Universidade de Évora - Escola de Ciências e Tecnologia

Mestrado em Biologia da Conservação

Dissertação

Mapping bottlenose dolphin (Tursiops truncatus) behaviour in the Southern coast of Portugal

Sofia Alexandra dos Reis Grave

Orientador(es) | Teresa Fernandes

Cláudia Estevinho Santos Faustino

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A dissertação foi objeto de apreciação e discussão pública pelo seguinte júri nomeado pelo Diretor da Escola de Ciências e Tecnologia:

Presidente	|	Paulo Sá-Sousa (Universidade de Évora)
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“Mapeamento do comportamento do golfinho roaz (*Tursiops truncatus*) na Costa Sul de Portugal.”

Resumo

O presente estudo visa mapear o comportamento do golfinho roaz na costa Sul de Portugal, descrevendo pela primeira vez tais comportamentos com uma componente geográfica. Este estudo baseia-se na análise de dados cedidos pela Associação para a Investigação do Meio Marinho (AIMM), recolhidos entre 2010 e 2020. Os resultados indicam que o golfinho roaz apresenta uma ampla ocorrência costeira ao longo da costa Algarvia. Foram encontradas diferenças significativas no tamanho do grupo entre as estações do ano, possivelmente, devido a fatores ecológicos da espécie. O comportamento de viajar foi o mais observado. As crias foram observadas, especialmente, no outono e verão, e estiveram presentes grupos que apresentaram todos os tipos de comportamentos. Foi também analisada a presença de barcos de dolphin-watching na proximidade dos golfinhos. Este estudo alarga o conhecimento acerca da ocorrência do golfinho roaz em Portugal, contribuindo também para a sua conservação.

Palavras-chave: Costa sul de Portugal; Golfinho Roaz; comportamento; dolphin-watching e mapeamento.

Abstract

The aim of this study is to map the behaviour of bottlenose dolphin in the southern coast of Portugal, describing for the first time their behaviours with a geographical component. The data analysed was provided by Association for the Research of the Marine Environment (AIMM), collected between 2010 and 2020 along the south coast of Portugal. Bottlenose dolphin showed a wide coastal occurrence along the coast of the Algarve. Differences were found in group size between seasons possibly due to ecological factors of this species. Travelling was the most observed behaviour. Calves were sighted specially in the autumn and summer, and were present in groups which display each of the behavioural activities recorded. The presence of dolphin-watching boats in the vicinity of dolphin sightings was also analysed. This study improves the knowledge about the occurrence of the species in Portugal, contributing to their conservation.

Keywords: South of Portugal; Bottlenose dolphin; behaviour; dolphin-watching; mapping.

1. Introduction

1.1 General introduction

Studies conducted in the south coast of Portugal have revealed the occurrence and the biodiversity of cetaceans (Brito et al., 2009; Castro, Cid, et al., 2020). There are currently 21 species of cetaceans described for Portuguese waters, 13 of which were recorded on the south coast of Portugal (Castro, Cid, et al., 2020). Nonetheless, the knowledge concerning cetacean distribution and abundance remains scarce and often geographically limited (Castro, Couto, et al., 2020; Vieira et al., 2009). For many coastal and oceanic species present along the mainland shore ranges the population size is not available and have never been target of continuous and long-term studies (Brito et al., 2009; Forcada et al., 2004).

Bottlenose dolphin is the second most frequently encountered species of cetacean along the mainland of Portugal (Castro, Cid, et al., 2020; Forcada et al., 2004; Vieira et al., 2009) however, only few studies have examined their occurrence in the waters off southern Portugal (Almeida, 2017; Castro, 2010) .

In the last decade, the increasing of human population and activities in the coastal areas has intensified the pressure on marine ecosystems (Monteiro et al., 2016). Anthropogenic threats and habitat degradation on marine ecosystems are more intensive near the shore (Correia et al., 2015).

Whale-watching is a marine commercial activity that allows the observation of whales, dolphins and porpoises in their natural habitat (Castro, Cid, et al., 2020). Whale-watching companies are increasing worldwide and have an important role in the socio-economic development of the regions. This activity provides opportunistic platforms to collect useful ecological information during the encounters with the dolphins which can be used for scientific purposes (Constantine et al., 2004).

The south coast of Portugal is a popular area for marine tourism (Castro, 2010) representing the region of mainland Portugal with the largest number of whale-watching companies (54 companies; 62.79% of the total number in Portugal) offering tours of whale-watching since 2000. There are 210 registered

vessels in Portugal of which 139 vessels are registered in the Algarve (66.19% of the total number) (Castro, Cid, et al., 2020).

In 2006 a Decree-law issued by the Portuguese Government to regulate the activity of whale-watching in Portuguese waters (Decree-law nº9/2006). Nonetheless, the legal requirements are not always fulfilled by the companies, namely with regards to the number of boats surrounding the same group of cetaceans (maximum of 3 boats) and the approach distances to the groups (maximum 30 meters) (Castro, Cid, et al., 2020).

In the Algarve, cetaceans are frequently exposed to an excessive pressure due to the large number of vessels around the animals and by a high number of daily tours that the companies make, especially during the summer (Castro, Cid, et al., 2020). Despite their global distribution the bottlenose dolphin is one of the mainly coastal species that is frequently exposed to human disturbance (Constantine et al., 2004).

The bottlenose dolphin is an important top-level predator in the marine ecosystem as they can consume significant quantities of prey, affect the distribution and abundance of prey species and may serve to structure marine communities (Croll et al., 1998). Due to their role on the dynamic of the ecosystems and their sensitivity to the health status of the marine ecosystems, this species is considered a keystone and a sentinel species (Monteiro et al., 2016; Wells et al., 2004). Consequently, the conservation of this species and their habitats is a priority in marine management projects, as measures directed to their protection tend to act as measures for the management of the area that will benefit the entire ecosystem (Correia et al., 2015; Wells et al., 2004) and promote the increase of biodiversity (Sergio et al., 2008).

The knowledge of geographical and temporal distribution of cetaceans is essential to support management and conservation strategies in relation to human activities (e.g., disturbance by shipping, dolphin-watching tourism, and others). This information is key to predict locations where animals concentrate as well as times where they do so. Such studies can also highlight times and areas of special significance for various stages of the species life cycle, such as calving or mating (Correia et al., 2015; Evans & Hammond, 2004).

The year of 2021 marks the beginning of the United Nations Decade of Ocean Science for Sustainable Development (Decade of the Oceans). The present study is relevant for the concept of the Decade of the Oceans, a worldwide initiative that motivates the scientific community to explore, discover and understand ocean systems to develop the scientific knowledge of the marine environment and, in this way, contribute to the sustainable development and recovery of the oceans (Direção-Geral de Política do Mar, 2021). The geographic information of the bottlenose dolphin and the mainly areas of behavioural activity occurrence in the South coast of Portugal, will provide scientific knowledge that can support future management and conservations strategies and contribute to a sustainable use of natural resources and support the Blue Economy in the Algarve region.

1.2 The Bottlenose Dolphin, *Tursiops truncatus*, (Montagu, 1821)

1.2.1 Description of the species

The common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821), hereby bottlenose dolphins, belongs to the Delphinidae family and is currently one of the best known cetaceans.

The name Tursiops derives from the Latin Tursio ("dolphin") and the Greek suffix -ops ("appearance") and it can be translated as "dolphin-like. Truncatus derives from the latin trunco- ("truncated") and the original description by Montagu (1821) was based on the worn teeth, as an identifying characteristic (Wells and Scott, 2009). In Portugal, the bottlenose dolphin is known as "Roaz" or "Roaz Corvineiro" deriving from their foraging habits and behaviours (ICNF, 2021).

Tursiops is a polytypic genus (Hershkotiz, 1966). Bottlenose dolphin is distributed worldwide, showing an extraordinary adaptation to the diverse conditions in different regions and consequently a geographical variation in morphology (Wells & Scott, 2018).

In general, the bottlenose dolphin can be distinguished from other dolphin species due to their medium size, robust body, a moderately falcate dorsal fin, and dark coloration, with a sharp demarcation between the melon and the short rostrum. Their coloration pattern consists mostly of grey tones, they are light grey to black dorsally and laterally, with a light belly, and their flippers, flukes, and dorsal fin are generally dark or medium grey (Wells & Scott, 1999). Adult lengths range from about 2.5m to about 3.8m, varying by geographic location (Mead and Potter, 1990). Sizes measures and coloration pattern have a great variability when both morphotypes are compared. The coastal dolphins are smaller and lighter in colour than the offshore ones (Wells & Scott, 1999), and also differ in mitochondrial DNA (Torres et al., 2003).

1.2.2 Worldwide distribution and habitat

Bottlenose dolphin is considered a cosmopolitan species and inhabits most temperate and tropical marine waters (Figure 1) showing a wide adaptation to a variety of marine environments, with an estimated 600,000 individuals worldwide (Wells & Scott, 1999).

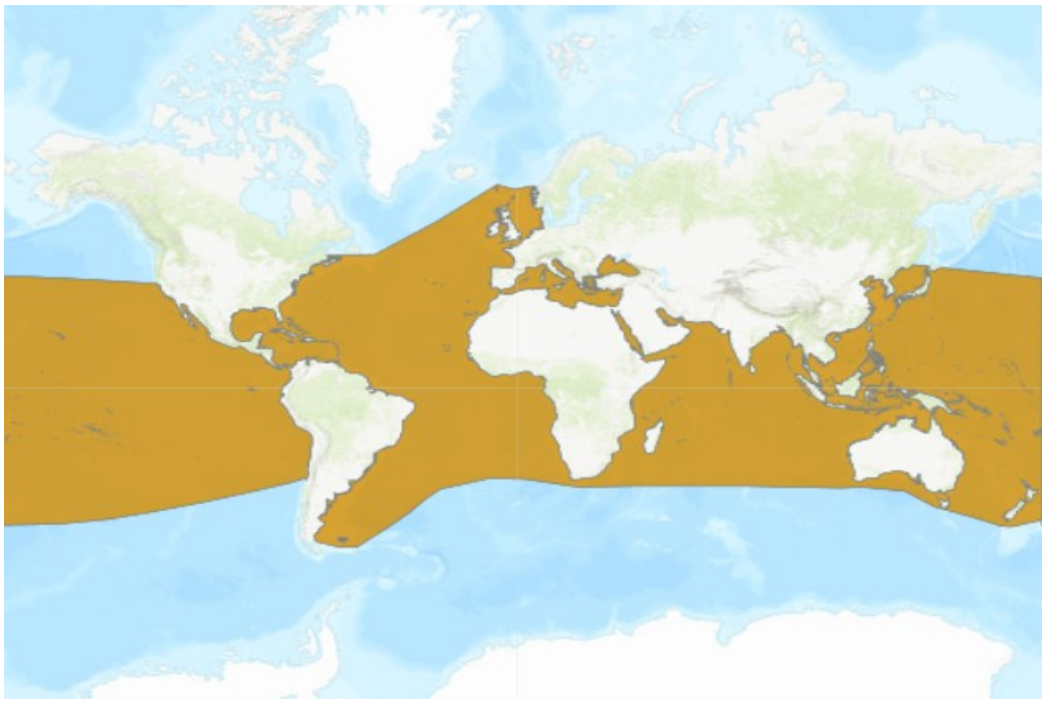

Figure 1 – Worldwide distribution of bottlenose dolphin highlighted in brown. (IUCN, 2019).

