just once and was excluded from the rest of the analysis. However it is possible that this activity was underestimated because when resting, the animals show no conspicuous surface activity which difficult group localization. Also, it was suggested by Neumann (2001) that the approach of the vessel may induce a switch from resting to other activities. In fact, short-beaked common dolphins often approach the research vessels and bow ride the wave (Perrin, 2009).

Travelling and feeding are known to often relate due to movements and variability of the prey (Newmann, 2001). Considering that food availability is the most important factor in determining an animal's activity budget, other behavioural activities will only be frequent after nutritional needs are satisfied (Doenier *et al.*, 1997). On the other hand, food resources are rarely uniform throughout the environment and predators need to travel between feeding areas.

Groups between 1-10 individuals were the most frequently sighted (45%) of the total encounters, followed by groups of 11-20 (25%), 21-50 (20%) and 51-100 (10%). Because preys are often distributed over many small patches it can be more efficient

for dolphins to split into smaller groups (Cañadas and Hammond, 2008). This may explain why traveling and feeding comprised the largest proportion of groups of 1-10 animals observed (50% and 43% respectively). Socializing was more frequent in groups of 11-20 animals (43%) (Fig. 4). This activity included copulation in one occasion, in a group of 11-20 animals, as well as persecution, belly-to-belly contact, with or without copulation, occasionally involving the repetitive intercourse of the same female by different males during the same observation. This is an identical behaviour to what has been described for New Zealand by Neumann (2001) and for Mediterranean by Cañadas and Hammond (2008).

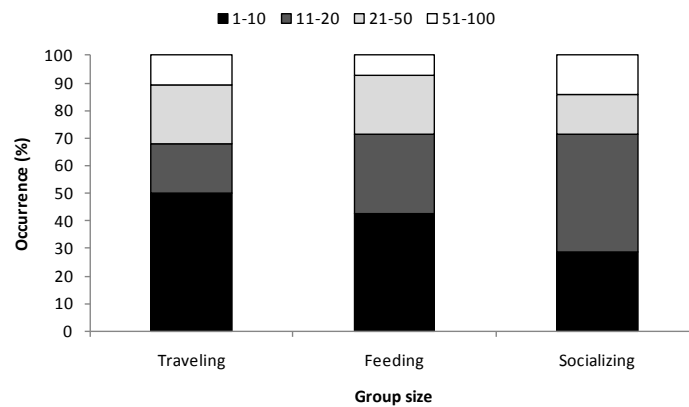


Fig. 4. Group size of common dolphin during traveling, feeding and socializing (n=49).



Fig. 5. Copulation of short-beaked common dolphin in Sesimbra. Photograph by Nina Vieira in 2009.

Calves were present in 65% of the total encounters and in 64% of traveling, 80% of feeding and 34% of socializing (Fig. 6). It is believed that the reproduction of common dolphins is nonseasonal (Reeves *et al.*, 2002) and the frequency of observations of calves throughout the year is concurrent to other studies (e.g. Universidad Autónoma de Madrid and Alnitak, 2002; Stockin *et al.*, 2008).

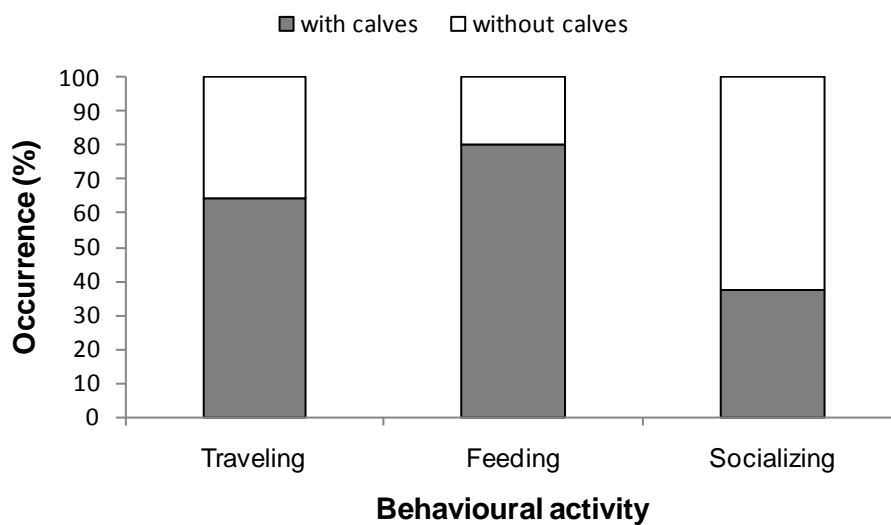


Fig. 6. Presence and absence of calves in common dolphin groups during traveling, feeding and socializing (n=51).

