

Francisco Cardoso de Freitas

**Study on the impact of cetacean watching in the
Algarve**



UNIVERSITY OF ALGARVE

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Algarve**

Masters in Marine Biology

Supervisor:

Dr^a Rita Castilho



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Resumo

As pressões antropogénicas impactam profundamente a natureza e são uma preocupação central dos conservacionistas. Espécies emblemáticas, como os cetáceos, não são uma exceção. Ao longo de grande parte dos séculos XIX e XX, os cetáceos foram considerados um recurso a ser colhido devido aos diversos produtos extraídos destes mamíferos. Esta captura em grande escala de mamíferos marinhos atingiu o seu pico em 1960, com os navios-fábrica, e esteve perto do fim na década de 1980, quando as populações de baleias ficaram gravemente ameaçadas. Finalmente, em 1986, a Comissão Baleeira Internacional (CBI) declarou uma moratória sobre a caça comercial de baleias, destinada a proteger as baleias da ameaça de extinção. Desde esta moratória, a interação predominante entre cetáceos e humanos mudou completamente na maior parte do globo. Atualmente, existe um forte apoio em grande parte do mundo para tratar as baleias como um bem público global intrinsecamente valioso que deve ser protegido para o benefício do planeta.

A observação de baleias é uma indústria de turismo baseada na natureza que se desenvolveu nos Estados Unidos durante a década de 1950. A observação de baleias é uma atividade que assenta na observação de espécies de cetáceos; todos os grupos de cetáceos são alvo desta atividade, incluindo Mysticeti e Odontoceti. A observação de baleias geralmente envolve passeios de barco, mas é também possível observar baleias de terra ou por via aérea (helicóptero ou avião). Os levantamentos terrestres também são considerados parte desta indústria, especialmente em locais onde as baleias estão muito próximas da costa, permitindo a observação a partir de pontos de vista bem posicionados, muitas vezes promovidos pelo turismo local. As ameaças à maioria das espécies de cetáceos ainda não são completamente compreendidas. Em 2008, havia tão poucos dados disponíveis sobre cetáceos que mais de metade das espécies foram classificadas, na categoria de dados deficientes, pela União Internacional para a Conservação da Natureza (UICN).

Portugal continental tem potencial para a observação de golfinhos, tal como previsto no relatório de 2001 do Fundo Internacional para o Bem-Estar Animal (FIBA). Desde um início lento em 1998, com 1.380 observadores de baleias, para em 2008, mais de 58.000. A atividade comercial de observação de baleias ou golfinhos, em Portugal continental, aumentou dramaticamente de 11 empresas em 2008, para 45 apenas na região do Algarve no ano de 2022. As operações marítimo-turísticas não regulamentadas e mal

supervisionadas podem causar impactos negativos nas populações de cetáceos, que podem ser agravados pelo aumento acentuado do número de operadores turísticos. As investigações sobre cetáceos têm dois modelos de atuação distintos os dados podem ser recolhidos através de plataformas dedicadas à investigação ou através de plataformas oportunistas. A maior parte dos dados recolhidos no Algarve e em Portugal continental têm origem em observações oportunistas. A falta de conhecimento e estudo sobre a abundância e distribuição de cetáceos no Algarve dificulta as possíveis medidas de mitigação dos impactos antropogénicos nestas espécies emblemáticas.

Como tal, a observação de baleias em contexto turístico é uma solução alternativa, proporcionando plataformas de investigação oportunista, para investigadores de cetáceos, financiadas por turistas. No geral, apesar dos dados oportunistas apresentarem grandes limitações que podem afetar a fiabilidade dos resultados, devido a limitações como a detetabilidade de diferentes cetáceos, a proximidade dos animais ou o tempo limitado por viagem devido a restrições empresariais ou legislativas. Os benefícios podem superar as limitações, uma vez que proporciona plataformas de pesquisa de baixo custo que de outra forma não estariam disponíveis. Estas plataformas provaram-se fulcrais para o nosso estudo, fornecendo novos conhecimentos sobre locais com falta de dados, como é o caso do Algarve. Como tal, no nosso estudo decidimos implementar duas metodologias oportunistas, com o intuito de combater a falta de dados sobre os cetáceos da região. Estas técnicas de investigação, foram as observações marinhas, onde os investigadores recolhiam dados em embarcações marítimo-turísticas, bem como as observações costeiras, feitas através de binóculos colocados em pontos vantajosos da costa algarvia, como faróis ou falésias. A distribuição dos cetáceos e a forma como utilizam os habitats são de enorme importância no esforço de conservação. A distribuição dos cetáceos é muito influenciada pela batimetria, ou seja, pela proximidade da costa e pela profundidade das águas, bem como pela quantidade de embarcações presentes na área. Estas variáveis oceanográficas apresentam diferenças significativas em todo o Algarve, particularmente entre as nossas duas áreas de estudo: a costa de arribas rochosas de Vilamoura, com águas mais rasas maioritariamente abaixo dos 50m e a região de Faro com profundidades até 500m. Como tal, no nosso estudo tivemos uma prevalência de espécies costeiras, tais como o roaz-corvineiro (*Tursiops truncatus*) e o golfinho-comum (*Delphinus delphis*). Também as variáveis antropogénicas recolhidas revelaram diferenças entre Vilamoura e Faro, sendo que estas áreas foram classificadas,

respetivamente, como zonas de grande e pequeno impacto. Os levantamentos de barco incluídos numa atividade turística proporcionaram-nos conhecimentos importantes sobre a distribuição dos cetáceos, utilização do habitat, abundância e diversidade de espécies em duas áreas adjacentes, mas distintas do Algarve. Os levantamentos de barcos também permitiram comparar diferentes abordagens de observação de baleias em áreas com alta e baixa densidade de barcos (Vilamoura e Faro). Vilamoura, onde a observação de cetáceos é aliada à visita de grutas, revelou-se uma zona de maior impacto para os cetáceos, uma vez que a densidade de embarcações é maior e o cumprimento da legislação é menor, sendo ao mesmo tempo um habitat menos diversificado. As viagens exclusivamente dedicadas à observação de cetáceos em Faro revelaram-se uma abordagem menos invasiva, uma vez que houve menos restrições de tempo, bem como uma mentalidade mais consciente por parte dos responsáveis, que levaram a um melhor cumprimento da lei e conseqüentemente a uma atividade menos impactante. Os levantamentos terrestres revelaram-se uma metodologia útil para aumentar o conhecimento sobre os cetáceos no Algarve, especialmente quando associados a levantamentos de barco. Esta metodologia também provou ter um grande potencial para ajudar a mitigar os impactos negativos dos cetáceos, especialmente no que diz respeito à aplicação da legislação. Como tal, esta metodologia deveria ser incluída na legislação de observação de cetáceos, tal como acontece nos Açores e na Madeira.

Abstract

Whale-watching activities can induce behavioural changes that may negatively affect cetacean populations. This activity is a growing industry in the Algarve and constitutes an essential share of all the maritime touristic activities in the area. The activity started in the Algarve during the last decade of 1900s and led to national law - Decreto-Lei n.º 9/2006 that regulates whale watching in waters under Portuguese jurisdiction. This study will tackle an identified gap in the Algarve concerning cetaceans' distribution, abundance, and behaviour. Will cover the area between the Alfanzina lighthouse and the East end of Armona Island to assess the impact of human activity on the cetaceans. Such data will be obtained by observing the boat-cetaceans interaction in situ (onboard) and recording and classifying the cetaceans' behaviour observed from land. The weak law enforcement usually conducts to greater proximity between the boat and the individuals. Therefore, we expect to observe some level of distress in the animals, which particular behaviours can detect. To mitigate this anthropogenic effect, we will gather data on the distribution and abundance of cetaceans and the number of surrounding boats. Such methodology abundantly used in the Macaronesia Islands, especially the Azores Archipelago, is still insufficiently used in the Algarve. We will compare two regions with different anthropogenic pressures, Vilamoura (high) and Faro (low). We will assess if land-based surveys are a reliable quantification tool to detect boat/cetacean interaction.

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List of abbreviations, acronyms, and symbols

B.sp - *Balaenopteridae species*

D.sp - *Delphinidae species*

BA – *Balaenoptera acutorostrata*

BE – *Balaenoptera edeni*

BB – *Balaenoptera borealis*

BP – *Balaenoptera physalus*

DD – *Delphinus delphis*

SC – *Stenella coeruleoalba*

OO – *Orcinus orca*

PP – *Phocoena phocoena*

GG – *Grampus griseus*

TT – *Tursiops truncatus*

A – Approaching

E – Evasion

I – Indifference

Nm – Nautical mile

ER – Encounter rate

Chapter 1: Introduction

Anthropogenic threats.