Studies carried out in different areas of the species range, and focusing on aspects such as genetic, morphological, and ecological differences have identified two distinct ecotypes: the coastal ecotype and the pelagic-oceanic ecotype (Louis et al., 2014; Torres et al., 2003, 2003; Wells & Scott, 2018). They are a result of niche specializations and/or social organization (Louis et al., 2014).

The pelagic-oceanic ecotype is primarily distributed in deep offshore waters (Wells & Scott, 1999), near oceanic islands, like Azores (Silva et al., 2008), on the continental shelf, especially along the shelf break, forming large groups with very large home-range (Pereira et al., 2013; Torres et al., 2003)

The coastal ecotype is distributed in a very shallow, coastal habitats including inlets, bays, estuaries, like the Sado estuary (dos Santos et al., 2007) and inshore waters (Torres et al., 2003) forming groups more restricted and sometimes resident (Shane et al., 1986).

In Europe, this species forms one metapopulation composed of several regional coastal subpopulations and a larger oceanic subpopulation (Bencatel et al., 2019).

1.2.3 Distribution in Portugal

Mainland Portugal has an extensive coastline with several complex and important oceanographic and topographic features, like submarine canyons and seamounts. Such dynamic environment is known to favour ecosystem richness and consequently is important for cetacean occurrence. Since the 19th century, many researchers have dedicated their efforts to study the occurrence off cetaceans in Mainland of Portugal (Brito et al., 2009; Correia et al., 2015; Silva et al., 2008).

For a long time, the bottlenose dolphin has been regularly reported along the Portuguese coastal waters, on the islands of Madeira and Azores, but this species is particularly known by the resident population in the Sado estuary, since at least the 1980s (Bencatel et al., 2019; ICNF, 2021). A resident population has been recently identified in the Azores archipelago (Quérouil et al., 2007). However, it is not possible to infer the population tendency of the bottlenose dolphin in the Portuguese coast due to the lack of data (ICNF, 2021).

The south of Portugal is an important area for bottlenose dolphin, where it can be frequently seen very close to the coast (Castro, 2010).

1.2.4 Life History

Bottlenose dolphins are long-lived mammals, females can live more than 50 years and males more than 40. Age at sexual maturity and dimorphism varies by region and females typically reach sexual and physical maturity at the age of 5 to 13 years. Males reach their sexual maturity at the age of 9 to 14 years (Connor et al., 2000; Wells & Scott, 2018). This species has a diffuse seasonal reproduction, with usually one or two peaks in the time of births around spring/ early summer and autumn (Connor et al., 2000; Mann et al., 2000) presumably due to water temperature, prey availability and predation risk (Wells & Scott, 2018).

After a gestation period that lasts approximately 12 months, a single offspring calve is born (Connor et al., 2000). Lactation is their primary source of nutrition for the first year of life (Wells & Scott, 1999). Typically, the calf remains with their mother until three years of age (Mann et al., 2000), with separation often coinciding with the birth of the next calf (Wells & Scott, 1999). Subadults leave the groups of mother but remain within the local population, after weaning (Connor et al., 2000).

1.2.5 Social Structure and Behaviour

Bottlenose dolphins live typically in groups composed by 2-15 individuals, although groups of more than 100 have been reported (Scott & Chivers, 1990; Shane et al., 1986). The group size is influenced by two prime factors: habitat structure and activity patterns (Shane et al., 1986), but several studies showed that anthropogenic activities (Constantine et al., 2004; Louis et al., 2015) and environmental changes (Lusseau et al., 2004) can also influence the social structure of the group. In general, bottlenose dolphins in bays and estuaries tend to form smaller groups than those in pelagic waters, but the trend does not continue linearly with the increasing distance from shore (Connor et al., 2000; Wells & Scott, 2018).

Bottlenose dolphin communities have a fission-fusion social structure with fluid association among individuals highly dynamic whose composition change over time and space (Connor et al., 2000; Louis et al., 2015). Some associations between individuals last from several hours to a few months or even for years, and may be adjusted in response to fluctuations in resource availability (Louis et al., 2015; Wells et al., 1987).

Group composition tends to be dynamic, with sex, age, reproductive condition, familial relationships, and affiliation histories is one of the most determinant factors (Wells et al., 2004; Wells & Scott, 2018). Basic social groups (subgroups) including nursery groups, mixed sex groups of juveniles, and adult males as individuals or strongly bonded pairs, may be stable or repeated over periods over time (Wells et al., 1987; Wells & Scott, 2018). Associations between males and females are not stable in most communities and tend to be related to reproduction (Louis et al., 2015).

Bottlenose dolphin appear to be active both during the day and at night showing several interactions between elements of a group such as: social interactions (sexual activities, interactions of dominance, play), feeding/foraging activities, resting and traveling (Connor et al., 2000; Shane, 1990; Shane et al., 1986; Wells et al., 2013). The frequency and duration of these behaviours can be influenced by environmental factors (such as season, tidal flow, sea temperature, depth, time of the day, bottom topography), human activities and

by physiological factors such as reproductive seasonality (Shane et al., 1986) (Wells, 2018). Dolphin responses to these ecological variables are somewhat unpredictable and can differ depending on the habitat in which the animals are studied and their prey distribution (Shane, 1990).

1.2.6 Conservation Status

The conservation status of bottlenose dolphin is Least Concern (LC) according to the Red List of the International Union for Conservation of Nature (IUCN), but there is evidence of declines in populations in Northern Europe, the Mediterranean and in the Black Sea (Wells et al., 2019). Coastal populations are inherently threatened by human activities that can affect their distribution, abundance (Pleslić et al., 2015) and ranging patterns.

This species is a priority species for conservation. It is protected by several national and international agreements and laws, namely through the Convention on International Trade in Endangered Species of Wild Fauna and Flora – CITES (114/90). It is also listed in the Annex II and IV of the EU Habitats Directive (92/43/EEC). This requires all state-members of the European Union to consider key areas inhabited by the bottlenose dolphin to be designated as dedicated Sites of Community Importance (SCIs) and Special Areas of Conservation (SACs) (Louis et al., 2015; Silva et al., 2008). It is crucial to determinate key-habitats for this species and establish monitoring programmes in order to improve and/or maintain the good conservation status of this species in Europe waters, in a long-term way (Almeida, 2017; Wilson et al., 1997).

Bottlenose dolphin is considered “Least Concern” in the Portuguese Red List. This species is protected by Decree-law nº 263/81, which protects all species of marine mammals in the Portuguese EEZ, by the Decree-law 361/89 - transposition of the Bonn Convention, Annex II and by the Decree-law 9/2006 that regulates the whale and dolphin watching activities in Portugal mainland (Castro, Cid, et al., 2020; ICNF, 2021).

1.3 AIMM – Marine Environment Research Association

AIMM is a non-governmental and non-profit association founded in 2010 and based in Albufeira that operates mainly in the South of Portugal.

Due to the rich diversity of species of cetaceans and the few studies available in the region, AIMM was born to contribute to the research and conservation of marine species and their ecosystems, and to be a reference in terms of research at a national and international level, specifically in cetaceans.

AIMM also conducts educational and public awareness projects, establishing partnerships with tourist whale watching companies, marine entities, universities, and other institutions, aiming to increase environment awareness and enhance the understanding of issues related to the marine environment.

Research conducted by AIMM, between 2010 and 2020, strongly suggest that the South coast of the Algarve is an important area for different species of cetaceans (Castro et al., 2013). Table 1 shows the species of cetaceans that AIMM recorded since the start of their activity. The most frequently species of odontocetes recorded were the common dolphin (*Delphinus delphis*), followed by the bottlenose dolphin (*Tursiops truncatus*) (Table 1).

Table 1 - Species of cetaceans recorded by AIMM team, between 2010 and 2019, with percentage of sightings and the conservation status (LC- least concern; DD- data deficient; NT- near threatened; EN- endangered; VU- vulnerable; empty fields with – means that there is no information available. Provide by AIMM team.

		Conservation Status			
Common name	**Scientific name**	**% sightings**	**Global**	**Europe**	**Portugal c.**
Common dolphin	*Delphinus delphis*	65.08	LC	DD	LC
Bottlenose dolphin	*Tursiops truncatus*	23.44	LC	DD	LC
Harbour porpoise	*Phocoena phocoena*	5.25	LC	VU	VU
Minke whale	*Balaenoptera acutorostrata*	2,.59	LC	LC	VU
Risso´s dolphin	*Grampus griseus*	1.53	LC	DD	DD
Striped dolphin	*Stenella coeruleoalba*	1.02	LC	DD	LC
Killer whale	*Orcinus orca*	0.45	DD	DD	DD
Fin whale	*Balaenoptera physalus*	0.36	VU	NT	EN
Humpback whale	*Megaptera novaeangliae*	0.09	LC	LC	-
Pilot whale	*Globicephala sp.*	0.09	PP	DD	DD
Sei whale	*Balaenoptera borealis*	0.07	EN	EN	-
Sperm whale	*Physeter macrocephalus*	0.02	VU	VU	-
Bryde´s whale	*Balaenoptera edeni*	0.02	LC	-	-

1.4 Thesis aims

The main aim of the present study was to map the occurrence and behaviours of the bottlenose dolphins on the South coast of Portugal, a unique topic in Portugal with great relevance in the field of biology and conservation of this species.

Such mapping will allow to increase the knowledge about the occurrence of the species and describe for the first time the behaviours with a geographic component in this area.

The study aims to address the following objectives:

- ✓ Map the location of bottlenose dolphin observed in the South coast of Portugal.
- ✓ Map the behaviours of bottlenose dolphin observed in the South coast of Portugal.
- ✓ Identify the occurrence of mother-calf pairs of bottlenose dolphin recorded in South coast of Portugal.
- ✓ Document the presence of boats during the encounters with bottlenose dolphin.

2. Methodology

2.1 Study Area

Mainland Portugal has a coastline of about 1200 km extended with several important oceanographic and topographic features (Brito et al., 2009; Falcão et al., 2003). The study area for this work is located in the south coast of Portugal with approximately 160km, from Sagres (on the West) to the Guadiana river mouth (Alveirinho Dias, 1998).

