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A importância da observação de cetáceos no Algarve: contribuições para uma atividade ambientalmente sustentável

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Biologia Marinha Aplicada, realizada sob a orientação científica da Doutora Catarina Eira, professora auxiliar do Departamento de Biologia da Universidade de Aveiro.

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palavras-chave Cetáceos, Observação turistica de cetáceos, Poluição sonora, Gestão sustentável, Portugal.

resumo

A observação de cetáceos tem evoluído de forma exponencial em todo o mundo, tornando-se uma atividade economicamente importante para diversas regiões. Contudo, vários investigadores discutem se esta progressão na atividade será ou não uma possível perturbação ou até uma ameaça para os cetáceos, sendo que existem tanto pontos positivos como negativos. Na costa sul do Algarve, área de estudo deste trabalho, houve um aumento tanto no número de empresas que realizam observação de cetáceos como no número de embarcações a realizar esta atividade. No presente estudo foram analisados relatórios de empresas que realizaram observação de cetáceos entre o ano 2007 e 2021 (n=92) e os formulários de requerimento da autorização para a licença da atividade (n=401). Tendo em conta o reduzido número de relatórios disponíveis, no âmbito do presente trabalho foi ainda construído um inquérito dirigido a empresas que realizam observação de cetáceos no Algarve. Para caracterizar a atividade e a sua frota de embarcações, foram analisados diversos parâmetros incluindo os tipos de barcos utilizados, o número de avistamentos, as espécies observadas, o número de viagens realizadas e de passageiros transportados e também o possível rendimento direto desta atividade nesta região. No Algarve, a maioria das embarcações são semirrígidos, com uma dimensão de 5 a 10 metros e apresentam uma lotação de 10 a 16 pessoas. É de extrema importância caracterizar esta frota, pois consoante as características dos diferentes tipos de embarcação, estes produzem mais ou menos ruído. Os cetáceos são organismos marinhos que utilização vocalizações para comunicar, navegar, alimentar entre outras funções e consequentemente são bastante afetados pela poluição sonora no oceano, sendo por isso necessário perceber qual tipo de embarcação será a menos impactante possível, para a observação de cetáceos. A espécie mais frequentemente detetada nesta região foi o golfinho-comum (*Delphinus delphis*) da sub-ordem Odontoceti e a baleia anã (*Balaenoptera acutorostrata*) da sub-ordem Mysticeti. Este trabalho permitiu detetar lacunas e definir uma lista de estudos necessários para caracterizar a atividade de observação de cetáceos no sul de Portugal e uma lista de recomendações para que esta atividade em Portugal continental seja uma atividade compatível com a proteção das espécies alvo.

keywords Cetaceans, Whale-watching, Noise pollution, Sustainable management, Portugal.

abstract Whale-watching (WW), has evolved exponentially around the world, becoming an economically important activity for various regions. Several researchers debate whether or not this progression in the activity is another possible disturbance or even a threat to cetaceans with both positive and negative arguments. On the southern coast of the Algarve, the study area of this work, there has been an increase in the number of companies and vessels doing this activity. In this study, reports made by whale-watching companies between the years 2007 and 2021 were analysed (n=92), as well as their licensing forms (n=401). However, a survey directed at whale-watching companies was also developed during the present study, due to the low number of available reports. In order to characterise the activity and the fleet of this region, several parameters were considered, including vessel types, number of sightings, observed species, number of trips, number of passengers and possible direct income of this activity in this region. In the Algarve, the majority of boats are Rigid-Hulled Inflatable Boat (RHIB), between 5 to 10 meters-long with a passenger capacity of 10 to 16 people. Fleet characterization is extremely important since different types of boats produce more or less noise. Cetaceans use vocalizations to communicate, navigate, and feed among other functions and therefore they are affected by noise pollution in the ocean. Therefore, it is necessary to understand what vessel type is the impacting possible for whale-watching observations. Data from the companies' reports revealed that common dolphins (*Delphinus delphis*) are the most frequently detected Odontoceti and minke whales (*Balaenoptera acutorostrata*) are the most often observed Mysticeti. This work allowed the detection of gaps and the definition of a list of necessary studies to characterize the whale-watching activity in southern Portugal and a list of recommendations to make this activity in Portugal´s mainland compatible with the protection of the target species.