Anthropogenic impacts profoundly impact nature and are a central concern of conservationists. Flagship species such as cetaceans are not an exception. Throughout much of the 19th and 20th centuries, cetaceans were considered a resource to be harvested for the many products extracted from these mammals (Brito & Sousa, 2011). This large-scale harvesting of marine mammals peaked in 1960 with the factory ships and came close to an end in the 1980s as whale populations became critically endangered. Finally, in 1986, The International Whaling Commission (IWC) declared a moratorium on commercial whaling designed to protect whales from the threat of extinction. Since this moratorium, the predominant interaction between cetaceans and humans has completely changed for most of the globe (Hoyt et al. 2001). Now, there is strong support across much of the world for treating whales as an intrinsically valuable global public asset that should be protected for the benefit of the planet (O'Connor et al., 2009).

Whale watching industry

Whale-watching (observing cetaceans in their natural habitat) is a nature-based tourism industry that developed in the United States during the 1950s (Würsig et al., 2009). There is some debate about whether or not whale-watching can be considered a form of ecotourism (Coria & Calfucura, 2012; Stamation et al., 2010). Nonetheless, its stakeholders, including operators and environmental non-governmental organisations, attribute to the activity many positive characteristics that relate it to ecotourism, as well as to conservation projects designed to connect social and economic development with biodiversity protection (Neves-Graça, 2004; Higham et al. 2014; Raschke et al., 2017). However positive the effects of whale-watching activities are, they also have considerable costs to the cetaceans and the members of coastal communities by disrupting their daily lives (Hoyt, 2001; Marçalo et al., 2015; Raschke et al., 2017).

Whale-watching is an activity that relies on the viewing of cetacean species; all groups of cetaceans are targeted by this activity, including both *Mysticeti* and *Odontoceti*. It does not include captive animals or swimming with trained animals, only wild animals in their natural environment. Whale watching usually involves boat-based tours, but another way is to observe whales from land or by air (helicopter or plane) (O'Connor et al., 2009).

Land-based surveys are also considered part of this industry, especially in locations where whales are very close to the shore, allowing for observation from well-placed vantage points, often promoted by local tourism (Amrein et al., 2020). The threats to most cetacean species are not yet completely understood (Sambolino et al., 2022). In 2008, so little data was available on cetaceans that more than half of the species were classified as Data Deficient by the International Union for Conservation of Nature (IUCN). In these circumstances, whale-watching is an alternative solution, providing opportunistic research platforms for cetacean researchers funded by tourists.

Whale watching in Portugal.

The Portuguese mainland has the potential for dolphin watching, as predicted in the 2001 International Fund for Animal Welfare (IFAW) report (Hoyt, 2001). From a slow start in 1998, with 1,380 whale watchers on the mainland, in 2008, over 58,000 whale watchers undertook trips in the existing 11 whale-watching operators. The number of operators has also dramatically increased to 33 in 2022, just in the Algarve (between Portimão and Tavira). This sharp increase in the number of whale-watching boats can induce severe negative impacts to the cetacean communities of the Algarve coast (Stamation et al., 2010). These may include changes in surfacing time, acoustic interference in calls and swimming behaviour with changes in direction, group size and coordination (Visser et al., 2011). Other effects include changes in essential behaviours, such as feeding or resting, which are detrimental for cetaceans, especially in situations where there is prolonged or repeated anthropogenic exposure (Parsons, 2012).

Tour operators offer dolphin watching exclusively, as no large cetaceans are easily observed in the coastal water of mainland Portugal (Correia et al., 2015). Most mainland participants in dolphin-watching tours had their experience through chance encounters with operators that combine whale-watching with nature-watching cruises. Chance encounters represent a clear difference compared to the type of whale and dolphin watching practiced in the other two Portuguese territories, the Azores and Madeira archipelagos, which offer dedicated whale and dolphin-watching tours (O'Connor et al., 2009).

In mainland Portugal it was established in 2006 the national law (Decreto-Lei n.º 9/2006), that regulates the whale-watching industry. This law was established for the protection and improvement of cetacean-watching on the Portuguese coast, stating not just

protective directives that the companies should follow, but also instructs them on what sort of behaviours and interactions are associated with the decrease of the disturbance placed on the animals. The behaviours stated in the law that are the most observed in stressful situations during these experiences are abrupt changes in direction and/or speed from the initially observed, evasive behaviour and constant distancing from the boats, an increase of the dive time, beating repetitively of the caudal fin in the water surface or protective behaviour by adults, like trying to distance calves from the boats or getting their bodies between the calves and boats. To avoid the occurrence of these behaviours the law has several prohibitive guidelines to protect the animals, such as intentionally provoking the separation of the pod, feeding and touching the cetaceans and diving with the animals. The law also has a defined approach regulation stating that less than 300 meters is the distance considered for the active approach of the animals. At all moments of the encounter, one should keep a parallel or rear position to the animals, giving them a free range of motion at 180° off their swim direction, avoid abrupt changes in the direction or speed of the boat and the boats should not get closer than 30 meters from the animals.

Although providing specific safeguards to cetaceans, it is a law difficult to enforce due to few detections means but also ineffective investigation, prosecution, conviction, and application of penalties (Parsons, 2012). Often, authorities responsible for monitoring whale-watching lack the knowledge, conviction, resources, or logistical support, because of that, compliance and monitoring may be very poor (Wiley et al. 2008). For example, it is frequently difficult to judge distances accurately at sea, especially during rough weather, making it hard for skippers or authorities to judge if boats are complying with legislation or not. In addition, guidelines that mention specific behaviours may not be practical, as nonscientist operators could misinterpret them or simply miss the exhibited behaviours (Whitt & Read, 2006). Many regions have accreditation schemes where operators receive training. Such methods can be beneficial if the standards for accreditation are high and the system is monitored, policed appropriately, and widely recognized (Parsons, 2012). Nonetheless, when effective guidelines are established and followed it reduces the negative impacts of the whale-watching industry (Corbelli, 2006.).

Mitigation efforts

The lack of knowledge and study of abundance and distribution in the area hinders the mitigation of anthropogenic impacts on cetaceans. In Portugal, the increase in the number of identified species over time and the number of sightings does not reflect an increase in cetacean abundance but rather the effort dedicated to the observation of these animals (Brito & Sousa, 2011). Most of the information obtained results from stranded or captured cetacean species observations. Most of the data gathered in Portugal originates from opportunistic observations (Marçalo et al., 2015).

In the Algarve, a single whale watching vessel operating from Faro detected ten cetacean species belonging to four different families: four belonging to the *Delphinidae*, four species of *Balaenopteridae*, one species of *Phocoenidae*, and one *Ziphiidae* species (pers.com. Alfredo Rodrigues). The most observed species both on coastal and high seas are the common bottlenose dolphins (*Tursiops truncatus*) and common dolphins (*Delphinus delphis*) (Correia et al., 2015). In Portugal, there is little knowledge regarding the whale-watching industry impact on cetaceans, unlike in other countries where significant impact was observed on some of the most common species found on the Portuguese coast (Constantine et al., 2004; Lusseau, 2004; Neuman et al., 2006; Stockin et al., 2008).

To reduce the impacts of whale-watching activities on cetaceans, more knowledge is needed about determinant biological factors such as the species usage of our coast, as well as their distribution and abundance. Only by increasing this knowledge can more determinant measures be taken to protect cetaceans such as conservation efforts, protection of habitat or changes in the law (Robinson, 2006, Parsons, 2012, Raschke et al., 2017). Due to cetacean species, biological and behavioural differences, a one size fits all legislation may not provide enough protection to all the species present under those general directives (Neves, 2010; Parsons, 2012). As such, directional approach must be undertaken to understand species-specific anthropogenic resilience to ensure the best possible protective results.

Land-based surveys enables a broad-view of the ocean, that can prove to be an essential tool used to mitigate and aid monitor whale-watching, without causing further disturbance in the animals (Morete, 2018), while at the same time overcoming the lack of resources, especially in locations that possess advantageous positions of surveillance and in

countries where the whale-watching takes place close to shore, like in the case of the Algarve (Silva et al., 2014). This methodology has been used successfully to increase knowledge and protection of several species worldwide, providing determinant information about their abundance and distribution, while at the same time protecting them from illegal situations and even improving whale-watching activities (Amrein et al., 2020).