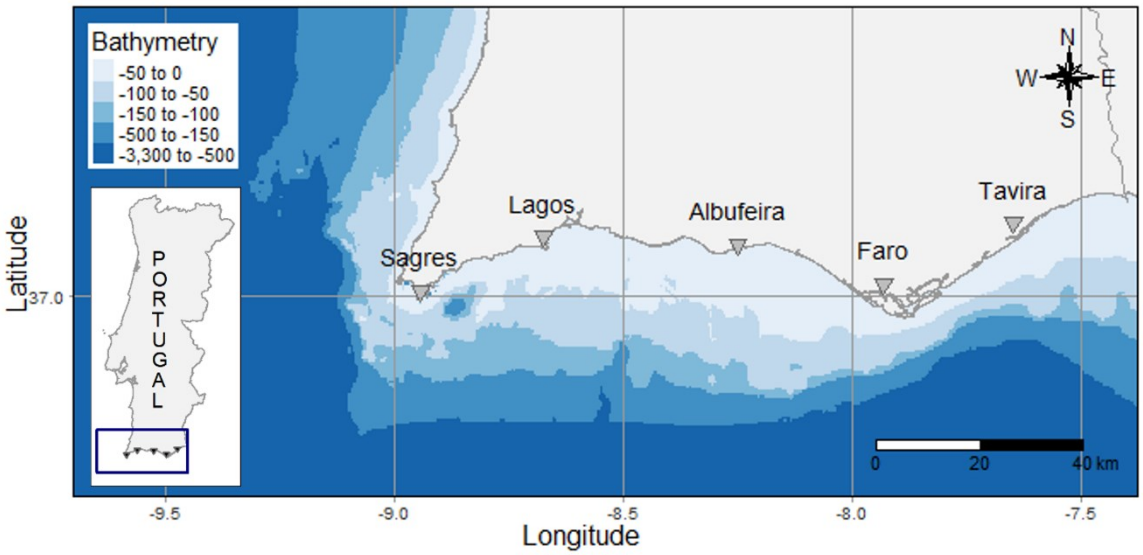

Figure 2 - Geographical location of the study area in the south coast of Portugal

The continental shelf is very short, varying between 7 km and 28 km wide (Marques, 1982) with a soft and well-defined slope, located at an average depth of 110 m to 150 m (Lopes & Cunha, 2010). It has approximately 2500 km2 inside the bathymetric depth of 200 m. The morphology reflects a geological evolution controlled by tectonic and sedimentary dynamics (Lopes & Cunha, 2010).

Due to its localization, this region is characterized by an intense wind-driven upwelling season spanning from March to October, and by an upwelling centre in the area of Cape St. Vincent (Castro, Couto, et al., 2020).

The Algarve coast is under the influence of several oceanographic currents. The north of the Cape St. Vincent is windy and affected by highly energetic

waves due to the open dominant marine agitation (from the NW quadrant) of the Atlantic. The southern coast region is sheltered from the conditions of the north Atlantic, and the currents are generally week (Alveirinho Dias, 1998), predominant drifts currents. The drift currents adapt to the coastal profile, moving parallel to the coast in both directions, near the 30 m isobathymetric line. The intensity of the drift currents reach speeds nearly 50 cm/s in extreme cases, even though typical flows below 25 cm/s (Castro, 2010).

The isobathymetry lines from 10 to 20 m follow the coastline with considerable regularity (Castro, 2010). The hydrologic characteristics, like salinity, the pH and temperature at surface are considerably uniform. The salinity is practically constant throughout the year varying between 36.1 to 36.3 at surface and 36.1 to 36,4 at a depth of 50 m. The temperature reaches the peak between July and august and reach minimum values between January and February (Ricardo, 2009). The water temperature in the Algarve during the summer months (June, July and august) is around 20ºC, meanwhile the water temperature reaches its peak in September and October (autumn) (seatemperature.org., 2020).

The continental slope is characterised by an irregular sea bottom surface, differing from that of the continental platform. The presence of submarine canyons and trenches, which facilitate the flow of the water masses and sedimentary load is another characteristic of the coast of Algarve. The most important canyons are those of Lagos, Portimão, Albufeira, Faro and the St. Vincent (Lopes & Cunha, 2010). This study focuses on the area between Sagres and Tavira.

2.2 Data Collection- Survey and Sightings

This study analysed data collected by the marine environment research association (AIMM) team along the southern coast of Portugal, between 2010 and 2020.

The data was collected using two different methods (opportunistic and scientific). Until the year of 2015, the data was only collected through the whale-watching companies (platforms of opportunity), which AIMM established partnerships with. AIMM interacted with 10 companies located mainly in Albufeira. From 2015, data was collected from dedicated research boat ("Ketos") additionally to the whale-watching companies. Boats visited the area up to a maximum of 25 nautical miles from shore (the boats used were not allowed to go further offshore due to permits and boat class) and operated between March and November of each year.

All whale-watching surveys occurred between 9h and 18h, lasting 90 min each. The number of surveys per day varied according to the availability of tourists, sea state and meteorological conditions. Surveys would occur when conditions were deemed safe by the whale-watching companies. In every trip two trained observers from AIMM team continuously searched for the animals covering 180º angle ahead the vessel. Due to the logistic of the whale-watching tours (number of tours per day and the time limit spend on the sea, 90min) and the vessels were only allowed to visit the area up to a maximum of 25 nautical miles from the shore, most of the surveys effort was made near to the shore.

From 2015, AIMM started to collect data also with their owned research vessel "Ketos" which is a 7m RHIB with 4-stroke 135 hp outboard engine. Surveys were conducted at an average speed of 12 knots and in sea conditions of Beaufort 0-3, swells not higher than 1.5m, good visibility (more than 5km) and no precipitation.

All surveys conducted along the south coast of Portugal, using either method, were conduct using random transects, with no pre-defined path. The majority of whale-watching trips and AIMM´s surveys were departed from the area of Albufeira.

When a group of bottlenose dolphins was observed, the boat approach them and the observers from AIMM team collected the following data: location of the animals (GPS position), date, time, bathymetry, group size, group composition (adults, juveniles, calves, new-borns), the initial cue, initial behaviour (the behaviour that the animals showed when the boat approach the group), general behaviour (behaviours that the animals showed along the observation) and final behaviour (the behaviours that the animals showed in the end of the observation, before the boat leaving the local), response of the animals to the boat, cohesion of the group, direction of travel of the animals, presence of marine birds and information on the number of boats present in a circle of 300m. A group was considered as any number of dolphins observed in apparent association and moving in the same direction, usually engaged in similar activities (Shane, 1990). Group composition was described according to the number of adults: individuals between 2-4 m long, apparently fully grown and physically mature; juveniles: immature animals approximately ≤ 2/3 the length of an adult, swimming in association with an adult and sometimes swimming independently; calves: animals ≤ 1/2 the length of an adult and in consistent association with an adult; and new-borns: animals with the same size or less than calves, exhibiting foetal folds and travelling alongside an adult (Bearzi et al., 1999; Mann et al., 2000; Shane et al., 1986).

For each encounter four categories of behaviour were used to characterize group behavioural activities observed (Table 2), (adapted from: Degrati et al., 2014; Harzen, 1995; Shane, 1990; Stockin et al., 2009):

Table 2- Description of behaviour activity recorded during the sightings

Behaviour Category	**Description**
Foraging	Dolphins exhibit nondirectional movement, frequent changes in heading prevent animals from making headway in any specific direction. At times it is possible to see dolphins harassing fish and fish jumping out of water. The animals move fast but the group does not change location.
Socializing	Dolphins observed chasing, copulating or engage in any other physical contact with other dolphins. Aerial behaviours such as breaching frequently observed.
Travelling	Dolphins engage in persistent, directional movement at low or high speed, making noticeable headway. All the group members swimming in the same direction.
Resting	Low level of activity, dolphins stay close to the surface in a tight group, exhibit slow drifting motion, rising slowly to breath and remaining stationary with occasional slow forward movement.

For this study, data from initial behavioural activities was analysed due to the less reaction of the animals to the boat and the high number of sightings recorded during the observations compared with general behaviour and final behaviour data.

2.3 Data analysis

Data was prepared for analysis by adding relevant information to the dataset. Namely:

- season of the year: spring (20 March to 20 June), summer (21 June to 21 September), autumn (22 September to 20 December) and winter (21 December to 19 March).
- behavioural activities were analysed individually: travelling (TR), foraging (FO), socializing (SO) and resting (RE); as well as analysed in combination of behaviours.
- maximum number of individuals: maximum number of dolphins that were recorded in each observation.
- maximum number of boats: number of boats according by the Decree-law 9/2006, with a legal number of boats (up to 3 boats is permitted) or above (higher than 3).

Data was organized using the program MS Excel. Data analysis was conducted using the statistical software R, a language and environment for statistical computing. Data was analysed using visual and numerical techniques. Hypothesis testing was implemented to investigate the proposed objectives.

To achieve the objectives of this study, two statistical hypotheses were analysed:

1. H0: There are significant differences in the group size of bottlenose dolphins sighted in each season of the year.
2. H0: There are significant differences in the group size of the bottlenose dolphin when each behaviour was observed in the presence and absence of mother-calf pairs.

Common statistical tests rely on assumptions that need to be fulfilled in order to be adequately applied, namely:

1. The observations are obtained independently and randomly from the population.
2. The data is normally distributed.

A non-parametric Kruskal-Wallis test, with a 95% confidence interval, was used to analyse the first hypothesis because the second assumption is not fulfilled, data for each season is not normal distributed. A pairwise comparison test was used to verify in which season the group size was significantly different. In cases where the test assumptions were not fulfilled the interpretation of results was done using plots.

3. Results

3.1 Bottlenose dolphin sightings

The results of the analysis of the spatial occurrence of bottlenose dolphin are based in the data collected during the 10 years of research.

Table 3 presents the number of sightings of bottlenose dolphin per year, recorded between 2010 and 2020. 1336 sightings were recorded in total. The year with higher number of observations of bottlenose dolphins was in 2016 with a total of 195 sightings and the one with the lowest was 2013 with 24 sightings.

During the 10 years of the study of the total sightings of the cetacean species characteristic in the Algarve region that AIMM team recorded, 23,95% of the sightings were bottlenose dolphins encounters.

Table 3 - Number of sightings of bottlenose dolphin (N. º sightings) and respective proportion from all the cetaceans observed (% sightings) in the Algarve between 2010 and 2020. Available from AIMM, 2020.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
N. º sightings	88	48	92	24	164	190	195	139	146	124	126
% sightings	14,26	11,62	17,9	3,52	23,77	24,9	22,89	18,41	32,3	19,53	23,95

Table 3, also shows the proportion of sightings that relate to bottlenose dolphin, from the total of observations (of all cetacean species recorded by AIMM). The year of 2018 was the one with higher percentage of sightings with 32,3% of total cetacean observations and the lowest was 2013 with 3,52% of sightings.

The information to measure the sightings effort as the number of kilometres travelled searching for the dolphins or even the hours spend looking for the animals was not available.