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1.Introduction

A global concern surrounds marine ecosystems, as the accelerating loss of biodiversity continues (IPBES, 2019). On a worldwide scale, human influences including pollution, overexploitation (Dulvy et al., 2003), climate change (Simmonds & Smith, 2009) and coastal development are leading to unprecedented consequences. In 2014, only 3% of the oceans were reported to be unaffected by human activities (García-Barón et al., 2020). Whale-watching (WW) is one of the many marine tourism activities that in some way interferes with the marine environment. It is therefore necessary to manage tourist interactions with marine mammals, which take place at a global, national and regional levels (Higham et al., 2014). In the latest years, the number of whale-watching companies in the Algarve has increased exponentially, and it keeps expanding every year (Castro, 2010). Consequently, the boating pressure has been considerably increasing in the coastal zones of larger cities, which can affect the cetacean populations occurring in the area (Castro, 2010; Laborde et al., 2011). Therefore, it is necessary to understand the evolution and the impacts of this activity over the years to effectively monitor and manage the whale-watching activity so that tourism is compatible with protecting cetacean populations on the southern coast of Portugal.

1.1 Whale-watching tourism

1.1.1 Worldwide

The perception of the importance of all-natural resources, such as marine resources, varies among user groups. Around 1986, when countries were questioning the outcomes of a worldwide ban on the industrial harvest of cetaceans, there was a shift and the era of nature-based tourism started, adding a different type of value to all cetaceans (de Oliveira, 2005).

The industry of marine tourism is described as “recreational activities that involve travel away from one’s place of residence and which have, as their host or focus, the marine environment” (Orams, 1999). These activities have mainly focused on marine mammals and other species like marine birds and sharks. Since these species are charismatic animals for most watchers, they can help teach people and promote attention for protecting marine fauna and their environment, although at the same time giving the possibility of short and long-term negative effects to the species that are being seen.

The definition of whale-watching according to Hoyt & Hvenegaard (2002) is any form of watching cetaceans in the wild on their habitat, including on boats, from land or even on small planes or aircrafts, as well as diving and swimming activities, in some places. Whale-watching can be commercial, opportunistic and research-driven or it can enclose all three forms simultaneously (Hoyt, 2009). Commercial whale-watching is the most common where tourists pay a specific amount of money to whale-watching companies depending on the countries for a guided trip to see cetaceans. Opportunistic whale-watching occurs when a trip is not particularly dedicated to watching cetaceans, but they are frequently seen and are probably mentioned in the business's marketing ideas (Parsons et al., 2006). Lastly, research whale-watching is conducted mainly only by researchers, but occasionally it can occur in combination with commercial whale watch companies (Hoyt & Hvenegaard, 2002). Whale-watching can also be separated into "commercial whale-watching" and "recreational whale-watching", because, in this last form, cetaceans are observed from personal vessels, unlike the commercial type already described above (Parsons et al., 2006). This distinction is also relevant because recreational observations are not managed or regulated and for that reason, the potential impacts may be unrecognised by stakeholders (Hoyt & Parsons, 2014). Whale-watching flourished out of the traditions of bird watching and other types of land-based wildlife watching. Nowadays, the best dolphin and whale tours include sightings of turtles, seals, seabirds and other marine wildlife making the whale-watching activity more appealing, enriching and educational to marine watchers (Hoyt, 2012). The very first commercial whale-watching trip happened in southern California in 1955. This tour was made by a local fisherman who charged $1 for some tourists to see gray whales (*Eschrichtius robustus*) (Hoyt, 2018). After this event, this industry started increasing and by the late 1980s, it was already around the globe, turning into an important economic and recreational activity. A world survey estimated the numbers of commercial whale-watching, and at this time it was thought that 4 million whale-watchers spent nearly 317.9 million dollars in 1991, with only 31 countries doing whale-watching and by 1994, the number went up to 5.4 million whale-watchers (Hoyt & Parsons, 2014). Since the early 1990s the growth rate increased 12% per year, which is much bigger than the overall tourism rate (3-4%) (Hoyt, 2001) and the total expenditures increased by 18.6% per year (Hoyt, 2001; Hoyt & Hvenegaard, 2002). In 1998, whale-watching was being offered in 87 countries by 492 different communities (Hoyt, 2001) and approximately 9 million tourists joined in whale-watching trips. In total, these excursions created a value of 299.5 million dollars in direct expenditures and over 1,049 million dollars in total expenditures (see Fig.1) (Hoyt & Hvenegaard, 2002). During the very high growth rate of whale-watching tourism, the lack of appropriate management measures created challenges and problems to the sustainability of the activity, which currently remains an issue of major concern. The next studies, ten years later in 2008, revealed that the whale-watchers numbers had risen to nearly 13 million people paying 2.1 billion dollars on tours in 119 different countries (see Fig.1) (Hoyt, 2001; O'Connor et al., 2009). Furthermore, it is also estimated that 3300 operators offer whale-watching tours around the globe, employing around 13 200 persons (Hoyt & Parsons, 2014).