Cetacean distribution and abundance

The distribution of cetaceans and the way they use their habitats is of detrimental importance to help on conservation efforts, so that governments can act to guarantee the best possible environment for these flagship species (Cañadas, 2005; Sahri, 2021). Due to legal and logistical limitations the whale-watching industry mostly impacts the waters close to shore, as such significant differences in these close to shore habitats can lead to the presence of different species and consequently different impacts the industry might have on cetaceans. Cetacean distribution is greatly influenced by bathymetries, proximity to coast and slope (Cañadas A. e., 2005; Sahri, 2021; Gonzalez Garcia, 2019; Cañadas A. R.-T., 2002), such oceanographic variables exhibit significant differences throughout the Algarve and especially between our two areas of study , the rocky cliff coast of Vilamoura, with shallower waters with bathymetries mostly under 50m and the Ria Formosa barrier island system of the Faro region with depths that can get to the 700m bathymetric line (Rosa, 2013; Ben-Hamadou, 2010). These depth and slope differences mean that the differences between both areas, despite their proximity, are not just the number of boats but also the habitat. The different oceanographic characteristics of each location create distinct habitats and consequently different sightings during cetacean watching trips as both regions have the features to be inhabited by shallow-waters cetaceans, usually associated with depths less than 400m, such as short-beaked common dolphin (*Delphinus delphis*) and bottlenose dolphin (*Tursiops truncates*) while deep-waters species, that prefer waters deeper then 600m such as the striped dolphin (*Stenella coeruleoalba*) are only expected to be sighted in one of our studies locations (Cañadas A. R.-T., 2002). Differences on the habitat and consequent species observed indicate differences on the potential of each region and with that different protective measures to its inhabitants .Despite the proximity of our studies locations they exhibit distinct characteristics, only understanding these differences and studying the potential of each

region regarding their suitability as cetacean's habitat can proper measures be applied for the conservation and mitigation of anthropogenic activities towards these species.

2. Objectives

Due to almost non-existing data on cetaceans from the mainland Portuguese coast, our study will bridge some gaps in knowledge by recording relevant data on the abundance, distribution, and behavioural observational data from the Algarve. The numerous whale-watching operators in the southernmost region of Portugal are a concern to the health of cetacean pods and as such assessing the changes in the expected behaviour and boat interactions are detrimental to evaluate the impacts of this activity. Only by increasing the scientific knowledge and the popular awareness about the species present in our shores, can we apply effective legislation that suits the protective factors needed for these populations' survival (Robinson, 2006).

Therefore, the aim of this study is to compare whale watching impacts in two distinct boat density areas and the distinct approach both have to the industry with the aim to understand how differently they impact cetaceans and consequently create a knowledge foundation that will allow more conscious conservation measures to better preserve these emblematic species.

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Chapter 2: Study on the impact of cetacean watching in the Algarve

Freitas, F.¹, Peres dos Santos, R.^{2,3}, Castilho, R.^{1,2}

¹Faculty of Sciences and Technology, University of Algarve, Gambelas Campus, 8005-139 Faro, Portugal

²Resources Restoration Connectivity Climate (R2C2), Center of Marine Sciences (CCMAR), University of Algarve, Gambelas Campus, 8005-139 Faro, Portugal

³Mingan Island Cetacean Study (MICS), Quebec, Canada

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Abstract

Whale-watching activities can induce behavioural changes that may negatively affect cetacean populations. This activity is a growing industry in the Algarve and constitutes an essential share of all the maritime touristic activities in the area. The activity started in the Algarve during the last decade of 1900's and led to national law - Decreto-Lei n.º 9/2006 that regulates whale watching in waters under Portuguese jurisdiction. This study will tackle an identified gap in the Algarve concerning cetaceans' distribution, abundance, and behaviour. Will cover the area between the Alfanzina lighthouse and the East end of Armona Island to assess the impact of human activity on the cetaceans. Such data will be obtained by observing the boat-cetaceans interaction in situ (onboard) and recording and classifying the cetaceans' behaviour observed from land. The weak law enforcement usually conducts to greater proximity between the boat and the individuals. Therefore, we expect to observe some level of distress in the animals, which can be detected by particular behaviours. To mitigate this anthropogenic effect, we will gather data on the distribution and abundance of cetaceans and the number of surrounding boats. Such methodology abundantly used in the Macaronesia Islands, especially the Azores Archipelago, is still insufficiently used in the Algarve. We will be comparing two regions with different anthropogenic pressure, Vilamoura (high) and Faro (low). We will assess if land-based surveys are a reliable quantification tool to detect boat/cetacean interaction.

Introduction

Anthropogenic impacts profoundly impact nature and are a central concern of conservationists. In many regions of the world, there is a lack of investment in conservation biology, leading to less knowledge and, consequently, bigger challenges when protecting species and ecosystems (Robinson, 2006). Flagship species such as cetaceans are not an exception, as studying them is a challenging process, especially due to their highly mobility but also due to small, scattered populations (Raschke, 2017). Throughout much of the 19th and 20th centuries, cetaceans were considered a resource to be harvested for the many products extracted from these mammals (Brito & Sousa, 2011). This large-scale harvesting of marine mammals peaked in 1960 with the factory ships and came close to an end in the 1980s as whale populations became critically endangered. Finally, in 1986, The International Whaling Commission (IWC) declared a moratorium on commercial whaling designed to protect whales from the threat of extinction. Since this moratorium, the predominant interaction between cetaceans and humans has completely changed in most countries (Hoyt et al. 2001). Often whaling has given place to whale-watching, an approach consisting of observing cetaceans in their natural habitat (Würsig et al., 2009).

Whale-watching is a nature-based tourism industry developed in the United States during the 1950s. Despite its intended natural format, there is some debate about whether or not whale-watching can be considered a form of ecotourism (Stamation et al., 2010; Coria & Calfucura, 2012). Despite whale-watching in its origin not being developed for the purpose of conservation, it can still be considered a tool for improving conservation efforts because it links human economic activities with a healthy and prosperous environment (Coria & Calfucura, 2012). However, it is not an activity without negative impacts on the target species and the environment. The industry poses risks to cetaceans as well as to their environment, especially in the case of boat-based activities (Finkler, 2004). Some common negative impacts that have been connected to whale-watching include impacts such as cetacean behavioural changes resulting in less resting, feeding, and socialization, shifts in habitat use, disruption of cetacean communication by boat noise, and exposure to increased levels of chemical pollution (Parsons, 2012). Although many of these impacts are short-term, there is concern that the continuous evolution of the whale-watching industry may lead to long-term, regional effects on target species.

The Portuguese mainland has the potential for dolphin watching, as predicted in the 2001 International Fund for Animal Welfare (IFAW) report (Hoyt, 2001). From a slow start in 1998, with 1,380 whale watchers, in 2008, over 58,000 whale watchers undertook trips in the existing 11 whale-watching operators. The commercial activity of whale or dolphin watching is centered in the Algarve region, where the number of operators has dramatically increased from 11 in the entire country to 45 just in the region of the Algarve in 2022. The unregulated and poorly oversight maritime tour operations can induce severe negative impacts on the cetacean communitie, which may be compounded with the sharp increase observed in the number of tour operators (Stamation et al., 2010). In this region, boat-based whale-watching has two distinct models of action; the trips can be considered either dedicated or opportunistic (O'Connor et al., 2009). Most of the data gathered in the Algarve and in Portugal's mainland originates from opportunistic observations (Marçalo et al., 2015). The lack of knowledge and study on the abundance and distribution in the Algarve hinders the possible mitigation measures of anthropogenic impacts on cetaceans.

The distribution of cetaceans and use of habitats is of critical importance to help conservation efforts. Cetacean distribution is greatly influenced by bathymetry, i.e, proximity to the coast and slope (Cañadas, 2002; Cañadas, 2005; Gonzalez Garcia, 2019; Sahri, 2021). Such oceanographic variables exhibit significant differences throughout the Algarve, particularly between two areas of study: the rocky cliff coast of Vilamoura, with shallower waters mostly under 50m and the Faro region with depths up to 500m (Ben-Hamadou, 2010; Rosa, 2013). These oceanographic differences suggest that most of the sightings in the Vilamoura area will be of coastal cetacean species, while in Faro, some deeper water species can be observed closer to shore. It is possible, therefore, that sightings in Faro are more diverse in terms of observed species.