The number of sightings of bottlenose dolphin per month is presented in Figure 3. It shows that the months with largest number of sightings were August (n= 393) and September (n = 317) on the other hand, March (n=3) and November (n = 11) were the lowest. Note, there was no data collected in December, January and February.

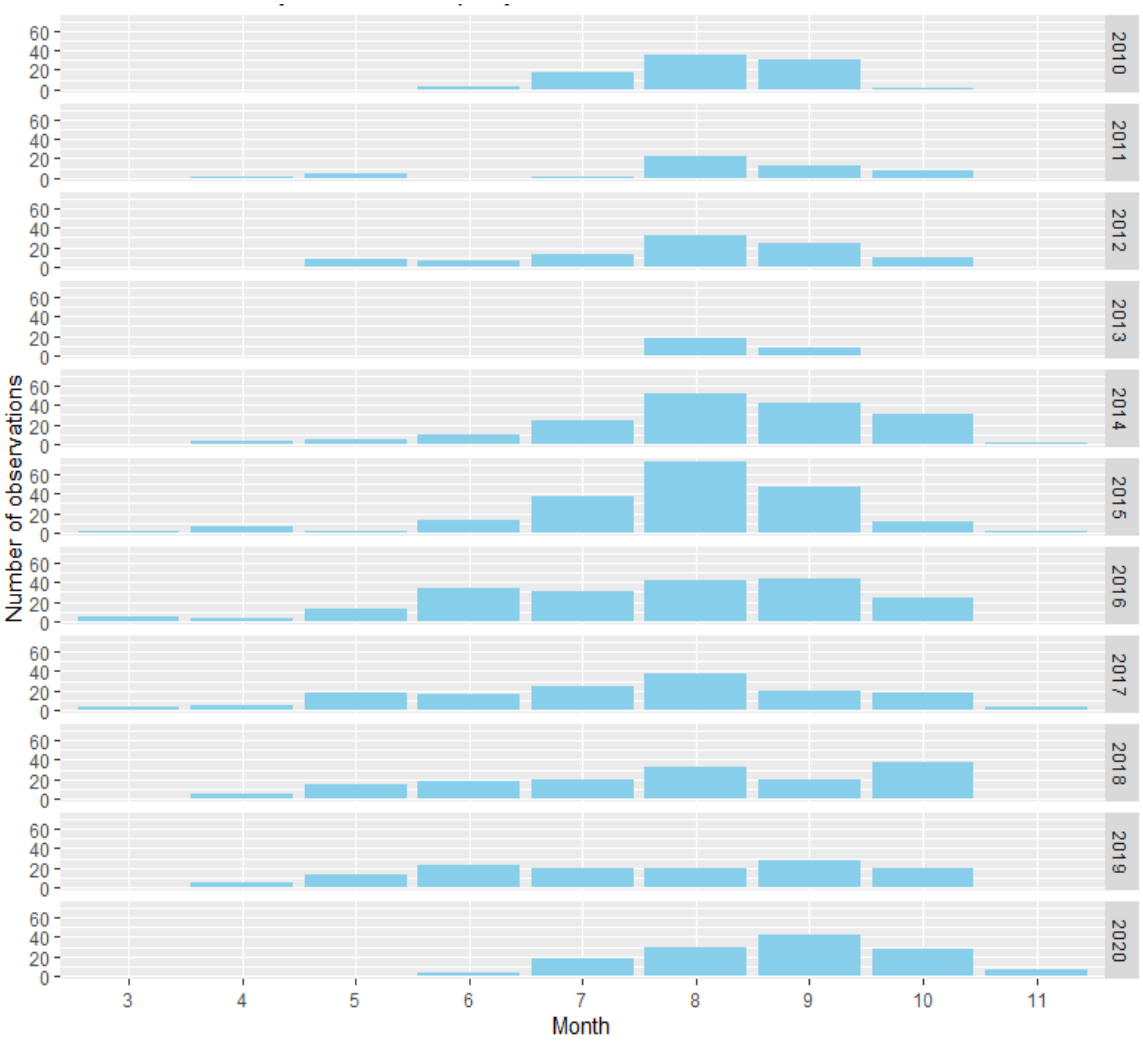

Figure 3 - Number of observations of bottlenose dolphin per month, for each year between 2010 and 2020.

3.2 Occurrence of bottlenose dolphin in the South coast of Portugal

A total of 1336 bottlenose dolphin (*Tursiops truncatus*) encounters were recorded. Figure 4 shows the occurrence of bottlenose dolphin along the coast of Algarve. It highlights that sightings occurred mainly around Sagres and Albufeira.

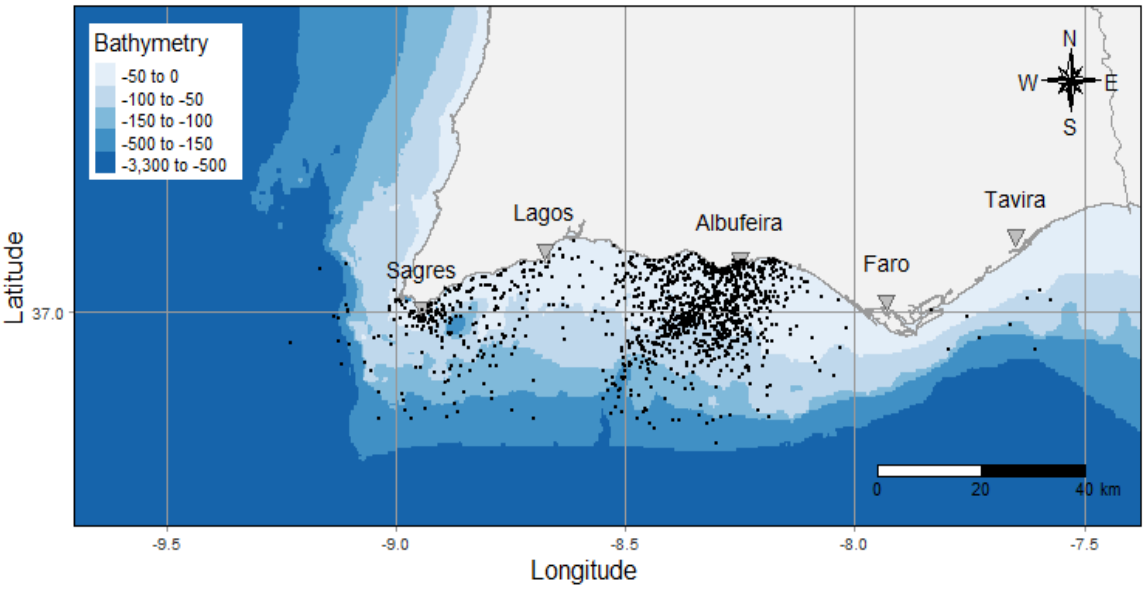

Figure 4 - Location of bottlenose dolphin observed along south coast of Portugal, between 2010 and 2020 (dark points) over a layer of bathymetry (shades of blue).

Also, most of the sightings were seen close to the shore. With regards to the bathymetry, most of the sightings of bottlenose dolphin were done between 0 - 500 m of depth.

In order to investigate the group size in each season of the year, a hypothesis was formulate using a statistical test. All the observations were independent from each other because all groups of dolphins were randomly sighted. Nonetheless, the number of samples for each season were highly different per season: autumn (n=288), spring (n=178) and summer (n=870). As such, to be precautious, it was assumed that the data was not normally distributed. There were only 2 observations made in the winter, so those data were analysed with autumn to avoid losing information.

The maximum group size of each observation recorded in the field was investigated. It was analysed to assess if there were differences in the group size of the dolphins in each season of the year.

The first hypothesis if there were significant differences in the group size of the bottlenose dolphins sighted in each season of the year was analysed. An initial inspection of the data using a boxplot (Figure 5) suggested that there were considerable differences between the group size between the summer (SU), spring (SP) and autumn (AU). It was verified by the statistical analysis results of the non-parametric Kruskal-Wallis test (p-value = 3.742e-05) that is smaller than p-value= 0.05, so the null hypotheses was rejected. Therefore, it confirmed that there were significant differences in the group size among the seasons. Additionally, a pairwise comparison test was used to determinate in which season the group size was significantly different.

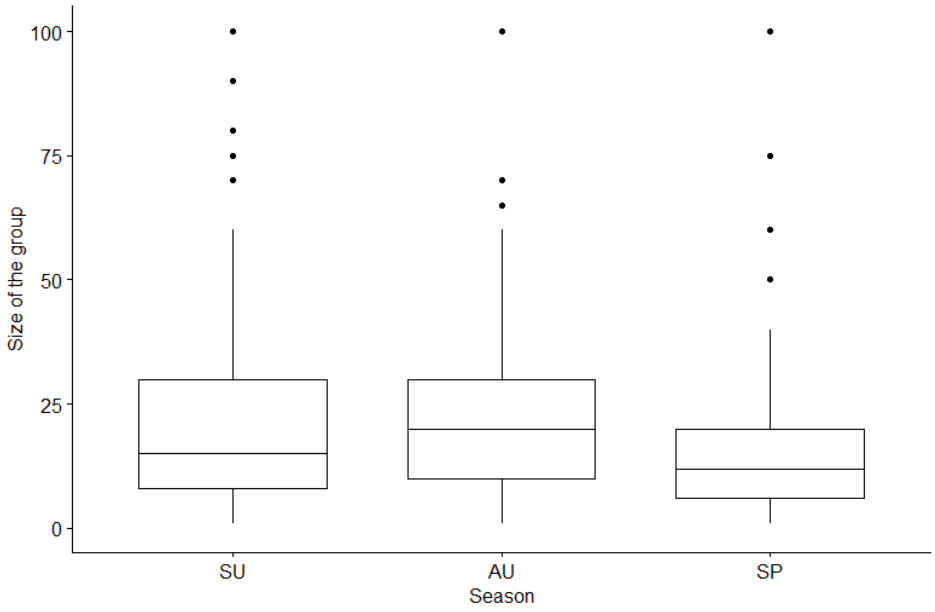

Figure 5 – Summary of in the group size observed in each season: summer (SU), autumn (and winter, AU) and spring (SP). Box plot 25%-75%, middle line is the median of the size group in each season. Points are the outliers and the vertical line show the minimum and maximum size of the group.

The pairwise comparison test (Figure 6) confirmed that the season most significantly different was spring among autumn (p-value= 1.8e-05) and summer (p-value= 0.0013).

```
        Pairwise comparisons using Wilcoxon rank sum test with continuity correction

data:  AIMM.ttr$Max.ind. and AIMM.ttr$Season

   AU      SP
SP 1.8e-05 -
SU 0.0218  0.0013

P value adjustment method: BH
```

Figure 6 - Results from the pairwise comparisons test, showing the significance between the seasons (significant p-values in seasons), as per output from R.