Tourism Year	No. of whale watchers worldwide	Average Annual Growth Rate (%)	Direct Expenditure (millions $ USD) (a)	Total Expenditure (millions $ USD) (b)	Countries worldwide with whale watching	No. of whale watchers in Europe (c)
1981	400,000	—	$4.1	$14.0	c8	<1,000
1988	1,500,000	20.8	$11.0-16.0	$38.5-56.0	c25	<10,000
1991	4,046,957	39.2	$77.0	$317.9	c45	199,000
1994	5,425,506	10.3	$122.4	$504.3	65	605,000
1998	9,020,196	13.6	$299.5	$1,049.0	87	1,418,000
2008	12,977,218	3.7	$872.7	$2,113.1	119	1,439,000
2018	na	na	na	na	125+	est 1,800,000

(a) Direct expenditure = Cost of whale watching tour (ticket price).
(b) Total expenditure = The amount spent by tourists going whale watching from point of decision, including transport, food, accommodation, and souvenirs, as well as ticket price, but not including international air fares.
(c) Estimated numbers include Iceland, Canary Islands, Azores and Madeira
na not available

Figure 1. Estimated worldwide growth of whale-watching. Sources: Hoyt (2001) and O'Connor et al. (2009).

As in the rest of the world, in Europe, the growth of whale-watching has been high and in the past ten years, the estimated number of whale watchers went from 418 000 in 1998 to 830 000 in 2008, indicating an annual growth of 7.1%. As a result of the growth in the number of whale watchers, the direct expenditure, indirect expenditure, and the overall total expenditure has increased (O'Connor et al., 2009). This industry was estimated to be worth over a billion dollars a year (Hoyt, 2001; O'Connor et al., 2009) and is very important for various coastal communities where it is the main contributor of income and employment (Parsons et al., 2003). It has expanded from 8 countries in 1991 to 22 in 2008 doing whale-watching observations and the estimated total expenditure in this year was almost 100 million dollars (O'Connor et al., 2009). Scotland had the major proportion of Europe's whale-watching tourists with nearly 27%. Ireland and Iceland account for 14% each, Spain 9% and Portugal and Madeira accounted for 7% each. In economic terms, Iceland and Scotland contributed to the main proportion of Europe's whale-watching incomes with 17% and 19% correspondingly, followed by Ireland, Norway, Spain, Madeira, Azores and Portugal mainland with almost 8-9% each. Considering the Portuguese archipelagos Azores and Madeira together with the Portuguese mainland, the proportion rises to approximately 23% of the revenues, therefore representing one of the largest portions of whale-watching incomes in Europe (O'Connor et al., 2009).