During the surveys some relevant behavioural events were detected. Aerial behaviour typical of common dolphins was frequently within our study area, such as the “pitch poling” (Fig.7). The dolphin leaps high vertically and falls lengthwise back into the water to create a large splash (Perrin, 2009). In other regions this behaviour is described for socializing activities and can also play a role in the context of non-vocal communication (Lusseau, 2006).

Mixed groups were found between common dolphins and striped dolphins (*Stenella coeruleoalba*). During our study period, striped dolphins were observed four times, in Sesimbra, traveling (n=1) and travelling and feeding (n=3) with common

dolphins in groups of 21-50 (n=2) and 51-100 (n=1). The association of these two species is not uncommon (e.g. Frantzis and Herzing, 2002; Cañadas and Hammond, 2008) and it can be seen as an advantage to striped dolphins when coming to shallower waters to follow coastal preys (Qu  rouil *et al.*, 2008). Common dolphins were also sighted in the vicinity (>100m) of a minke whale (*Balaenoptera acutorostrata*) in Sesimbra, and during observations of opportunity (outside our survey effort) in close proximity of humpback whale (*Megaptera novaengliae*) (Fig. 7). It is known that common dolphins may approach mysticetes to “bow ride”, which is possibly the origin of bow riding vessels (Perrin, 2009).



Fig. 7. Common dolphin female jumping out of water in Sesimbra. Photograph by Nina Vieira in 2008.



Fig. 8. Mixed group of common dolphins and humpback whale off Sesimbra. Photograph by Lu  s Quinta.

Overall, common dolphins use the study area to conduct all the activities of its daily life. Further and long term research is needed to clearly understand their behaviour, habitat use and patterns of residency along the coast of Portugal mainland. In the future a consistent behavioural study with focal-observations of individuals, both from boat and land platforms, and a creation of a photo-id catalogue will be promoted.

References

Bearzi, G., Reeves, R.R., Notarbartolo-di-Sciara, G., Politi, E., Cañadas, A., Frantzis, A. and Mussi, B. (2003). Ecology, status and conservation of short-beaked common dolphins *Delphinus delphis* in the Mediterranean Sea. *Mammal Review* **33**, 224–252.

Brito, C., Vieira, N., Sá, E. and Carvalho, I. (2009). Cetaceans' occurrence off the west central Portugal coast: a compilation of data from whaling, observations of opportunity and boat-based surveys. *Journal of Marine Animals and Their Ecology* **2**, 4pp.

Cañadas, A. and Hammond, P.S. (2008). Abundance and habitat preferences of the short-beaked common dolphin *Delphinus delphis* in the southwestern Mediterranean: implications for conservation. *Endangered Species Research* **4**, 309-331.

Doenier, P.B., Delgiudice, G.D. and Riggs, M.R. (1997). Effects of winter supplemental feeding on browse consumption by white-tailed deer. *Wildlife Society Bulletin* **25**, 235-243.

Evans, W.E. (1994). Common dolphin, white-bellied porpoise *Delphinus delphis* Linnaeus, 1758. In 'Handbook of Marine Mammals'. v.5 (Eds Ridgway, S.H. and Harrison, R.) pp.191-224. (Academic Press: London.)

Frantzis, A. and Herzog, D.L. (2002). Multi-species associations of striped dolphins (*Stenella coeruleoalba*), short-beaked common dolphin (*Delphinus delphis*),

and Risso's dolphins (*Grampus griseus*) in the Gulf of Corinth (Greece, Mediterranean Sea). *Aquatic Mammals* **28**, 188-197.

Gallo Reynoso, J.P. (1991). Group behavior of common dolphins (*Delphinus delphis*) during prey capture. *Anales del Instituto de Biología, Universidad Nacional Autónoma de México, Serie Zoológica* **62**, 253-262.