3.3 Behavioural activities

3.3.1 Temporal

Table 4, shows the number of occurrences of each behavioural activity sighted during the encounters with bottlenose dolphin per year, between 2010 and 2020. Off the 1336 observations, a total of 1219 sightings contained information about the behavioural activities. The year with higher recorded number of travelling behaviour was 2014 (n=116) and the least was 2013 (n=21). For foraging activity, the year of 2014 (n=30) had the most observations and 2013 (n=0) did not occur any sighting of this behaviour. 2016 was the year with more sightings of socializing behaviour (n=45) and again 2013 had no records of this behaviour (n=0).

For all years combined, the most observed activity was travelling (n=822), followed by socializing (n=236) and feeding (n=156). Resting was only recorded 5 times.

Table 4 - Number of occurrences of each behavioural activity recorded, per year, between 2010 and 2020.

Year	Travelling	Foraging	Socializing	Resting
2010	64	12	26	0
2011	27	14	6	1
2012	45	7	5	2
2013	21	0	0	0
2014	116	30	13	1
2015	111	18	25	0
2016	85	19	45	0
2017	106	21	20	0
2018	90	16	39	1
2019	82	14	22	0
2020	75	5	35	0

Some encounters with bottlenose dolphin presented more than one behavioural activity. For example, the behaviours travelling-socializing were sighting in the same group 91 times, travelling-foraging 26 times, foraging-socializing 18 times, resting-travelling 3 times and only one sighting of travelling-foraging-socializing.

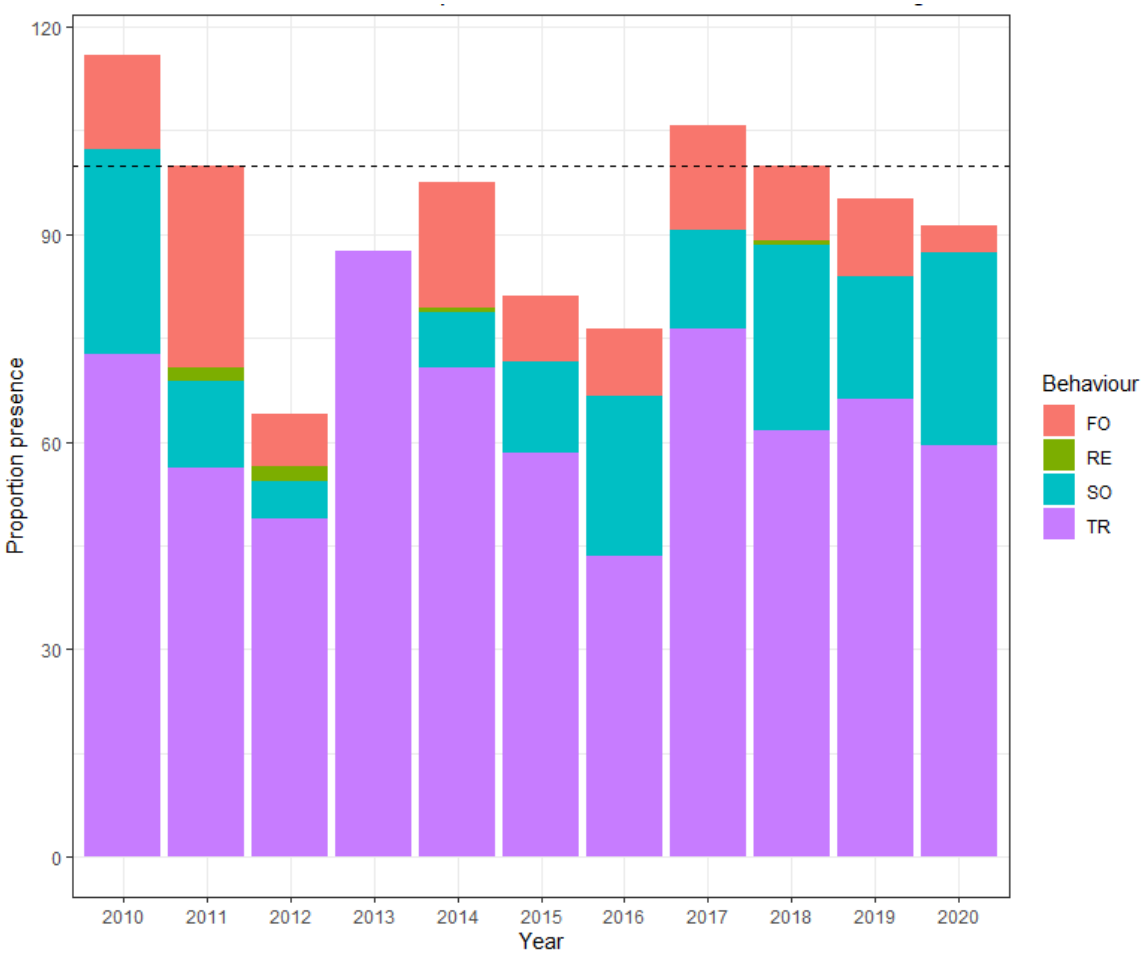

Figure 7 - Cumulative proportion of occurrence of each behavioural activity class sighting in groups of bottlenose dolphin along the south coast of Portugal, per year, between 2010 and 2020. The horizontal line at 100% highlights occasions when there was overlap of classes (exceeding 100%). Data behaviour activity recorded: FO (foraging), RE (resting), SO (socializing) and TR (travelling).

Figure 7, shows the cumulative proportion of times each behavioural activities was present, per year. When the proportion is above 100% it means there were multiple behaviours overlapping on some sightings that year.

Travelling was the behaviour most observed (that appears with higher percentage of presence) in every year during the period study. During 2013 only travelling behaviour was observed (87.5%).

For socialising behaviour, the year when it was most observed was 2010 (29,55%) and the least was 2012 (5,43%). Lastly, feeding behaviour was most observed in 2011 (29,17%) and least observed in 2020 (3,97%).

3.3.2 Occurrence of the behavioural activity

Figure 8, presents the behavioural activities observed during the encounters with the bottlenose dolphin in each season. It shows that all the behaviours were observed very close to the shore and spread along the south coast of the Algarve.

Summer was the season with higher number of sightings with a total of 787 sightings, followed by autumn with 270 sightings and spring with 162 sightings. During winter it was only recorded one observation of the behaviour resting and it was analysed with autumn data to avoid losing information.

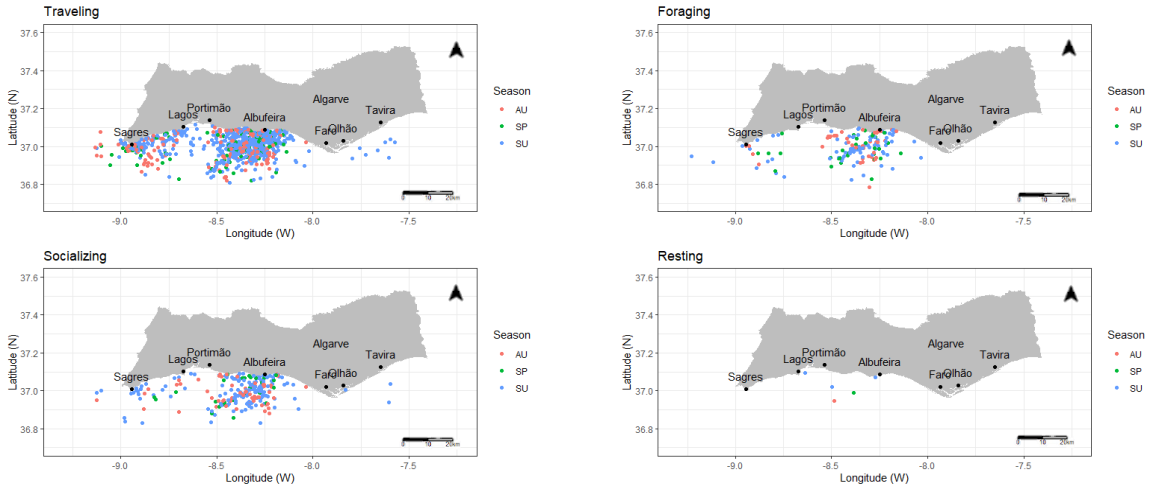

Figure 8 – Location of bottlenose dolphin observed highlighting each behavioural activity recorded (Travelling, Foraging, Socializing and Resting), Data points are coloured per season: AU (autumn) in red, SP (spring) in green, SU (summer) in blue.

The travelling behaviour was the one with most percentage of sightings in every season of the year, between 2010 and 2020. For summer the percentage of travelling behaviour was 69.76%, for autumn 63.33% and for spring 62.96%.

For the socializing behaviour the season with higher percentage of sightings during the encounters with the dolphins was autumn with 21.85%, followed by summer with 19.06% and spring with 16.67%. For the foraging behaviour the season with higher percentage of sightings was spring with 19.75%, followed by autumn with 14.44% and summer with 10.80%.

3.4 Occurrence of mother-calf pairs

3.4.1 Temporal

Table 5 shows that from the 1336 sightings of bottlenose dolphin groups, 734 contained at least one mother-calf pair (MC Pres) and 602 sighting did not (MC Abs).

Table 5 - Number of sightings of bottlenose dolphin groups that contained at least one mother-calf pair (MC Pres) and groups that did not (MC Abs), per year, between 2010 and 2020.

	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
MC Abs	51	25	63	9	80	82	100	62	55	37	38
MC Pres	37	23	29	15	84	108	95	77	91	87	88

The percentage of the presence and absence of pairs of mother-calf in bottlenose dolphin groups is shown in Figure 9. Throughout the years it is possible to see that there is a tendency to an increase of the presence of mother-calf pairs among the year of the study.

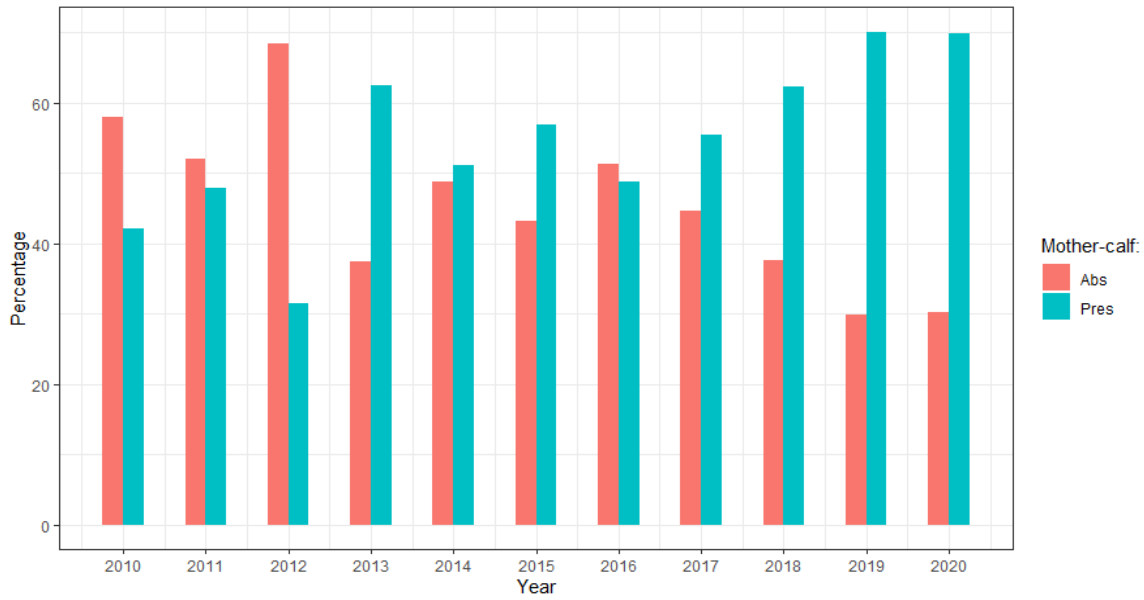

Figure 9 - Percentage of presence of mother-calf pairs (Pres), in blue and absence of mother-calf pairs (Abs), in red on bottlenose dolphin groups in relation to presence (Pres) between 2010 and 2020.