In Europe, the most prominent type of cetacean whale-watching depends on the country. While large cetaceans are more easily observed in areas such as the coastal waters of Norway, Iceland and the Azores, small cetaceans such as dolphins, are easily observed in Portugal and Spain, for example (O'Connor et al., 2009). The initial whale-watching boat tours in Europe occurred in 1980s to see resident dolphins over Gibraltar. In the 1980s, boat-based whale-watching was increasingly directed towards large cetaceans starting up in Italy, Norway and Azores. Since then, dolphin and whale watching has increased steadily, spreading to all of Europe. Currently, these animals have considerable value to the European coastal communities, through education, research, income from tours and as symbols of a strong marine ecosystem which is important to local people and attractive to tourists (Hoyt, 2003). European cetacean watch tours are known for having a high standard, with attention to safety, research, conservation values and education. There is still room for improvement on many company tours. All around Europe, in general, the best season for watching cetaceans is between May and October (Hoyt, 2003).

1.1.2 In Portugal's mainland

In recent years, there has been an increasing awareness of the marine tourism and marine mammal resources value and how they can benefit local economy, as a result of a growing whale-watching industry. In Portugal, the industry of whale-watching began around the 1980s in Azores and Madeira (Hoyt, 2018). The whale-watching activity started in 1998 in Portugal's mainland, initially in the Sado estuary, because of the presence of a resident bottlenose dolphin population (Hoyt, 2001), which made the estuary one of the greatest places for dolphin watching on the mainland at that time (Castro et al., 2012). This industry had a slow start in 1998 and the number of whale watchers on the mainland was only 1380, but by 2008 the estimated number was over 58 000. In 2008, 11 companies accounted for a direct expenditure of approximately 1,815 million dollars and a total expenditure of 6,138 million dollars, turning into one of the very important maritime-touristic activities in Portugal (O'Connor et al., 2009). This demonstrates that, as predicted in the 2001 IFAW report by Erich Hoyt, Portugal's mainland has the potential for being a successful dolphin watching country. A specific law for the whale-watching companies in Portugal mainland was established only in 2006 - Decreto-Lei n. º 9/2006, meaning that in the previous years, this activity did not have any defined rules of good conduct for the activity (Castro et al., 2011).

At that time, the whale-watching companies in the Algarve coast or the Sado estuary only offered trips to see small cetaceans, because they are more abundant on the Portuguese mainland coast than large cetaceans. However, nowadays it is possible to see large cetaceans, for example, on the Algarve coast mainly the minke whale (Castro et al., 2021; Bastos-Santos et al., 2016) and the fin whale (Brito et al., 2009; Castro, 2010), but small cetaceans are still the most abundant and watched on the mainland coast. As mentioned above, most observations corresponded to dolphins in the Portuguese mainland up to 2008. On the south coast of Algarve, the most seen species are the short-beaked common dolphin and bottlenose dolphins (Castro et al., 2013, 2015; Cid et al., 2013; Laborde et al., 2011).

In the beginning, roughly part of the mainland's dolphin watching trips was offered by opportunistic operators, which blended whale-watching with other nature watching cruises. On the other hand, Portugal islands (Azores and Madeira) offered mainly dedicated dolphin and whale tours (O'Connor et al., 2009). The main regions of Portugal's mainland that do whale-watching tours are in Setúbal near Lisbon and on the south coast of Algarve, having departure points along the entire length of the coast. This region is a very known holiday spot for the Portuguese as for the rest of the Europeans. According to surveys gathered at that time, 40% of the dolphin watchers are foreign and 60% are Portuguese. In the Algarve, generally trips last from one and half hours to three hours and cost around $41 for an adult and $25 for a child. The main whale-watching season is between June and September and the mean estimated employment in that period of time is 71 persons (O'Connor et al., 2009).