Evaluating the effectiveness of existing regulations and guidelines for cetacean watching in the Algarve can help identify potential gaps and areas for improvement. This research can involve monitoring adherence to best practices and assessing compliance levels, which is basically assessing the number of boats and the distance of these to the observed cetaceans. The results from this work may inform mitigation measures of the impacts to decrease the anthropogenic effect on the cetaceans. It is, therefore, necessary to know the

distribution, abundance, and usage of the Portuguese coast by these marine mammals. Land-based surveys enable a broad view of the ocean, which has proved to be an essential tool for monitoring whale-watching without causing further animal disturbances (Morete, 2018). Additionally, it is highly advantageous as it requires less infrastructure and human resources, although specific training is needed to spot the animals through binoculars. Obviously, the existence of surveillance positions close to shore and at relatively high altitudes (cliffs or lighthouses) is a pre-requisite.

The goal of this study is to evaluate the impact of boat-based interactions on cetaceans in the Algarve region by comparing two adjacent zones. These two zones have marked a different number of boat licenses, which, together with distinct commercial strategies, may produce diverse anthropogenic impacts. The study will produce results from land-based observations for 6 months and is a valuable contribution to bridging the existent knowledge gap regarding cetaceans on the Southernmost coast of Portugal.

Material and Methods

Boat surveys

Boat data was collected between the Alfanfina lighthouse (near Portimão) and the East of Armona island; this area covers about 43 nautical miles (nm) of the Algarve coastline and adjacent waters. There are four main ports/marinas (Olhão, Faro, Vilamoura and Albufeira), and in proximity to Portimão (Figure 1), all these marinas are cetacean-watching boat departure locations. Surveys in the Vilamoura region were mainly conducted from Vilamoura to the Alfanfina lighthouse, a 19 nm stretch of coast with the constant presence of boats from Vilamoura and Albufeira and occasionally boats from Portimão on cetacean sightings year-round. Faro region surveys covered the 17 nm coastline between Praia de Faro and Armona island. Boat presence was inconsistent during the year, except on a few occasions when the whale-watching industry worked outside of the tourist season. These surveys were conducted from July 2021 to June 2022 when the whale-watching companies had clients, and the weather conditions made it possible to conduct the trips safely. Survey trips departed from two ports/marinas on Faro and Vilamoura, Faro tours were cetacean-dedicated, while in Vilamoura, opportunistic tours were undertaken with cave sightseeing combined with cetacean watching; both trips had a duration between 2h to 3h with the number of trips varying each day from one to three. Data collected on the boat focused on the interaction between the animals and the vessels (approaching, indifference or evasiveness) and the behaviours such as feeding (foraging), resting, travelling, or bow-riding, sightings coordinates, and group structure were also recorded, and monitored the number of boats present during each encounter. For a better understanding of our most relevant classification, which is the total boat number during each encounter, boat numbers will be compartmentalized in three distinct groups: 1 to 3 boats were considered as a legal situation (LS), due to constant boat change 4 to 5 boats was classified as a possibly legal situation (PLS) and over 6 boats were classified as an illegal situation (IS). This data was gathered to be analyzed against the Portuguese cetacean legislation's most objective protection guidelines to understand its effectiveness.

Land surveys

Land data was collected from the Culatra Island on Santa Maria lighthouse, an advantageous point with a height of 49 meters on a sand barrier island lacking naturally elevated points. From a viewpoint on the cliffs of Falésia Beach, this location is 53 meters above sea-level. These locations can provide a maximum range of about 12nm when visibility is excellent, with these conditions over a 7/8 nm range of sight overlaps, as observed in Figure 1.



Figure 2.1. Map of the Algarve region encompassing our study area, observation locations are marked with arrows Vilamoura (blue) and Faro (orange). The average and maximum range for land observations are represented with blue and red circumferences for each region. Red arrows represent the limits of the study area for boat surveys. The white line represents the legal limit for whale-watching boats, the green line represents the maximum distribution and legal limits for the whale-watching industry.

This data was collected between January and June 2022, 1-3 times a week, when visibility was at least 3nm and the Beaufort scale was three or lower. Data collected inland was obtained from look-out spots on the locations previously mentioned with the help of binoculars (25x70 and 20x80). The observation with binoculars has two ranges due to visibility conditions. With optimal conditions, approximately 12 nM is the maximum distance we expect to observe animals, while suboptimal visibility decreases the range to less than 6 nM.

Every land-based survey had a length of around 1h30, divided into three different 30-minute scans of the study area; due to the topography of the coast, the lighthouse location has a broader area of observation (260°), ideally suited for two observers than the one in Falésia beach (160°). This data did not follow a strict schedule in the days and hours of observation due to the benefit of randomness in interpreting abundance and distribution data. Data was collected for such data as date, hour, species, heading, distance, sea state, visibility, number of boats, behaviour and number of individuals.

Land-surveys provide a different methodology to analyze distribution since they allow for a consistent observation of our study area, contrary to the more limited in range boat-surveys. This difference may prove to be detrimental when analyzing the distribution of cetaceans in these regions by helping to clear some of the potential issues associated with the use of a single methodology of recording data.

Data analysis

We used an integrated development environment for R (RStudio version: RStudio 2022.02.2, +485) with R-packages such as *dplyr* and *tidyverse* for table manipulations, *stat*, for the statistical analysis of distribution, abundance and boat-cetacean interactions, *raster* for Geotiff analyzes and *ggplot2* to generate graphical visualization of the observed cetacean's data and environmental information, such as depth, position, or distance to the coast. Cetacean spatial distribution was analyzed using an open-source Geographic Information System (QGIS) software for biological and non-biological datasets, with data from the online platform Emodnet (emodnet-bathymetry.eu).

Cetacean distribution was mapped for our study areas, one map for each dataset collected both from land and boat surveys; the two methodologies were combined in order to mitigate the bias associated with the short duration of our dataset with an increase in the replicates and approaches to data gathering.

For land distribution, a grid survey of 4km square was created to improve the analyses and interpretation of the study area. For the distribution analysis of land survey data, the encounter rate (ER) for each of the grids was calculated using the formula:

$$ER = \frac{\text{Sightings}}{\text{Hours}} \times 100$$

where the sightings are the total number of encounters per grid, and the hours represent the observation effort for that grid. The effort time was divided according to the visibility in each survey and classified into one of the four categories: <3nM, <6nM, <9nM and <12nM.

We did not calculate an ER from boat-based surveys since we did not possess total boat distance or survey tracking to use as an effort. As such, we utilized the coordinates for each encounter and calculated distribution via heatmaps/Kernel distribution in QGIS. This approach creates a density raster of an input point vector layer using kernel density estimation, heatmaps allows easy identification of hotspots and clustering of points. The density is calculated based on the number of points in a location, with more clustered points resulting in larger values. The radius used to fit our areas better was 2000 meters, and for better image definition, the pixel size selected was 50 meters. Species richness was calculated via the Shannon Diversity Index (H) for each of the study areas:

$$H = -\sum_{j=1}^S p_i \ln p_i$$

where P_i is the proportion of records of each species (Shannon, 1949).

Results

In this study, data collection was divided into two methodologies, land and boat surveys, from July 2020 to June 2021. During this period, we collected 686 boat records, 420 from surveys departing from Faro and 266 from Vilamoura. From January to June 2021, we completed 178 land recordings, 103 from the Santa Maria lighthouse (Faro) and 75 from the Falésia cliffs (near Vilamoura). The distribution of the 10 recorded species is uneven across our study areas, with nine species in Faro and six in Vilamoura. Boat surveys posed challenges for species identification. We found varying diversity levels between the two locations, identifying nine species in Faro and six in Vilamoura, with five species common to both regions, as such we obtained a significantly different Shannon Diversity Index with Faro having 1,302 and Vilamoura 0,725. The 10 species identified during our surveys were the short-beaked common dolphin: *Delphinus delphis* (Dd) (N = 219), common bottlenose dolphin: *Tursiops truncatus* (Tt) (N = 332), Risso's dolphin: *Grampus griseus* (Gg) (N = 2), striped dolphin: *Stenella coeruleoalba* (Sc) (N = 19), harbour porpoise: *Phocoena phocoena* (Pp) (N = 7), Orca: *Orcinus orca* (Oo) (N = 4), fin whale: *Balaenoptera physalus* (Bp) (N = 25), sei whale: *Balaenoptera borealis* (Bb) (N = 7), minke whale: *Balaenoptera acutorostrata* (Ba) (N = 7) and Bryde's whale: *Balaenoptera edeni* (Be) (N = 2). During two of our Faro surveys, it was not possible to identify the species of *Mysticeti* observed, as such, the sightings were classified as *Balaenoptera* species (Bsp).