In this study, the year when more groups were seen with mother-calf pairs was 2019 with 70.16% of sightings and the least was 2012 with a percentage of 31.52%. The year that showed more absence of mother-calf pairs was 2012 with 68.48% of the sightings and the lowest was 2019 with 29.84%. The year of 2013 had the lowest number of sightings of the bottlenose dolphin (Table 3), the percentage for the presence of mother-calf pairs in the groups is relatively high 62.50% compared to the other years.

3.4.2 Occurrence of mother- calf pairs among the seasons

The proportion of mother-calf pairs present in the encounters per season is illustrated in Table **6**.

Table 6 - Percentage of mother-calf pairs present during the sightings in each season of the year, between 2010 and 2020. Data for season: autumn (AU), spring (SP) and summer (SU).

Season	MC Abs	MC Pres
AU	37.98%	62.02%
SP	52.25%	47.75%
SU	45.86%	54.14%

Autumn was the season with most proportion of sightings (62.02%) of pairs of mother and calf, followed by summer (54,14%) and spring (47,75%). There were no pairs mother-calf recorded during winter, so it was excluded from the analysis.

The occurrence of the presence of mother-calf between 2010 and 2020 in each season along the south coast of Portugal is represented in Figure 10.

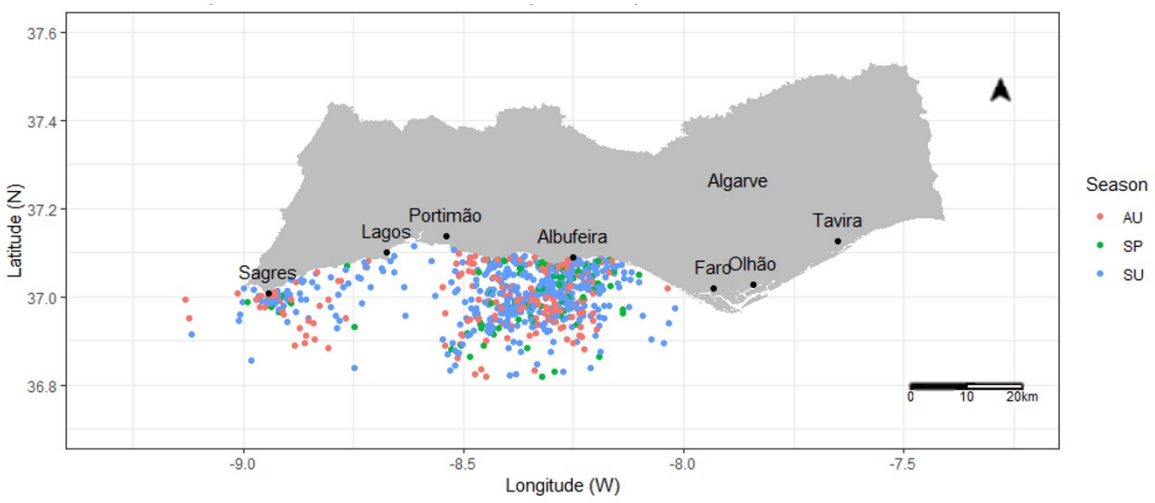

Figure 10 - Location of bottlenose dolphin with presence of mother-calf pairs, per season along the south coast of Portugal, between 2010 and 2020. Data points are coloured per season: AU (autumn) in red, SP (spring) in green, SU (summer) in blue.

Despite the high number of mother-calf pairs recorded in summer (n=471), autumn was the season with more percentage of the presence of calves in the sighting with 61,81%.

Formal statistical tests could be implemented to investigate possible changes in the group size of bottlenose dolphin displaying the different behaviours (travelling, socializing, foraging and resting) with presence and absence of calves. For this, the test assumptions were first analysed.

The first assumption in which variables need to be independent is not met in this case because during an encounter with a group of dolphins it was possible to see more than one behaviour at the same time. As such, behavioural activities data is not independent. The second assumption (data normally distributed) is also not fulfilled. There were almost no data collect for some behavioural activities sighted, for example the resting activity (n= 5).

Even though the requirements for a statistical test were not achieved, it is possible to draw some information from Figure 11. Namely, the size of the bottlenose dolphin groups with the Presence (Pres) and absence (Abs) of calves in each behavioural activity between 2010 and 2020.

Figure 11, shows the comparison between the group sizes and the presence or absence of mother-calf pairs for each of the behaviours that the animals displayed. For this study, the behavioural activity classes were analysed separately travelling (TR); socializing (SO), foraging (FO) and resting (RE), but it was also recorded sightings where the group of the animals display more than one behaviour. There were observations where the behavioural activity was not recorded (NA), mostly in cases when mother-calf pairs were present. The behaviour resting was recorded only 5 times (RE) and 3 of them were associated with travelling (RE, TR).

It also suggests that were a difference in the size of the group with the presence and absence of calves in the behaviours that occurred alone such as travelling (TR), socializing (SO) and foraging (FO). Groups with presence of calves were bigger than groups without calves for every behaviour except the combination of RE-TR and TR-FO-SO (small samples).

The behaviour foraging (FO) showed the biggest group size with presence of calves. From a group size of 20 animals for the groups with absence of calves the dolphins didn't show any of this behavioural activities FO, SO, TR, FO-SO and TR-FO.

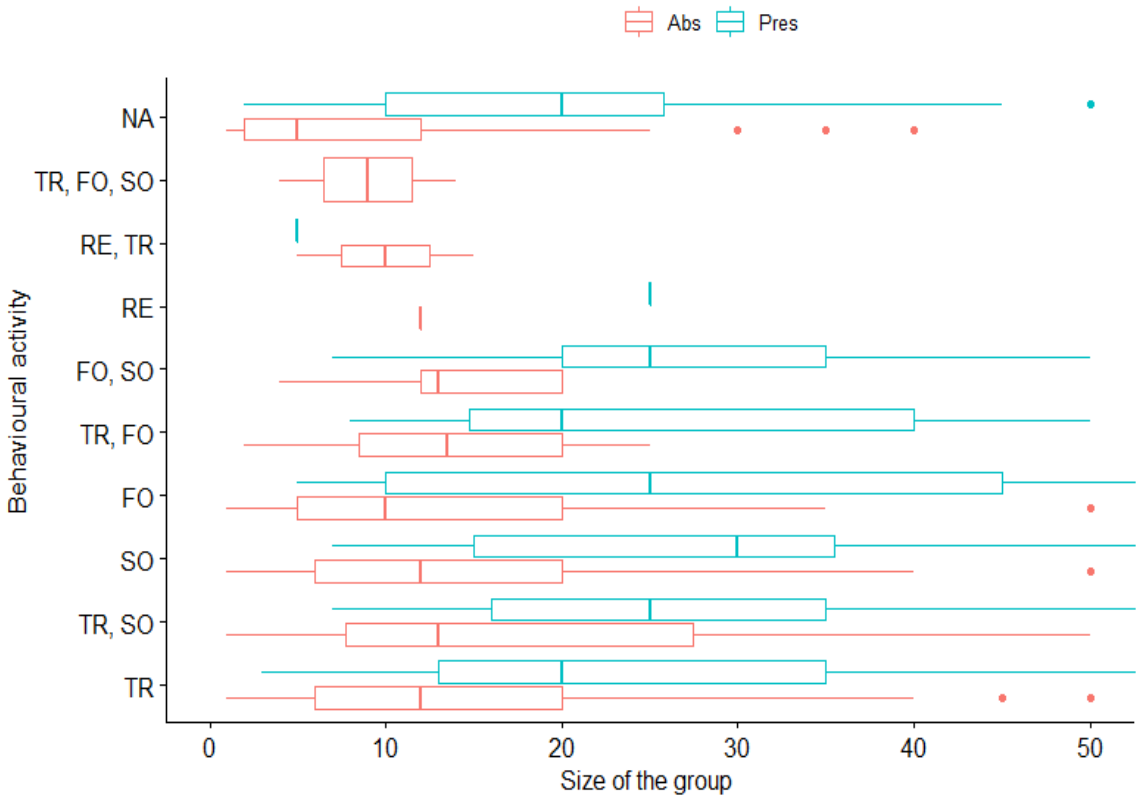

Figure 11 – Summary of the dolphin groups size with the presence (Pres) in blue, and absence (Abs) of calves in Red, in each behavioural activity travelling (TR), foraging (FO), socializing (SO) and resting (RE), between 2010 and 2020. Data plot shows the 25%-75% of size group data and the middle line in the box plot shows the median of group size. Points are the outliers. The horizontal lines in the extremity of box plot are the minimum and the maximum size group for each behavioural activity recorded.

3.5 Presence of boats during sightings with bottlenose dolphin

The occurrence (percentage) of sightings with legal number of boats, up to 3 boats permitted around the animals (green) and sightings with number of boats higher than 3 (red) is presented in Figure 12.

Of the 1336 encounters with bottlenose dolphins during the study period of 10 years, there were 400 occurrences in which the number of boats exceeded the number established by law. Despite this, the number of sightings with legal boats around the animals was 695.