1.2. Whale-watching problems and successes

The enormous growth in whale-watching over the years has emphasised the need for management and regulations for this activity, to combat the emergence of possible problems, especially in confined areas, where multiple companies can offer two to three daily tours. Under these conditions, there is a special need to consider some questions such as how many boats can be with the same group of marine mammals, how close they can approach, whether there is sufficient infrastructure for all visitors who go whale-watching, among many others. To guarantee all of these matters, there is the need to make effective regulations and guidelines and to promote their enforcement (Higham et al., 2014; Hoyt, 2018). With a growing number of people interested in these activities, as the industry developed, the number of dedicated whale-watching tours and vessels escalated leading to high densities of vessels around marine mammal groups in some locations. Even in areas with restrictions on the number of vessels near whales, once one vessel leaves, another one can easily replace it, resulting in the animals' continuous disturbance by vessels (Hoyt & Parsons, 2014).

The issue of vessel crowding in European waters first appeared in the Canary Islands during the 1980s and 1990s when there were over a hundred boats doing whale-watching trips in this area, some of them unregulated (Hoyt & Parsons, 2014). These unlicensed operators, many times used unrealistic advertisement photos, had loud music on board while watching the animals and generally had a bad code of conduct and no safety guides (Hoyt, 2012). Several NGOs (Non-Governmental Organizations) and the government in this region took measures and created workshops and training programmes for licensed operators, removed the unlicensed boats and enforced the regulations. In contrast, in other countries like New Zealand, to avoid some of these problems even before this activity started to expand, a restricted number of permits were issued. Every company has become a specialist in marine mammals and the renewal of permits depends on good practices, which will otherwise be revoked (Hoyt, 2018). For some time, South Africa did not allow boats to operate in the oceans, preferring to promote a land-based industry. Eventually, two permits per area were issued to whale-watching boats. In these areas where regulations are stricter, inevitably the activity becomes more sustainable because there is less competition between the existing companies as there are fewer of them and the impacts on the animals tend to be lower. Although there are many regions where licensing and regulations are on paper, in some of them compliance might be extremely low (Scarpaci et al., 2004) if unsuitable monitoring occurs.

With the expansion in the availability of boat-based whale-watching tours all over the world, land-based whale-watching (initially one of the main forms of marine tourism) has become less important in the whale-watching activity even though land-based observation had no direct impact on cetacean species. Some species of dolphins and whales have a predisposition to be curious about the vessels and to approach them and this tendency can lead to management problems, particularly when it is mandatory to keep a safe distance from the animals (Hoyt, 2003; Hoyt & Parsons, 2014).

Some recent studies have discovered short-term behavioural responses from dolphins and whales to the whale-watching vessels. The responses from the interaction with boats range from alterations in behaviour, like less time resting or longer time underwater, abrupt changes in direction and speed and even in socializing, vocalization patterns or foraging (Higham et al., 2014). Distinct species, individuals and populations can react differently to the same stimulus: some seem to not react at all, and others can have a massive response (New et al., 2015). Behavioural responses can as well be different according to the number of vessels, vessel type, type of engine and power and proximity of the approach. Noise pollution from operating vessels can cause problems to species that use sounds to communicate, forage, breed or navigate (Foote et al., 2004; Sousa-Lima & Clark, 2008). Comparing boat sizes, larger boats generally have more impact on the species as they are potentially louder and more difficult to manoeuvre. In addition to the impacts of larger boats, there has also been a preference by operators to acquire faster boats to get to the observation zones faster and to be able to transport more tourists per day (Hoyt & Parsons, 2014). Inevitably, boats travelling at higher speed are more likely to collide with cetaceans, because there is less time for the boat to manoeuvre or for the animal to dodge the boat in time. According to IWC (2005), whale-watching vessels who travel at more than 13 knots are at high-speed with potential impacts on marine mammals. In the case of the long-term negative impacts, the most prevalent is the decline in reproductive success of animals who were interacting with humans previously (Bejder et al., 2006; Higham et al., 2014; Lundquist, 2014; Williams et al., 2009).