Lusseau, D. (2006). Why do dolphins jump? Interpreting the behavioural repertoire of bottlenose dolphins (*Tursiops* sp.) in Doubtful Sound, New Zealand. *Behavioural Processes* **73**, 257–265.

Mann, J. (1999). Behavioral sampling methods for cetaceans: a review and critique. *Marine Mammal Science* **15**, 102-122.

Neumann, D.R. (2001). The activity budget of free-ranging common dolphins (*Delphinus delphis*) in the northwestern Bay of Plenty, New Zealand. *Aquatic Mammals* **27**, 121-136.

Newmann, D.R. and Orams, M.B. (2003). Feeding behaviours of short-beaked common dolphins, *Delphinus delphis*, in New Zealand. *Aquatic Mammals* **29**, 137-149.

Perrin, W.F. (2009). Common dolphin, *Delphinus delphis* and *Delphinus capensis*. In 'Encyclopedia of Marine Mammals'. (Eds Perrin, W.F., Wursig B. and Thewissen, J.G.M.) pp.255-259. (Elsevier: San Diego, California.)

Quérrouil, S., Silva, M.S., Cascão, I., Magalhães, S., Seabra, M.I., Machete, M.A. and Santos, R.S. (2008). Why Do Dolphins Form Mixed-Species Associations in the Azores? *Ethology* **114**, 1183–1194.

Reeves, R. R., Stewart, B. S., Clapham, P.J. & Powell, J.A. (2002). 'National Audobon Society Guide to Marine Mammals of the World.' (Alfred A. Knopf: New York.)

Robinson, K.P., Einfeld, S.M., Costa, M. and Simmonds, M.P. (2010). Short-beaked common dolphin (*Delphinus delphis*) occurrence in the Moray Firth, north-east Scotland. *Marine Biodiversity Records* **3**, 1-4.

Shane, S.H. (1990). Behaviour and ecology of the bottlenose dolphin at Sanibel Island, Florida. In 'The Bottlenose Dolphin'. (Eds S. Leatherwood and R.R. Reeves) pp. 245-265. (Academic Press: San Diego, California.)

Silva, M. A. (1999). Diet of common dolphins, *Delphinus delphis*, off the Portuguese continental coast. *Journal of the Marine Biological Association of the United Kingdom* **79**, 531-540.

Stockin, K.A., Pierce, G.J., Binedell, V., Wiseman, N. and Orams, M.B. (2008). Factors Affecting the Occurrence and Demographics of Common Dolphins (*Delphinus* sp.) in the Hauraki Gulf, New Zealand. *Aquatic Mammals* **34**, 200-211.

Stockin, K.A., Binedell, V., Wiseman, N., Brunton, D.H., Orams, M.B. (2009). Behavior of free-ranging common dolphins (*Delphinus* sp.) in the Hauraki Gulf, New Zealand. *Marine Mammal Science* **25**, 283-301.

Teixeira, A. M. A. P. (1979) Marine mammals of the Portuguese coast. *Sonderdruck aus Z. f. Säugetierkunde* **44**, 221-238.

Universidad Autónoma de Madrid and Alnitak. (2002). Identificación de las áreas de especial interés para la conservación de los cetáceos en el Mediterráneo español. Memoria final. Dirección General de Conservación de la Naturaleza, Ministerio de Medio Ambiente.

Wise, L., Ferreira, M., Silva, M., Sequeira, M., Silva, A. (2005) Estudo das interações entre mamíferos marinhos e a pesca de cerco na costa oeste portuguesa. *Relat. Cient. Téc. IPIMAR, Série digital* (<http://ipimar-iniap.ipimar.pt>), nº 25.

Wise, L., Silva, A., Ferreira, M., Silva, M.A., Sequeira, M. (2007). Interactions between small cetaceans and the purse-seine fishery in western Portuguese waters. *Scientia Marina* **71**, 405-412.

CHAPTER 4: GENERAL DISCUSSION

4.1. Cetaceans' occurrence off the West Portuguese Coast

From the results of our effort between January 2007 and October 2009, five species of cetaceans were identified off Portugal mainland coast including four species from the suborder Odontoceti, common dolphins, bottlenose dolphins, striped dolphins and harbour porpoises, and one species from the Mysticeti, minke whales.