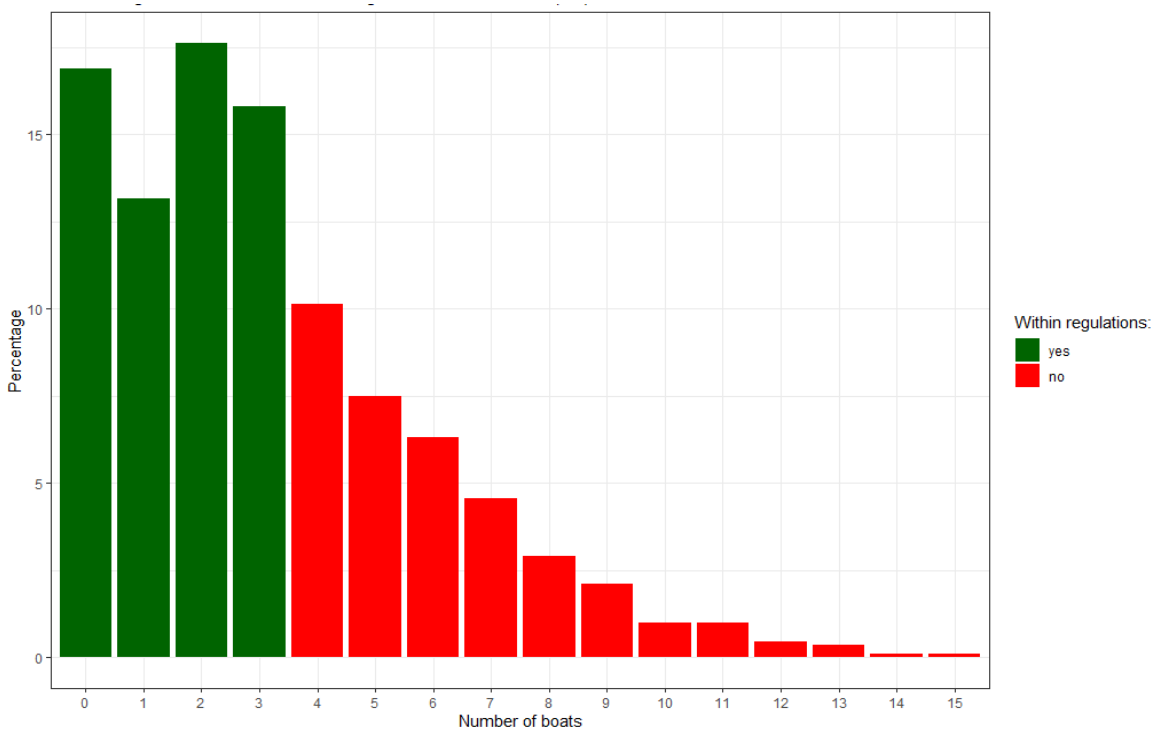

Figure 12 – Occurrence (percentage) of the total number of boats around the group in each sighting. Colours highlight if the number is within the legal number of boats (3 boats permitted, in green) or above (higher than 3, in red).

The total number of occurrence (percentage) of legal boats (max. 3 boats permitted) 63,5%, during the encounters with dolphins is higher than the sightings where the legal number of boats was not verified 36,5%. The number of boats mostly frequently present around the dolphins was two (17,63%). Furthermore, there was a maximum of 15 boats recorded around the animals during the observations (0.09%).

3.5.1 Spatial occurrence of Boats

The spatial occurrence of the number of boats within regulation of (Decree-law nº9/2006) is demonstrated in Figure 13.

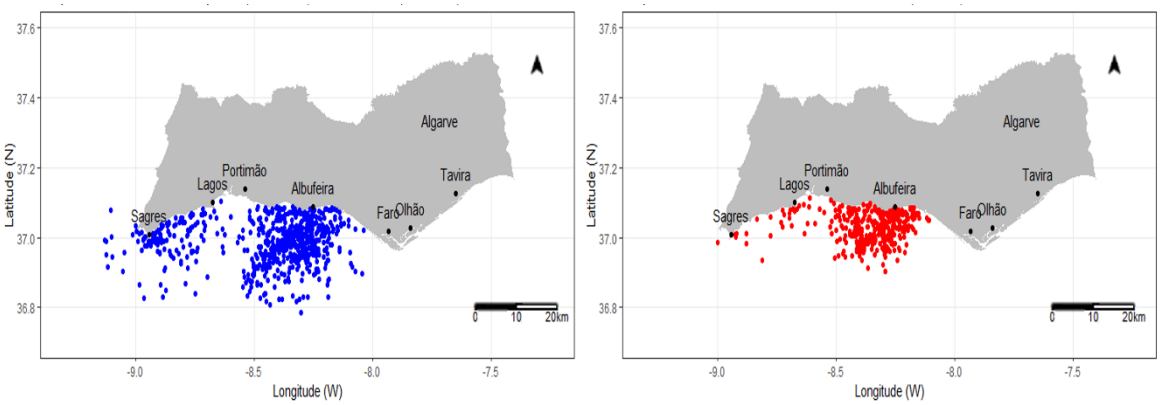

Figure 13 - Occurrence of the sightings with number of boats less than 3 (blue) and the sightings with more than 3 boats (red) in the south coast of Portugal, between 2010 and 2020.

Figure 13, also shows that most of the sightings with more than 3 boats present are found concentrated in the closest to the coast in the area of Albufeira. The map with occurrence of legal number of boats indicate that the sightings were spread out in the coast and found more offshore. In the area of Sagres there were more sightings with legal number of boats concentrated close to the coast.

4. Discussion

4.1 Sightings and occurrence of bottlenose dolphin in the south coast of Portugal

Bottlenose dolphin is the second most observed species in the south coast of the Algarve (Castro, Cid, et al., 2020). In the present study, of the total sightings of cetacean species, 23.95% the bottlenose dolphin was recorded revealing that this area could be an important zone for this species. The number of sightings were not constant throughout the years (Table 3) and months (Figure 3). Until 2015 AIMM team depended on the availability of the different whale-watching companies, so the numbers of sightings were lower than 100 per year. The numbers of sightings increased when AIMM acquired their own research vessel “Ketos”. The year of 2020 was marked by the pandemic Covid-19 and AIMM only started to work in the month of June. Nevertheless, the numbers of sightings of bottlenose dolphin on this year are similar to the previous three years.

In regards to the time of the year in terms of months, there were several limitations that may have influenced the number of surveys conducted during the study that need to be considered. Most of the surveys were done during summertime and there were no surveys during the months of winter (December, January and February). There are some factors that can influenced the number of trips per months, such as: availability of tourists, the sea state, meteorological conditions and when the whale watching companies considered that is safe to conduct the activity (Castro, Couto, et al., 2020).

The occurrence of the bottlenose dolphin along the south coast of Portugal is shown in Figure 4. Most of the sightings were made between 0 – 500 m of depth due to technical limitations to the distance offshore (boats were not allowed to go further 25 nautical from shore). There was less possibility and opportunities to search for the dolphins in water deeper than 150/500 so most of the survey effort was done in shallow waters. Most of the sightings were recorded around Albufeira and this can be explained because AIMM base is located in Albufeira.

Bottlenose dolphin is one of the most studied small cetacean species, essentially due to their worldwide distribution (Shane et al., 1986) in coastal and inshore habitats. According to (Wells & Scott, 1999) this species shows a preference for coastal habitats and is common over the continental shelf, especially along the shelf break. The preference of bottlenose dolphin for shallow waters can be related to the feeding habits of this species, perhaps as response to its ecological characteristics and adaptations to distinct environments, preying mostly on benthic and demersal fishes (Bearzi et al., 2008; Blanco et al., 2001; dos Santos et al., 2007; Shane, 1990; Shane et al., 1986). Due to the plasticity and the opportunistic habits of this species, bottlenose dolphin have the capacity to change from ocean to coastal waters and seasonal or permanent ecological and behavioural adaptations to shallow waters (Bearzi et al., 2008). To better understand how these animals use deeper waters, it would be interesting to increase the survey effort along the Algarve coast for deeper waters.

There were significant differences in the dolphin group size between seasons (summer, autumn, and spring) (Figure *5*). The season with larger group size was autumn (median size group 20) followed by summer (median size group 15) and spring (median size group 12). Spring was the season that was most significantly different from autumn (p-value= 1.8e-05) and summer (p-value= 0.0013) season, in terms of dolphin group size.

Shane et al., (1986), suggest that largest groups of dolphins increase the capacity to locate their food sources and their protection against the predators. Bottlenose dolphins are considered opportunistic feeders with a diversified diet that may include crustaceans, cephalopods, pelagic and benthonic fish, according to availably and abundance of local resources (dos Santos et al., 2007). The availability of prey species is one of the main factors responsible for changes on the movements of the animals and habitat use (Almeida, 2017). Seasonal changes in group size have been reported along different locations and it is inconstant. In Florida, no significant seasonal variation was found in group size. In contrast, in Argentina and off the west coast of Florida larger groups were observed during the winter, while in Texas it was noticed an increase of group size in the winter (Shane et al., 1986).

Knowledge of bottlenose dolphin preferences on fish and cephalopod species and occurrence in the Algarve is insufficient. It would be interesting and crucial to study the variety and occurrence of bottlenose dolphin prey to potentially explain variations of group size in each season, as well as to highlight any sensitive areas where animals would congregate to forage and feed.

4.2 Behavioural activities

The number of occurrences of the initial behavioural activity, travelling (TR), foraging (FO), socialising (SO) and resting (RE), recorded among bottlenose dolphin is shown in Table 4. The travelling behaviour represent a greater proportion (Figure 7) of sightings during the 10 years of collection, followed by socializing and foraging. Travelling was the most observed behaviour, and this can be expected as migration plays an important role in cetacean distribution (Gowans & Whitehead, 1995).

In a single sighting it was often possible to observed more than one behaviour with the same group of dolphins (Figure 7). In this study, various combinations of behaviours were recorded TR-FO-SO, RE-TR, FO-SO, TR- FO AND TR-SO. It was also reported in others studies the synchronization of behaviours such as resting and foraging. These two behaviours seem to be essential for group cohesion and that groups take advantages through optimising care of offspring, anti-predator defence and increasing efficiency of food resources. However, synchronization of behaviours is poorly understood in bottlenose dolphins (Constantine et al., 2004).

The occurrence of the behavioural activities observed during the encounters with the dolphin in each season is shown in Figure 8. The behaviour most seen during summer was travelling (69.76%). During the autumn, the behaviour with higher percentage of occurrence was socializing (21.85%) and during spring, foraging (19.75%) was the behaviour most recorded. In the case of the occurrence of resting behaviour it was only recorded 5 times during 10 years of this study. Neuman (2001) suggest that the approach of the vessels may trigger a change in the behaviour from resting to other activities. Also, it is possible that the observers had difficult to identify due to animals showing no conspicuous activity.

Some studies conduct in Portugal have reported a strong tidal currents in research sites and it appear to be important areas for foraging, consequently, this areas are not considerate a proper area for resting behaviour (Constantine et al., 2004). This can justify the low occurrence of resting behaviour in the south coast of the Algarve.

The behaviour of bottlenose dolphin can be influenced by many ecological variables such as time of the day, season, water depth, bottom topography, tidal flow, and human activities. Their response to these ecological variables may be unpredictable and can differ considerably depending on the habitat in which animals are living (Shane et al., 1986).

4.3 Sightings and spatial occurrence of calves

Figure 9, shows the percentage of mother-calf pairs sighted during the 10 years of this study and it shows that there may be a tendency for the increase of the presence of mother-calf pairs among the years.