Some marine mammal species are considered endangered or vulnerable in the IUCN Red List, and these particular groups perhaps should not be involved in whale-watching tours, except land-based whale-watching (Beasley et al., 2010). This proves that the "one size fits all" perspective when managing and implementing regulations for whale-watching activities is not an effective way to manage the industry. Since different species, individuals or populations living in different areas have different characteristics, managing them all in the same way might become ineffective and inappropriate (IWC, 2012). Additionally, some whale-watchers may have impractical expectations of what they will encounter when they book whale-watching trips, because of what is shown in the media or the tricks that whales and dolphins can make in captive cetacean facilities. In return, operators might be compelled to manoeuvre their vessels to get closer and satisfy their clients with effects on the animals observed in the wild (Orams, 2000). As a result, this has significant repercussions in terms of managing whale-watching as an ecological and sustainable activity (Hoyt & Parsons, 2014).

1.3. The ecological role of cetaceans in the ecosystems

Marine mammals come in a variety of types, shapes and sizes. Cetaceans (whales, dolphins, and porpoises) and pinnipeds (seals, sea lions, and walruses) are the two most seen and well-known groups of marine mammals. The Cetacea presently includes 89 living species divided into Mysticeti (baleen whales) and Odontoceti (toothed whales) (Perrin, 2022). Some cetaceans are very long-lived, such as the baleen whales, the larger toothed whales and some dolphins (O'Shea & Odell, 2008), like the killer whale, which can live till the age of 80 to 90 years in some cases. Cetaceans live in social groups for the most part. Although a few species are sometimes solitary, they occasionally congregate for breeding or feeding. Large whale pods are usually only a few dozen individuals, whereas marine dolphin schools can gather several thousands. In the Mysticeti group, there are four families of baleen whales. Some main characteristics of these species are the presence of baleen plates of keratin with fringes instead of teeth, the symmetrical skull and the double blowhole. These species usually appear in smaller groups than the majority of odontocetes and have a simpler social structure. Almost all Misticetes migrate over large distances during the year and are batch feeders that feed on small fishes and invertebrates (Carwardine, 2019). Odontocetes are considered small to medium-sized cetaceans, except for the sperm whale, which can measure 18 m. Toothed whales are characterized by the presence of teeth, an asymmetrical skull commonly with a concave shape, a single blowhole, the existence of a melon, an advanced system of nasal sacs and elevated nasal bones over the rostrum (Carwardine, 2019). Odontocetes mainly capture individual prey, which primarily comprises fish and cephalopods (Jefferson et al., 2015). Toothed whales and dolphins in particular, have incredible acoustic abilities, including the ability to learn about their surroundings through passive listening and a sophisticated sense of echolocation. Although the sense of hearing is supposedly the dominant on odontocetes, they also seem to have excellent vision (Ballance, 2018).

All species of cetaceans have very important ecological roles in the marine environment. Marine mammals were previously almost completely valued as goods to be taken from the ocean (meat, baleen whalebone, oil and spermaceti), although these days they have been progressively valued for the numerous ecosystem services they provide (Roman et al., 2014). Cetaceans can make key trophic influences on the marine environment and as well as act as ecosystem engineers (Jones & Gutierrez, 2007), influencing diversity, fluxes and making physical changes in the ocean environment. Cetaceans affect the marine ecosystems mainly in four ecological pathways, as prey, detritus, consumers and in nutrient vectors (Estes et al., 2011). The ecosystem function and structure are influenced by bottom-up (that directly involves the primary production and the energy transport up through the food webs) and top-down (where consumers affect their prey), and cetaceans are known for having an important role in both processes (Estes, 2006; Roman et al., 2014). Through their faecal matter, cetaceans emit iron, nitrogen, and other components to the marine environment. Since many cetaceans can feed in rather deep waters or travel between breeding and feeding areas, their faecal material represents an influx of nutrients that would otherwise be lost to the ecosystem (Ballance, 2018).