The occurrence and distribution of common and bottlenose dolphins were analyzed through environmental parameters to infer about habitat use in the study area and habitat partitioning seems to be occurring between the two species in Sesimbra. Common dolphins are the most sighted species and their importance in coastal communities of cetaceans along the coastline will be addressed ahead.

Bottlenose dolphins are relatively well known and are the most studied small cetacean species, mainly due to their worldwide distribution (Shane *et al.*, 1986) and coastal or inshore habitats. In Portugal, they occur near shore and are resident in the Sado Estuary (dos Santos and Lacerda, 1987; Augusto, 2007). Generally, they show a preference for shallower waters and probably for different prey species as a response to its ecological characteristics and adaptations to distinct environments. The plasticity and the opportunistic habits of this species allow an incursion from ocean to coastal waters and seasonal or permanent ecological and behavioural adaptations to shallow or confined waters. This issue is particularly important since the region of Sesimbra is probably within the range distribution of the resident population of bottlenose dolphins in Sado Estuary. This small resident population is threatened and presently is protected under an Action Plan of Conservation. The possibility of an encounter between these different groups (coastal and resident) is considered but needs to be monitored. A

catalogue of photo-identification of individuals observed in Sesimbra is now being undertaken.

Striped dolphins occur worldwide in tropical and temperate waters (Rice, 1998) and is one of the most frequent species in adjacent waters of Portugal (Certain *et al.*, 2008; de Stephanis, *et al.*, 2008). A study on feeding ecology in the Bay of Biscay (Spitz *et al.*, 2006) pointed out that individual striped dolphins have oceanic habits but make temporary incursions over the shelf. This capacity requires enough ecological and behavioural plasticity to exploit coastal habitats, including the use of areas characterized by submarine canyons which create spatially defined patterns in food availability (Gannier, 1999). Also the association with other species, typical of striped dolphins, is an advantage to forage coastal preys (Quéroil *et al.*, 2008). From our results, showing their presence in mixed-groups with common dolphins, we can consider that the sightings of striped dolphins in Sesimbra are related with the availability of resources in this region. A study dedicated to this species has never been conducted in Portugal mainland, although its status is “Least Concern” in the ICNB Red List.

Harbour porpoises are usually difficult to survey due to their small size and undemonstrative behaviour at the surface (Hammond *et al.*, 2002). Most probably the number of sightings recorded in this study is underestimated (only 2 observations were registered in Póvoa de Varzim). Resident populations are suspected to exist in Cape Mondego, Arrábida and Costa da Galé so it would be expected to have more sightings in our surveyed locations near those regions. Although it is considered widespread some conservation measures are being implemented and much of the research about harbor porpoises has focused on by-catch (Hammond *et al.*, 2009). There are some evidences of decline in abundance in some areas as, for instance, in the Black Sea (Hammond *et al.*, 2008). In Portugal the status of the species is “Vulnerable” mainly due to by-catch in fishing vessels (Cabral *et al.*, 2005). The lack of information about density and

habitat use makes very difficult to understand the degree of impact of human activities in the populations of small cetaceans (Wise *et al.*, 2007).

The only species of baleen whale observed, minke whale, is usually found in the North Atlantic during summer (Rice, 1998; Robinson *et al.*, 2009) as occurred in this study (observations between March and September). Its conservation status is “Vulnerable” for Portugal mainland coast because the species is found very near shore and is involved in fishing accidents (Cabral *et al.*, 2005). During and outside our survey campaign at least two minke whales were found alive entangled in cables and fishing nets (Fig.1). We can only speculate if the animals are approaching the coast for protection after getting entangled or if they are being injured in the area. In either case a more detailed study about the interaction of cetaceans with fishing activities within a continuous research and conservation program should be implemented.



Fig. 1. Entangled minke whale off Sesimbra, in 2009. Photo from Nina Vieira.