The proportion of the mother-calf pairs present in the encounters per season is shown in Table 6. Summer was the season with higher number of pairs mother-calf (n=471) seen in the groups of dolphins. However, in terms of sightings proportions the autumn was the season with higher percentage occurrences of mother-calf pairs. This may reveal in this study, that there is a high probability to find mothers with their calves among the season summer and autumn during the encounters with the dolphins.

Bottlenose dolphin births have been reported for all seasons (Wells & Scott, 2018). This species seems to have a considerable flexibility in their seasonality of reproduction and diffuse peaks (Urian et al., 1996), usually one or two peaks in the time of births around spring/early summer and autumn (Bearzi et al., 1999; Connor et al., 2000; Mann et al., 2000). Females tend to give birth seasonally presumably due to water temperature, prey availability and predation risk (Wells & Scott, 2018). Warm water is known to be thermally more efficient for small calves and the mothers (Mann et al., 2000). The greater food available favour seasonal births, allowing females to maximize intake during mid-lactation when nutritional stress is likely to be greatest, during the warmest months (Blasi et al., 2020; Mann et al., 2000). The energy demand for the females lactation is reduced and calves need to spend less energy to regulate body temperature (Blasi et al., 2020).

In the Algarve the water temperature during the months of summer (June, July and august) is around 20ºC, meanwhile the water temperature reaches it peak in the month of September and October (autumn) (seatemperature.org., 2020). So, this information highlights the largest observations of mother and calf pairs during summer and autumn.

Bottlenose dolphin is characterized by extensive maternal investment. Calves depends nutritionally on their mother for a period at least the first 18 months of life and free-ranging calves may continue for 3-6 years, with separation normally coinciding with the birth of the next calf (Blasi et al., 2020; Mann et al., 2000; Wells & Scott, 1999). Female reproductive strategies focus mainly on calf protection from predators and/or conspecifics, and their nutritional needs. Therefore, their reproductive success is likely related to social and ecological factors such as group size and water depth (Mann et al., 2000). (Urian et al., 1996), suggest that local environmental conditions are considered to have an important influence on the seasonality of reproduction in the populations of bottlenose dolphins. For example, the birth period of bottlenose dolphins from Florida has been described during Autumn and in Europe around mid-summer (Castro, 2010). However, seasonality was not found in Portugal, births are registered year-round in the case of the resident population in Sado estuary (Blasi et al., 2020).

Due to technical limitation on the survey vessels, the present study was only conducted in shallow waters. The percentage number of the present of calves (Table 5) is shown that it is an important area for occurrence of calving. Females spend time in safest areas for feeding, socializing, resting and caring for their calves (Blasi et al., 2020). It was suggested that many females move into safer areas to give birth and rear calves (Blasi et al., 2020) since shallow waters may allow the detection and protection against predators. Another advantage is that prey density may be higher in shallow waters compared to deep waters providing better diet for females (Mann et al., 2000).

Bottlenose dolphin is characterized by a fission-fusion society where individuals leave and join the groups on a fluid basis, with associations lasting minutes to years (Blasi et al., 2020; Mann et al., 2000; Shane et al., 1986). Figure 11, shows the size of the bottlenose dolphin groups with calves in each behavioural activity. It suggests that there were differences in the group size when animals were travelling, socializing and feeding. In this study, the size of groups with calves was considerable larger than the size of groups without calves, when animals were displaying all behaviours, except for the combination of resting-travelling and travelling-foraging-socializing behaviours.

Foraging was the behaviour with larger group size in the presence of calves. The bottlenose dolphin is known to be opportunistic feeder having flexible feeding strategies and taking advantage of any readily available food source (Scott & Chivers, 1990; Shane et al., 1986). In general, the largest groups may provide potential advantage for pairs of mother-calf due to the increasing of foraging efficiency and therefore fertility and productivity, as the location of food resources is facilitated by collaboration among individuals through increased alertness and surveillance (Bearzi et al., 1999; Blasi et al., 2020). It also provides the increasing of assistance and protection, predation ability, reduced maternal investment and more opportunities for social learning (Bearzi et al., 1999; Blasi et al., 2020). In contrast, it was reported that groups engaged in travelling, feeding and resting were approximately the same size and were smaller than socializing groups in Florida (Shane et al., 1986). The variation of group size may be related to activity cycles of the animals, biogeographic region, prey availability and other factors (Bearzi et al., 2008). There is a tendency for this species to form groups of a specific size to engage in a particular activity however, these trends are dependent on the habitat of the animals (Shane et al., 1986).

4.4 Presence of boats during sightings with bottlenose dolphins

In this study the occurrence of the legal and non-legal number of boats present during the dolphins sighting according to national legislation (Decree-law n.º9/2006) was analysed (Figure 12 and Figure 13). A higher number of sightings with a legal number of boats (max. 3 boats permitted) was recorded than in occasions where the legal number of boats was exceeded. However, there were 241 sightings without data recorded during summertime, which would be important to analysed because specially in this season the boats pressure is high in this region (Castro, Cid, et al., 2020).

Marine mammals are considered charismatic megafauna since people care more about them than other species or groups (Castro, 2010), and bottlenose dolphins are one of the main target species for dolphin-watching companies (Castro, Cid, et al., 2020). The south coast of the Algarve is becoming popular for ecotourism and nowadays is the region with higher number of companies developing the dolphin-watching tours (54 companies;62.6% of the total national number), (Castro, Cid, et al., 2020).

There is growing evidence that dolphin behaviour is affected by the prolonged direct (or physical) number of boats present during the encounters and noise caused by the boat traffic (Bearzi et al., 2008; Constantine et al., 2004). In this study, the resting activity was recorded only 5 times during 10 years of the study, and this may be explained by the approach of the vessels which may trigger a change in the behaviour from resting to other activities.

Despite the Decree-law n. 9/2006 that regulates the whale and dolphin watching activities in Portugal mainland, there are still 36.5% of occurrences with illegal number of boats in the vicinity of dolphins. It is known that cetaceans in south of the Algarve are frequently exposed to an excessive pressure because many of the companies are operating in an irregular way, namely with regards to the excessive number of vessels present by the group of dolphins, as well as the high number of daily tours (Castro, Cid, et al., 2020).

Figure 13, shows the occurrence of the sightings with a legal and illegal number of boats. It reveals that the dolphins were highly exposed to excessive number of boats close to shore (n= 400), confirming that bottlenose dolphins frequently suffer human disturbance mainly in coastal areas (Constantine et al., 2004).

Each whale-watching company owes one or more vessels for its activity. In 2013, there were only 37 licensed vessels in the Algarve and this number increased over the years, specially between 2019 and 2020 with an annual increase of 25,23% in the number of licensed whale-watching vessels (Castro, Cid, et al., 2020). In 2020, there are 210 vessels registered in Portugal of which 139 are operating in the Algarve region (66,19% of the total). Competition between the companies is increasing and this may drive an increase in the excessive number of vessels around the animals, in turn leading to an increasing pressure that cetaceans are being exposed to daily by human activities.

It was not possible to establish a relation between the number of boats and the disturbance on the animals due to the data collection protocol. There are other factors that can influence their behaviour that were not analysed for this study. For example, there is evidence that the cumulative behavioural disturbance from dolphin-watching tourism may affect the dolphins reproduction (Blasi et al., 2020). Nevertheless, it would be interesting and crucial to the conservation of cetacean species, to conduct studies that analysed the pressure that animals are being exposed to every day by human activities in the Algarve to help the management of the local marine ecosystems and provide more information for future conservation strategies.

5. Final considerations

This work provides information on the occurrence of bottlenose dolphin in near shores areas in southern coast of Portugal between 2010 and 2020. The contribution of this dissertation is relevant since it is the first approach towards mapping behaviours in this region, and it provides relevant behaviour information for the conservation of bottlenose dolphin.

The results of the occurrence this species suggest that the south coast of the Algarve is an important area for this species (Cid et al., 2013). There was a high concentration of sightings in the bathymetry of 0-150m of depth, given to the survey effort was conducted near to the shore. Nevertheless, some studies have reported strong tidal currents and the presence of submarine canyons on this region can provide attractive spots for dolphins due to increase of food availability (Lopes & Cunha, 2010) and therefore, this area appears to be important for foraging. So, it would be interesting for futures research to study the diet and prey distribution of bottlenose dolphin in this region since it plays an important ecological factor for their occurrence and distribution.

The occurrence of bottlenose dolphin related to the season of the year was analysed in this study. The season with largest group size of dolphins was autumn which can be related to the high percentage of groups with presence of mother-calf pairs during that same season (62.02%). During the sampling period, it was possible to see a considerable number of calves which suggest that the dolphins use the study area for breeding and nursery area. Also, this species was found close to the shore in warmest months as it is thermally efficient for calves and mothers, and provides increase of food availability (Mann et al., 2000).

The high pressure that cetaceans are exposed to daily due to maritime traffic in the south coast of Portugal is an issue that needs to be given more attention. Several studies report the disturbance and the change in behaviour that the animals are subject to every day (Castro, Cid, et al., 2020; Constantine, 2001; Constantine et al., 2004; Neumann, 2001), specially during summer. It is necessary to promote awareness among people and whale-watching

companies to this issue and improve management strategies to decrease the negative impact of maritime traffic on the animals.

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 Special Areas of Conservation in European waters. Bottlenose dolphin is also a top-predator and a keystone species in marine ecosystems so projects that address its conservation should be a priority since direct measures to their protection will also benefit the entire ecosystem.

There is currently a proposal for the creation of a Marine Protected Area of Community Interest (AMPIC) on the south coast of the Algarve, put forward by the Centro de Ciências do Mar (CCMAR) of the University of Algarve. Data on megafauna has been taken into account highlighting the importance of the occurrence of marine species on this region (Cid et al., 2013). Spatial planning requires good knowledge of the geographical and temporal occurrence and distribution of cetaceans to support management and conservation strategies in relation to human activities, to preserve the high natural heritage of the oceans in a sustainable way promoting the safeguarding of the marine megafauna (Cid et al., 2013; Correia et al., 2015; Evans & Hammond, 2004).

This study is relevant because the knowledge of geographical and temporal distribution of cetaceans is essential to support management and conservation strategies in relation to human activities (e.g., disturbance by shipping, dolphin-watching tourism, and others). It also includes in the aims of the 14 sustainable development goals (SDGs) for the protection of marine life. The increasing of knowledge about the occurrence of bottlenose dolphins in the south coast of Portugal and also the information that is determinant to predict areas and times of animals concentration to highlight areas with potential significance for various stages of life cycle, such as calving and mating (Correia et al., 2015; Evans & Hammond, 2004). It is crucial to determinate the sensitive areas for bottlenose dolphin in the south coast of Portugal in order to plan strategies for the management to conciliate the biodiversity and the human activities, to reach a sustainable use of the natural resources of the region.

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