Whale carcasses sequester carbon to the deep-sea when they die and sometimes sink to the bottom and bring rare but essential food supply and habitat for deep-sea organisms (Roman et al., 2014). Cetaceans also host in their body a range of parasites or commensal organisms, which are entirely reliant on cetaceans during their whole life cycle. Additionally, other species benefit from cetaceans' ability to drive prey to the surface, by disorienting or injuring it (Obst & Hunt, 1990). Cetaceans are also very important as consumers since they consume tons of prey because of their massive high metabolic rates, body sizes, and positions as apex predators (Lascelles et al., 2014), which have ramifications for the establishment of marine ecosystems (García-Barón et al., 2020). Top-down control via cetacean predation appears to be a key structuring force for marine ecosystems, especially as larger whale populations recover after the massive commercial exploitation of the past (Pitman et al., 2015).

1.4. Cetacean species found on the south coast of Algarve

In all the Portugal's mainland coast, there are already records of the presence of 28 different species of cetaceans, 21 Odontoceti and 7 Mysticeti (Vingada & Eira, 2018). The Algarve is considered one of the most important in the country to observe marine mammals, where prior records (sightings and strandings information) reported the occurrence of 12 cetacean species (Sequeira et al., 1996). However, data from stranded cetaceans have already revealed the occurrence of 22 species in the Algarve coast (RAAlg, 2021) adding another 10 species since Sequeira (1996). All species that occurred till the end of 2021 on the south coast of the Algarve are the short-beaked common dolphin (*Delphinus delphis*), bottlenose dolphin (*Tursiops truncatus*), harbour porpoise (*Phocoena phocoena*), risso's dolphin (*Grampus griseus*), striped dolphin (*Stenella coeruleoalba*), atlantic spotted dolphin (*Stenella frontalis*), sperm whale (*Physeter macrocephalus*), long-finned pilot whale (*Globicephala melas*), short-finned pilot whale (*Globicephala macrorhynchus*), killer whale (*Orcinus orca*), false killer whale (*Pseudorca crassidens*), cuvier's beaked whale (*Ziphius cavirostris*), sowerby's beaked whale (*Mesoplodon bidens*), true's beaked whale (*Mesoplodon mirus*), dwarf sperm whale (*Kogia sima*), pigmy sperm whale (*Kogia breviceps*), minke whale (*Balaenoptera* *acutorostrata*), sei whale (*Balaenoptera borealis*), fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), blue whale (*Balaenoptera musculus*) (RAAlg, 2021) and lastly only in 2021 a bryde's whale (*Balaenoptera edeni*) was sighted for the first time in the south coast of the Algarve by a local portuguese non-governmental and non-profit organisation called AIMM (see Fig.2 and Fig.3) (Castro et al., 2021).