From this study it can be noticed that Sesimbra is a very important area for cetaceans. This area has two characteristics which can be advantageous for these animals: 1) it is a sheltered region due to restrictions to fisheries and nautical activities by the rules of the marine park Prof. Luiz Saldanha, 2) important oceanographic features may increase the abundance of feeding resources for cetaceans. More studies about this issue are required since it was not our aim to analyze the abundance of preys in the region. Also, it is known, from whaling data, observation of opportunity and

grey-literature, that others species of cetaceans, dolphins and baleen whales, occur in Portuguese waters. Due to the objectives of this work, and the research projects in which was inserted, all the boat surveys covered inshore habitats, so we did not expected to find more species of mysticetes. For future projects it will be relevant to extend the surveyed areas a little more offshore.

As stated before, common dolphin is the most frequent species of Portuguese mainland west coast and has been observed in the three locations surveyed. The present study analyzed their occurrence according to different environmental parameters such as sea surface temperature, depth and distance from shore. Distribution in sympatry with bottlenose dolphins, predominant behavioural activities and association with another species were also analyzed. The initial objectives were achieved and are resumed in the papers presented.

Common dolphins occurred year-round with calves in groups typically with 1 to 10 animals although, in some cases, groups of one hundred of individuals were observed. With a preference for epipelagic and mesopelagic fish, namely sardine (*Sardina pilchardus*) (Silva, 1999), the species may explore submarine canyons and adjacent waters. Our study area has optimal features for prey richness and the sightings of groups of common dolphins travelling and feeding around the 100m depth may indicate that they are using it as feeding areas. Common dolphins seem to use the Portuguese coast for all its daily vital activities including foraging with different techniques, and breeding. A more directed study about behaviour ecology of this species with designed methodology for behavioural research is required in order to further study the habitat use of this species.

It was also observed that common dolphins form mixed-groups, namely with striped dolphins, possible in a mutualist association for both species, and may have a sympatric relation with bottlenose dolphins in some locations. Common dolphins have no conservation status in the Portuguese Red List but it is known that the species is the

main target of by-catch off Portugal mainland coast (Wise *et al.*, 2007) and during our campaigns several individuals were observed with serious injuries in dorsal fins (Fig. 2). Once again, a study about the interactions with fisheries regarding both by-catch and depredation should be considered in a near future.



Fig. 2. Common dolphin injured off Sesimbra. Photos from Cristina Brito.

4.2. Present constraints and future approaches

Overall, further research is needed and urgent for common dolphin as well as for other cetaceans' species occurring off Portugal. An estimative of abundance in Portugal mainland does not exist for each species, the information about their feeding ecology is sparse and the first steps on behavioural activities and habitat use are being done at this moment. Only with a better understanding of cetacean populations, and most particularly common dolphins, it is possible to identify and monitor the impact of relevant human activities, which can range from fisheries, to dolphin watching programs and new technologies both inshore and offshore. Ecological aspects as mating and breeding seasons, occurrence depending on SST, and availability of prey resources can only be studied with long term and uniform approaches. Transect distance sampling should be the next step in cetacean research off Portugal mainland coast to obtain information on density and size of cetaceans' populations (Faustino,

2010). Linear transects in Póvoa de Varzim and Sesimbra were already defined by our research team and it is our goal to implement this designed survey in the next campaigns.

In synthesis the study of cetaceans has grown up in Portugal over the last 30 years and seems to have gained more importance in this new decade. Some academic theses are trying to contribute to improve the research in our waters, some papers are being published and participation on conferences of the specialty is being promoted. It is known that a significant number of species use, in some way, Portuguese waters but the ecological parameters which define that use are not identified. Abundance, patterns of residency, habitat use, behavioural activities, status of conservation, among other topics, are some of the questions that need to be made, studied and answered. Regarding conservation and management of marine resources and habitats it is expected a more pro-active attitude from Portuguese governmental institutions, as happened this year with a great step forward with the ratification of Portugal as a party to the ASCOBANS (Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas).

4.3. References

Augusto, J. (2007). Análise da estrutura social, da composição dos grupos e associações nos golfinhos-roazes (*Tursiops truncatus*) residentes na região do Sado. Dissertação para obtenção do grau de mestrado. Faculdade de Ciências da Universidade de Lisboa.