The number of vessels with cetaceans spotted during boat tours ranged from 1 - 9 in Faro (Figure 2.2 top A-C) and increased to 1 -18 in Vilamoura (Figure 2.2 bottom A-C). The areas are categorized as high- and low-pressure zones based on reports of an illegal excess of boats, totalling 95 instances in Vilamoura and two in Faro.

We observe significant differences between our study sites in the analyzed parameters (Figures 1 and 2). The average time spent with the animals was usually higher in Faro (21 minutes) than in Vilamoura (15 minutes), both within legal limits. Even though the encounters were shorter, in Vilamoura, the average number of boats in the beginning, end and during the sighting were higher for most of the reported species. The average number of boats was always within the legal limits in Faro, while in Vilamoura, all species except for Pp have averages over what is permitted by law.

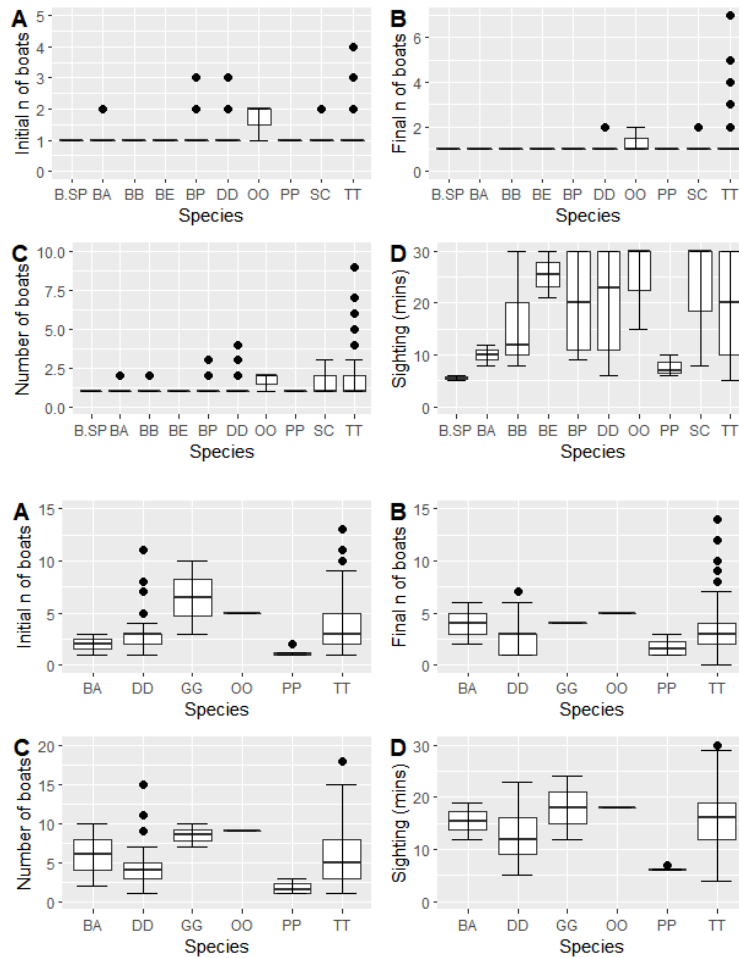


Figure 2.2- Faro (top) and Vilamoura (bottom) surveys, A is boxplot representative of the initial number of boats per species, B is the final number of boats per species, C is the total number of boats per species and D is the time spent surveying each species.

In both the Faro and Vilamoura regions, cetacean sightings were categorized into legal situations, possibly legal situations, and illegal situations. In Faro, among 397 total sightings, 97% were legal situations, 2% were possibly legal situations, and 1% were illegal situations, while in Vilamoura out of 229 cetacean sightings, 33% were legal situations, 26% were possibly legal situations, and 41% were illegal situations. Most encounters in Faro involved a single boat (79%) and cetaceans responded to the boat with approaching (34%), indifference (59%), or evasive behaviours (7%) while in Vilamoura cetaceans responded to the boat with approaching (35%), indifference (35%), or evasive behaviours (30%).

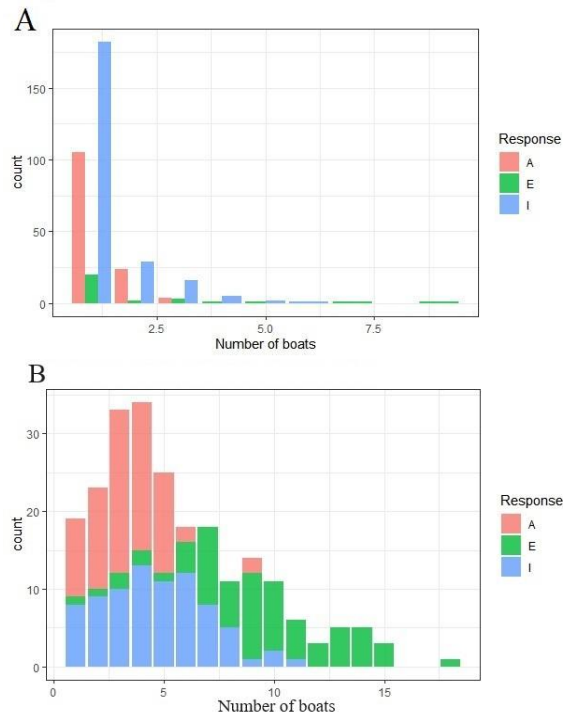


Figure 2.3– Bar graphs of two variables. Faro is represented in **A** and Vilamoura in **B**, connecting the number of boats in each interaction to the consequent response of the cetaceans to each registered vessel number. Response to boats was classified as approaching (A), evasion (E) and indifference (I).

During our surveys, we also registered the behaviour displayed by each pod. This data allowed us to associate each species’ response to the actions observed from the boat (Figure 2.4). The species selected for this analysis were common and bottlenose dolphins since they are the most sighted species in both our study areas, consequently leading to a more conclusive understanding of the possible flagship behaviour that can be associated with high-stress situations.

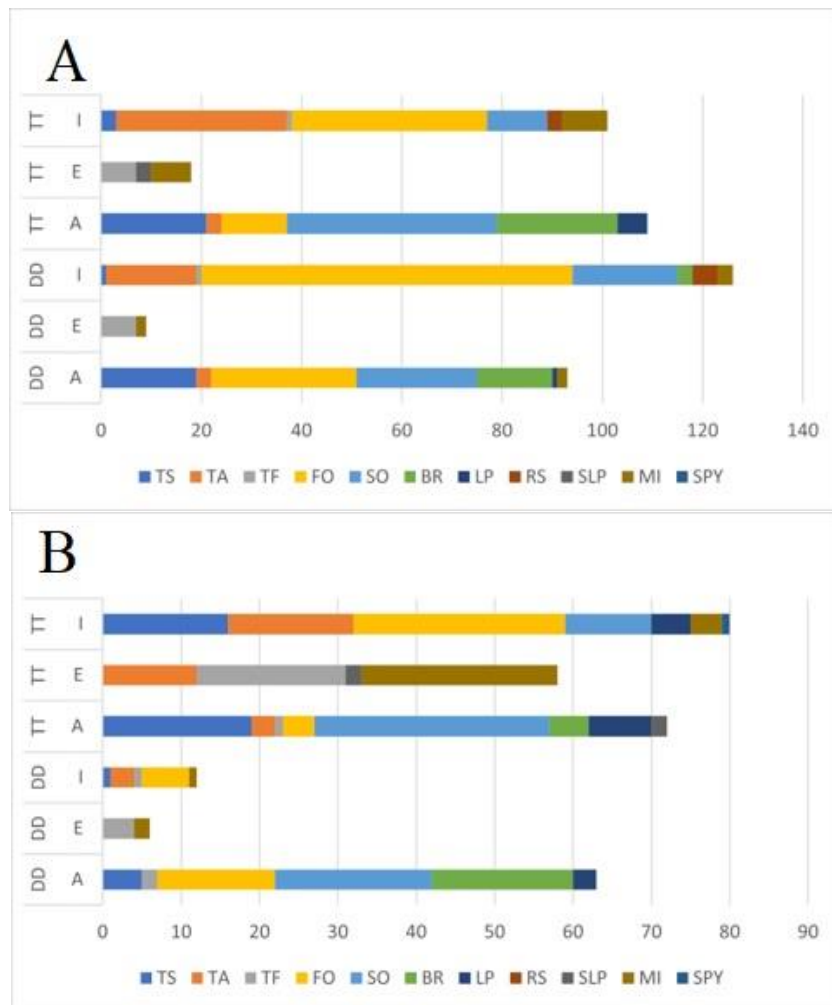


Figure 2.4 – Multiple variable bar graph (Faro **A** and Vilamoura **B**), that represents the most common behaviours exhibited by the two most common sightings species, *Tursiops truncatus* and *Delphinus delphis*, for each of the three quantified responses to boats. The behaviours recorded during our study were TS (travelling slowly), TA (travelling average), TF (travelling fast), FO (foraging), SO (socializing), BR (bow-riding), LP (leaping), RS (resting), SLP (tail slapping), MI (milling) and SPY (spy-hopping).