Cabral, M.J. (coord.), Almeida, J., Almeida, P.R., Dellinger, T., Ferrand de Almeida, N., Oliveira, M.E., Palmeirim, J.M., Queiroz, A.I., Rogado L. and Santos-Reis, M. (2005). 'Livro Vermelho dos Vertebrados de Portugal.' (Instituto da Conservação da Natureza: Lisboa.)

Certain, G., Ridoux, V., van Canneyt, O. and Bretagnolle, V. (2008). Delphinid spatial distribution and abundance estimates over the shelf of the Bay of Biscay. *ICES Journal of Marine Science* **65**, 656–666.

de Stephanis, R., Cornulier, T., Verborgh; Sierra, J.S., Gimeno, N.P. and Guinet, C. (2008). Summer spatial distribution of cetaceans in the Strait of Gibraltar in relation to the oceanographic context. *Marine Ecology Progress Series* **353**, 275–288

dos Santos, M.E. and Lacerda, M. (1987). Preliminary observations of the bottlenose dolphin (*Tursiops truncatus*) in the Sado estuary (Portugal). *Aquatic Mammals* **13**, 85-80.

Faustino, C.E.S., Silva, M.A., Marques, T.A. and Thomas, L. (2010). Designing a shipboard line transect survey to estimate cetacean abundance off the Azores archipelago. *Arquipélago. Life and Marine Sciences* **27**, 49-58.

Gannier, A. (1999). Diel variations of striped dolphin distribution off the French Riviera (Northwestern Mediterranean Sea). *Aquatic Mammals* **25**, 123–134.

Hammond, P.S., Berggren, P., Benke, H., Borchers, D.L., Collet, A., Heide-Jørgensen, M.P., Heimlich, S., Hiby, A.R., Leopold, M.F., and Øien, N. (2002). Abundance of harbour porpoise and other cetaceans in the North Sea and adjacent waters. *Journal of Applied Ecology* **39**, 361-376.

Hammond, P.S., Bearzi, G., Bjørge, A., Forney, K., Karczmarski, L., Kasuya, T., Perrin, W.F., Scott, M.D., Wang, J.Y., Wells, R.S. and Wilson, B. (2008). *Phocoena phocoena*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.3. www.iucnredlist.org. (Downloaded on 19 September 2010).

Hammond, P.S.; Macleod, K., Gillespie, D. Swift, R., Winship, A., Burt, M.L., Cañadas, A., Vázquez, J.A., Ridoux, V., Certain, G., Van Canneyt, O., Lens, S., Santos, B., Rogan, E., Uriarte, A., Hernandez, C. and Castro, R. (2009) Cetacean Offshore Distribution and Abundance in the European Atlantic (CODA). Final Report.

Quérrouil, S., Silva, M.S., Cascão, I., Magalhães, S., Seabra, M.I., Machete, M.A. and Santos, R.S. (2008). Why Do Dolphins Form Mixed-Species Associations in the Azores? *Ethology* **114**, 1183–1194.

Rice, D. W. (1998). 'Marine Mammals of the World. Systematics and Distribution.' Special Publication Number 4. (The Society for Marine Mammalogy.)

Robinson, K.P., Tetley, M.J. and Mitchelson-Jacob, E.G.(2009). The distribution and habitat preference of coastally occurring minke whales (*Balaenoptera acutorostrata*) in the outer southern Moray Firth, northeast Scotland. *J Coast Conserv* **13**, 39–48.

Shane, S.H., Wells, R.S. & Würsig, B. (1986). Ecology, behavior and social organization of the bottlenose dolphin: a review. *Marine Mammal Science* **2**(1):34-63

Silva, M. A. (1999). Diet of common dolphins, *Delphinus delphis*, off the Portuguese continental coast. *Journal of the Marine Biological Association of the United Kingdom* **79**, 531-540.

Spitz, J., Richard, E., Meynier, L., Pusineri, C. and Ridoux, V. (2006). Dietary plasticity of the oceanic striped dolphin, *Stenella coeruleoalba*, in the neritic waters of the Bay of Biscay **55**, 309–320

Wise, L., Silva, A., Ferreira, M., Silva, M.A., Sequeira, M. (2007). Interactions between small cetaceans and the purse-seine fishery in western Portuguese waters. *Scientia Marina* **71**, 405-412.