We can observe that the cetaceans' behaviours vary according to their response to the boat. Some behaviours seem to be more prevalent in certain boat responses than others (Figure 2.4). Foraging is the most observed behaviour in Faro (34%) and the second most in Vilamoura (18%) but only in situations where the response to the boat is Approaching our Indifference. On the other hand, travelling fast is a behaviour mostly observed in situations of Evasiveness. It is also visible that the diversity of behaviours observed during Evasive situations is significantly lower than for Approaching or Indifference Response.

In Faro, three behaviours were observed in Evasive situation and as such, can be considered as ways of behaving potentially associated with causing stress or harmful situations to the animals, which were travelling fast (4%), milling (5%), and tail slapping

(1%), out of these actions only milling was observed more times in other responses, Indifference, than for Evasive. The two most observed behaviours in Faro were foraging (34%) and socializing (22%), both habits, essential to these species's life, and were only observed in Approaching and Indifference Response. Nonetheless, other behaviours, such as Resting are rarely observed (2%), which can indicate some negative impacts of whale watching on cetaceans. In Vilamoura, we have four behaviours observed for the Evasive response once again: travelling fast (10%), milling (11%) and tail slapping (1%); the other action observed in Evasive responses was travelling average (12%). None of these In Vilamoura, are exclusive to Evasive responses in Vilamoura, but all of them except travelling average are more common in Evasive situations than for Approaching or Indifferent responses. Once again, the two most common ways of behaving were foraging (18%) and socializing (21%).

In Faro, the kernel distribution map boat surveys identified the area immediately South of the mouth of the Ria Formosa Natural Park, as the biggest hotspot of the region in an area ranging from shore shallow waters to the 50-meter bathymetric. Another hotspot in Faro was more to the Southeast in waters between the 100-300 meters bathymetric lines. All hotspots determined are within the legal limits of 6 nautical miles (Nm) from the coast (represented by the black line) for most cetacean-watching vessels (Figure 2.5A). In Vilamoura (Figure 2.5B) the boat survey map reveals dispersed hotspots throughout our study site, with the biggest hotspot in the coastal waters of Falésia Beach all the way to Albufeira. The bay of Armação de Pêra also has some hotspots in an area South of the Bay in waters between the 30- and 50-meter bathymetric lines.

By observing our distribution map, we can see a big difference in depth represented by the bathymetric lines on both maps. Within, the legal search area for most vessels' maximum depth for Vilamoura is slightly over 50 meters while in Faro it goes as deep as 700 meters. In Faro, the depth of our sightings ranged from 3 to 760 meters, while in Vilamoura the depth range is from 3 to 104 meters.

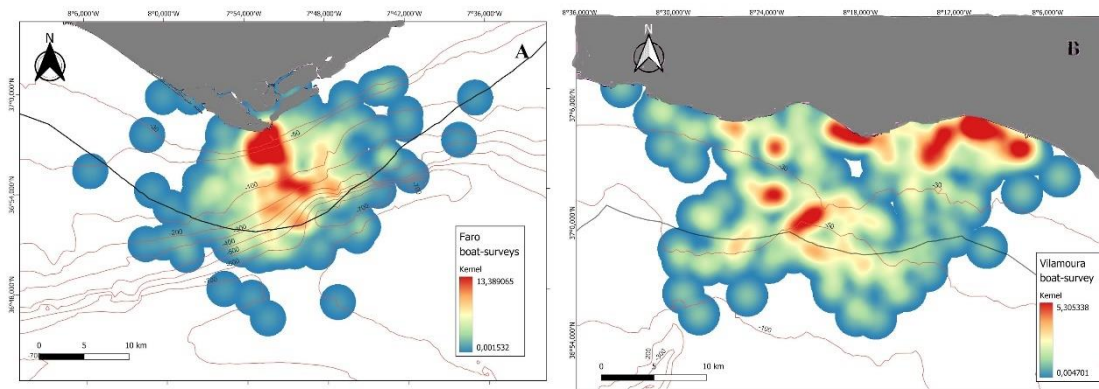


Figure 2.5 – Distribution heat map for boat surveys in Faro (A) and Vilamoura (B) regions representing the abundance of encounters in both study areas, with more encounters represented in red and less with blue. This map also exhibits the bathymetric lines for both regions (pink lines) and the 6 nautical miles line (black line) representative of the limited distance that most boats should operate from the coast.

In the Faro region, the land-survey distribution map (Figure 2.6A) displayed a pattern similar to the kernel distribution, revealing a hotspot southeast of the Ria Formosa’s mouth in waters ranging from 50 to 300 meters. However, it did not show as high cetacean density in shallow waters. Instead, it indicated higher Encounter Rates (ER) in the shallows near Culatra Island rather than Deserta Island as observed in boat surveys. Nevertheless, both maps highlighted the waters south and southeast of the Ria Formosa natural park inlet as the most abundant cetacean area around Faro. In Vilamoura, data collected from boat-surveys and land-surveys differed, with their geographical distributions not completely overlapping due to the limited range of land surveys, which covered the bay of Albufeira and Vilamoura, whereas boat surveys extended to Portimão. The land-based data produced a distinct distribution map, with Falésia Beach coastal waters not being identified as a hotspot. However, the land-survey hotspot southwest of our survey site coincided with the hotspot south of the Armação de Pêra Bay (Figure 2.6B).

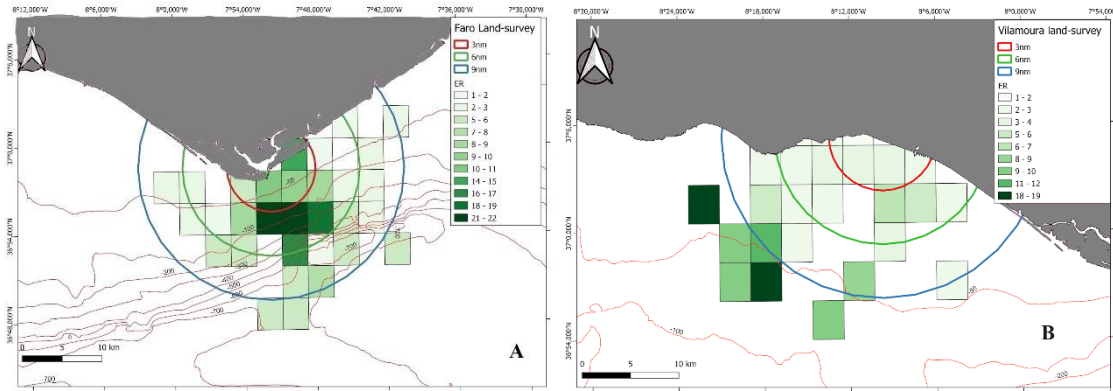


Figure 2.6 – Distribution heat map for land surveys in Faro and Vilamoura regions representing the abundance of encounters in both study areas, with more encounters represented in dark green and less in light green. This map also exhibits the bathymetric lines for both regions (pink lines), as well as the 3 nM (red line) 6 nM (green line) and 9 nM (blue line) observations range from the lookout spot.

Land-based surveys provided less conclusive data regarding species identification due to the difficulty associated with the distance, particularly at distances greater than 5 nautical miles and without boat confirmation. In Faro where land-based surveys were mutually working with boat-surveys the number of inconclusive identifications regarding cetacean species accounted for 31.4% of observations, in Faro, it was possible to identify a total of 7 species. In Vilamoura where the boat-surveys and land-surveys always occurred independently only 2 species were identified successfully, while during most of the sightings, 52%, it was not possible to identify the species. In both regions, a significant difference was recorded as the number of failed surveys in Vilamoura were 21 compared to 4 in Faro.

Discussion

Benefits and caveats

Overall, despite opportunistic data presenting major limitations that can affect reliability of results, due to limitations such as different cetacean detectability, animal proximity or limited time per trip due to business constraints. The benefits might outweigh the limitations since it provides inexpensiveness and constant research platforms that otherwise would not be available. Such platforms can provide new insights, on data deficient locations, usually associated with a lack of dedicated money for research, proving detrimental in cetacean conservation actions (Stamation, 2007; Higham, 2014; La Manna, 2020). Despite that, there is no denying that whale watching can have negative impacts on exploited pods (Neves, 2010; Parsons, 2012).

Boat-surveys included in a touristic activity provided us with important knowledge regarding cetacean distribution, habitat usage, species abundance and diversity in two adjacent but distinct areas of the Algarve. Boat-surveys also allowed us to compare different whale watching approaches in areas with high and low boat density (Vilamoura and Faro). Vilamoura proved to be a more impactful area to the cetaceans, since boat density is higher and compliance with legislation is lower, while at the same time being a less diverse habitat. The dedicated whale watching trips in Faro proved to be a less invasive approach, since there were fewer time constraints and more conscient mindsets that led to a better compliance of the law and consequently a less impactful activity.

Limitations of this study are associated with difficulty to control and analyze the boat distance to the animals and in some cases the total number of boats per encounter, which is of detrimental importance for our study, in this regard methodologies like land-surveys may provide an important help since more eyes are controlling each interaction. Other limitations come from the different perspective and opinion that researchers might have regarding the behaviour exhibited by cetaceans, in this study, this may cause some influence since, in the Faro region, data was recorder by multiple researchers, this can and was mitigated by the sharing of opinions and knowledge between the researchers, but it is something that will never disappear. Visibility is something that must also be addressed, since this study is focused on the information obtained from dolphins when these are on the surface, which only correspond to a part of the animal behaviour and of

the interactions between boat and pod, this is an issue that can be mitigated with more advanced resources such as hydrophones and water-proof cameras.

Land-based surveys proved to be a useful methodology to increase cetacean knowledge in the Algarve, especially when associated with boat-surveys. This methodology also proved to have great potential to help mitigate negative cetacean impacts, especially regarding legislation enforcement. As such, this methodology should be included in cetacean watching legislation like it occurs in the Azores and Madeira. Nonetheless, this technique also has some issues such as the resolution of the binoculars, that change in every observation, as do human eyes, which can cause inconclusive readings and inaccurate information, as such, land survey data must always be interpreted with caution and with regard for the observers' experience, as such for better data gathering using both methodologies is the ideal.

Whale watching impact

Boat pressure is unequivocally different between our study areas. This occurs since the compliance with legislation differs greatly between Faro and Vilamoura, the main reason for that difference is the business approach and the knowledge of crew and owners. Business philosophy and mental predisposition by owners and skippers have been associated with different levels of impact caused by whale watching (Higham, 2015). Business approach differs greatly since in Faro tours are exclusive for dolphin watching while in Vilamoura they are opportunistic tours that cause illegal situations recorded in Faro to be mostly caused by private boats while in Vilamoura were mainly due to whale-watching vessels. Time constraints is the biggest issue in this regard since in Faro boats have far more time to comply with rules while skippers in Vilamoura are in a constant rush and have small gaps to observe cetaceans. In Vilamoura lack of knowledge is a problem as well since, contrary to Faro, skippers and owners are not biologists and have very few knowledge about animal behaviour, at the same time legislation does not support a strong position within companies for biologists to be seen as more than just a luxury and have difficulty in enforcing stronger and safer conservation measures in these trips. Both situations lead to distinct direct impacts and different datasets in these adjacent regions.

The long-term effects of direct impacts, such as boat-induced stress, may have severe ramifications, individually, but also in habitat usage and in the social dynamic of pods

(Higham, 2014; Bejder, 2022). The most common whale-watching impacts are noise pollution and harassment by boats (Raschke, 2017). These impactful behaviours can be greatly affected by compliance with legislation. The prolonged extent of invasive or unpredictable behaviours by boats will cause cetaceans to evade from them (Christiansen, 2010). Evasive behaviours can occur in horizontal or vertical movements. The most common behaviours demonstrated in both cases are prolonged diving periods and increase in swimming speed (Lusseau, 2003). In our study, travelling fast was registered more commonly in evasive situations, with clear stress factors caused by vessel presence. It was also the more common behaviour reported in the high-pressure zone (Vilamoura) than in the low-pressure zone (Faro), 9% and 4% respectively. Another behaviour recorded that could be bridged in this situation is milling. This behaviour was attributed when no specific behaviour was identifiable, like in situations of confusion or longer dives, like in vertical evasion, once again this behaviour was observed more often in Vilamoura (12%) than in Faro (7%).

Our results show that in case of high boat numbers, the number of cases of avoidance increases, with the cetacean behaviour resembling that of predator avoidance, when surrounded by boats, which indicates high levels of stress during touristic observations (Lusseau, 2003; Williams, 2007). Our study provides further evidence of such occurrences as in Vilamoura, the high boat density area, the evasion rate was 30% of the encounters, while in Faro was only 7%. Animals targeted by whale watching vessels usually change their behaviours in the presence of boats (Parsons, 2012; Lusseau, 2014). Higher energy spendings behaviours such as travelling and milling were more commonly observed in Vilamoura, 35% and 12% of sightings, while in Faro they represented 27% and 7%, respectively, while foraging rates were significantly higher in Faro than Vilamoura (34% and 17%), socialization rates were very similar for both regions, most concerning was the resting rates as this behaviour was not observed in Vilamoura and represented only 3% of behaviours observed, revealing that even in low boat density, whale-watching impacts may be less but still felt by cetaceans. The classified behaviours that tend to be more common in the presence of boats are milling, travelling, and diving while resting, feeding, and socializing decreased (Arcangeli, 2009).

In our study, encounter duration was the only measure that was larger in Faro than in Vilamoura, indicating that in the Algarve, the number of boats present is possibly the main cause of stress from whale watching. Whale-watching impacts become more severe

when more boats are present around cetacean pods over extended periods of time (Bejder L. 2006). To assess the diversity of each region the Shannon Diversity Index was calculated, and significant differences were shown, with Faro classified as 1,302 and Vilamoura as 0,725. This difference may suggest significant habitat degradation due to whale-watching activity, as habitat abandonment was documented for areas with intense boat pressure (Parsons, 2012; Lusseau, 2014; Scarpaci, 2014). The species diversity index and success rate of boat trips indicate that cetaceans may be favouring the less impactful region of Faro.

Besides the growing industry of whale watching, the way the companies proceed can have different impacts on pods. This problem is of great importance in Vilamoura since it is a regular occurrence for whale-watching boats to spend all their daily trips, sometimes 12 hours a day (mostly in summer), with the same pod of dolphins with boats interchanging amongst themselves in order to not lose the pod and guarantee a successful trip for their clients, this can lead to declining population sizes in association with growing whale watching industries, suggesting that many of the short-term impacts identified in short term studies like our own can translate into long-term, negative effects (Bejder , 2006; Arcangeli, 2009; Lusseau, 2014; Scarpaci, 2014; Gonzalez Garcia, 2019).

Whale watching preferentially targets coastal cetaceans (Delfour, 2007). Coastal cetaceans are the most pressured species since they are easier for vessels to find, and the profits are higher since less fuel is spent finding these animals. More extended trips into deeper waters in more exposed conditions also increase the chance of seasickness, a common reason for low visitor satisfaction (Stockin, 2008). Coastal species mostly prefer waters from coastline to 400 meters deep, this includes species like the *Tursiops truncatus* and *Delphinus delphis*, deep-water species like *Grampus griseus* and *Stenella coeruleoalba* mostly inhabit waters deeper than 600 meters (Cañadas., 2002). As expected, the species sighted more often in our study were coastal species, *Tursiops truncatus* and *Delphinus delphis*, which accounted for 80% of our collected data. Both species have been described as the most common cetacean species in mainland Portugal (Vieira, 2009; Hammond, 2013). *Tursiops truncatus* and *Delphinus delphis* were found in very similar bathymetric conditions, similar distribution was found in Azorean waters (Silva, 2003; Gonzalez Garcia, 2019), with *Delphinus delphis* occupying a slightly narrower range of depths not being present in waters shallower than 30 meters, in Faro this corresponds to a small distance from the coast around one kilometre and explaining

why both species were sighted almost the same number of times, in Vilamoura, *Delphinus delphis* were also only observed in waters deeper than 30 meters, this water depth can only be found significantly farther from the coast in this region of the Algarve at around six kilometres.

This depth difference between both areas may not just influence DD sightings and species diversity between these regions but also species-specific whale-watching impacts. As previously stated, most whale-watching boats in Portugal are limited by coast distance during their searching activity (6nM or approximately 11 Km), meaning that in Vilamoura in half of that area, only one very common species in Portugal can be found, the TT. As such, and as our data reflects, the negative impacts caused by overexposure to boats suffered by this species are significant, with more evasive than approaching responses to boats, as well as high rates of high energy spending behaviours like travelling fast and milling (Stockin, 2008; Christiansen, 2014). In order to overcome these problematic cetaceans, may increase their energetic outtake by outpacing the vessels or by changing their migratory routes (Parsons, 2012; Higham, 2014). In Faro, the combination of low boat impact and higher diversity of species led to very few observations of evasion from boats, a completely opposite situation from Vilamoura. DD had similar evasion values for both our regions, further enhancing the negative impact of over-exploration of nearshore waters caused by whale-watching companies (Constantine, 2004; Whitt, 2006; Amrein, 2020).

Long-term impacts on cetaceans from continued anthropogenic pressure are a concern, especially those related to reproductive success (Davidson, 2012). Despite the short-term period of our study and calf impact mainly affecting populations in the long-term, we still decided to analyze the evasion rates of Tt and Dd pods with and without calves, in order to understand if any tendencies were observed. In both our study areas, higher evasion rates were registered, for both observed species, in pods with calves than in pods only composed by adults and juveniles. We also observed that a lower number of boats was needed to trigger evasive responses in pods containing calves. Slow reproduction rates observed for most cetaceans will leave them particularly susceptible to long-term population impacts, as populations take long to recover from human pressure such as whale watching (Davidson, 2012; Argüelles, 2016; Sprogis, 2020). These impacts are mostly impactful on nursing pods with less fit calves, leading to negative implications regarding population growth (Weinrich, 2009; Argüelles, 2016; Sprogis, 2020). All

cetaceans suffer from this type of human pressure, nonetheless, mothers and calves are the ones more impacted as they are the most vulnerable (Sousa-Lima, 2008; Argüelles, 2016). Females have high energy expenditure while nursing their young, any stressful occurrences that will lead to extra usage of energy will have severe negative consequences for both mother and offspring (Weinrich, 2009; Scarpaci, 2014). Vessel collision is also a matter of great concern for mothers and calves (Davidson, 2012; Amrein, 2020). As calves are less physically fit, boat avoidance becomes more difficult for them and their pods, because pods are limited to the evasion capability of calves, maintaining them in stressful situations or forcing them to abandon their young in order to escape (Lusseau, 2003).

Mitigation strategies

Knowledge about cetaceans is of detrimental importance when trying to create regulations that will allow for the protection of such species (Robinson, 2006; Parsons, 2012). The lack of knowledge and study on the abundance and distribution of cetaceans in mainland Portugal hinders the possible mitigation measures of impactful anthropogenic activities. This is greatly evidenced by the fact that legislation in the Azores, a heavily studied region, has more protective measures than in mainland Portugal. Land-based surveys as a tool to improve whale watching have been part of the Azorean legislation for almost two decades, while in mainland Portugal our study was the first to use this methodology. Land-based observations are commonly used in that region as a guiding system for whale-watching vessels to find cetacean pods distributing the impact of the industry to various pods so as not to overburden them with human contact, as lookouts in the Azores also are very strict with the compliance of the number of boats surrounding cetaceans (pers.com. Víctor Silva). Besides its impact in whale-watching situations this methodology has also proven very effective in the increase of cetacean knowledge, especially when associated with boat surveys (Morete, 2018; Amrein, 2020). The data gathered during our study also associates combined methodology between land and boat surveys with more conclusive data, as the boat can be guided to gather data difficult to obtain from the coast such as group size, behaviour and species. Combined methodologies also led to fewer failed surveys as the no-sighting rate was much higher in Vilamoura than Faro, other factors such as habitat usage and diversity of species also influenced these results, but combined methodology was very helpful in many surveys. The use of both methodologies also provided two different distribution maps that combined, provide

a more solid possibility of the most used areas by cetaceans in this part of the Algarve. Due to all these benefits land-based surveys seem to be a very helpful tool and have the possibility to help mitigate whale watching impacts in the Algarve, due to it benefiting all interested parties, with increased help finding animals at sea, increased knowledge for scientific research and especially regarding compliance to the legislation because boats are easy to observe and regulated from land.

In order to lessen the negative impacts whale watching has on cetaceans, new protective legislation must be created but previously established rules should also be reviewed. The approach to cetacean distance legislation should be changed as the current regulation allows for too much freedom of approach by vessels to cetaceans. Allowed distance to approach cetaceans should be changed from 30 to 100 meters, and limitation of boats not partaking in observation should be changed from 100 to 300 meters, also there should be different rules according to the endangerment status of species. These sorts of directives were applied in other regions of the world, such as Australia and Canada and they are related to less invasive whale watching when properly executed (Stamation, 2010; Kessler, 2013; Stevenson, 2014; Moore, 2021). Such short distances between boats and cetaceans not only increase the probability of collision but also difficult the regulation of distance since we are considering highly mobile animals, that are constantly changing their position and can become more stressed if human-free surfacing areas are unavailable (Lusseau, 2003; Arcangeli, 2009). The one-size-fits-all legislation should be changed in order of a more species-specific legislation (Parsons, 2012) since different species respond differently to the presence of boats as demonstrated in our study. As such the number of boats allowed to approach cetaceans should be species-specific. To better suit new species-specific legislation not only cetacean response to boats must be considered but also their size, whaling history, extinction risk and reproductive rates (Davidson, 2012).

Mother and calf groups should also be protected by specific legislation, as these are the most sensitive groups to anthropogenic interaction (Sprogis, 2020). Our study is not the first to call for such measures since it was a focal point (Hoarau, 2020). With the findings of increased evasion rate in the presence of calves in the Algarve, legislation to protect them should be considered. (Hoarau, 2020), also called for the training of officers trained to protect wildlife and mitigate whale-watching impacts. Despite thinking this is a good measure, we consider biologists to be the most suitable people to fill this role, current

Portuguese legislation determines that every company should have a person either with biology or animal-behaviour studies responsible for creating an adequate and informative cetacean-watching program. This current legislation can easily be overturned since biologists do not have to be present for the companies to follow the law. If legislation was changed so that every company was forced to have at least one biologist at sea every working day, companies would stop seeing specialized personnel as luxury but as integral parts of their operation, which consequently would increase the strength of their position and the application of more positive whale watching policies. This change would also lead to more informative and educational tours not just regarding cetacean morphology but also public awareness and conservation efforts which have been linked with positive changes in whale-watching activities (Kessler, 2013; La Manna, 2020; Moore, 2021)

If better regulatory measures are implemented and legislation compliance can be confirmed, renovation of licenses include a percentage of compliance with regulations, potentially creating a mandatory incentive for whale watching to comply with legislation as suggested by (Kessler, 2013). Adopting an evolutive mindset regarding anthropogenic pressure will allow for a better management of a continuously growing touristic industry. Such a progressive approach will allow for a continuously evolving structure that will enable regulations to adapt with growing knowledge of human activity impacts and cetacean characteristics (Keith, 2011; Stevenson, 2014).

Conclusion

Overall, despite opportunistic data presenting major limitations that can affect the reliability of results, due to its limitations. Boat-surveys included in a touristic activity provided us with important knowledge regarding cetacean distribution, habitat usage, species abundance and diversity. Land-based surveys proved to be a useful methodology to increase cetacean knowledge, especially when associated with boat-surveys. This methodology also proved to have great potential to help mitigate negative cetacean impacts, especially regarding legislation enforcement. Nonetheless, to better preserve these emblematic animals, further studying is needed to consolidate the base foundation of knowledge created by this study. Only by increasing our knowledge about these animals can proper action be taken to protect them. Despite that, the findings in this study indicate that current legislation is insufficient to protect cetaceans. As such, reviews on current legislation are needed for habitat improvement in the Algarve region.

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