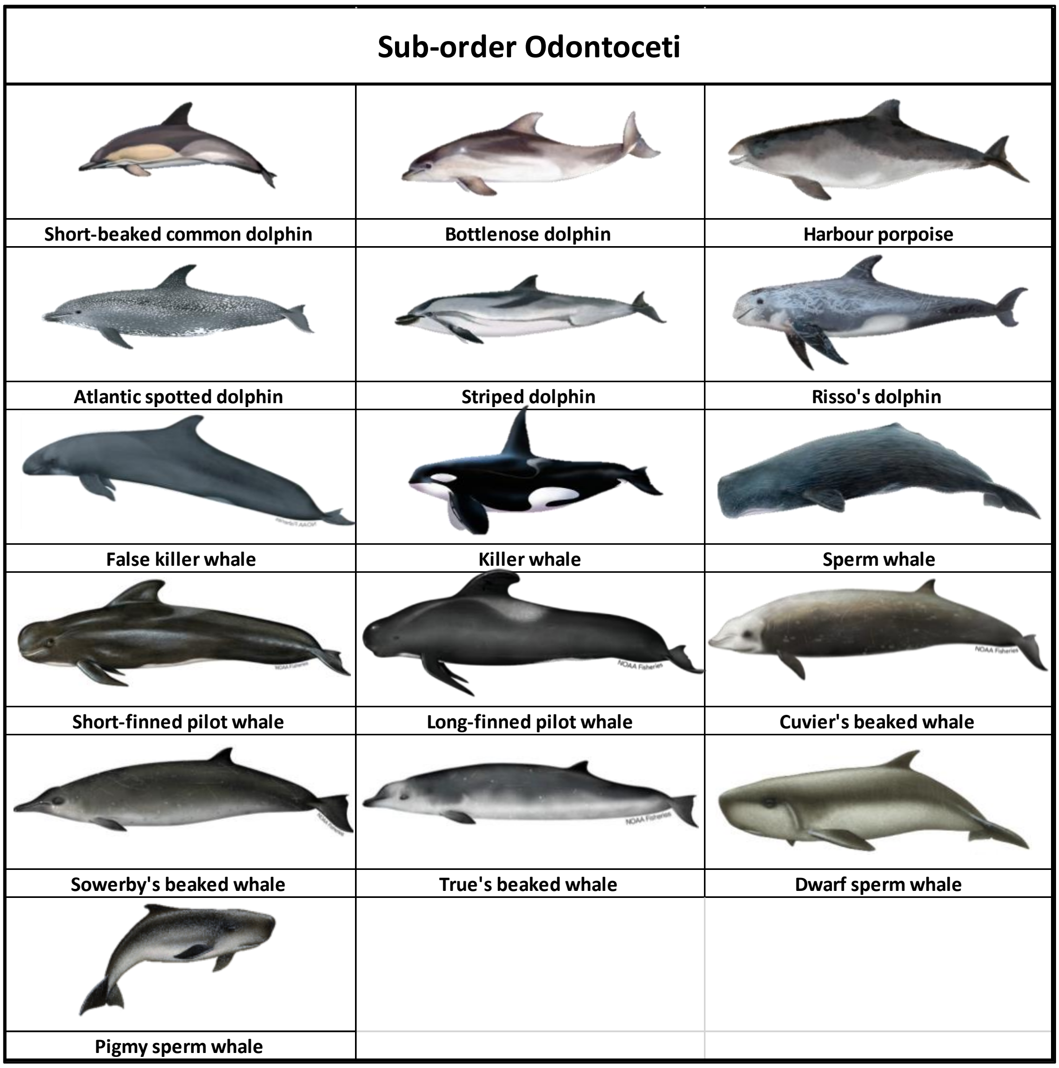


Figure 2. Illustrations of all species recorded on the south coast of Algarve belonging to the sub-order Odontoceti. All illustrations are not in scale. Illustrations source: Short-beaked common dolphin (© Tokio Illustration); Bottlenose dolphin (© Tokio Illustration); Harbour porpoise (© Tokio Illustration); Atlantic spotted dolphin (© Uko Gorter Illustration); Striped dolphin (© Tokio Illustration); Risso´s dolphin (© Tokio Illustration); Killer whale (© Tokio Illustration); Sperm whale (© 2017 - 2022 PNG Arts); Short-finned pilot whale (© NOAA Fisheries); Long-finned pilot whale (© NOAA Fisheries); Cuvier's beaked whale (© NOAA Fisheries); Sowerby's beaked whale (© NOAA Fisheries); True's beaked whale (© NOAA Fisheries); False killer whale (© NOAA Fisheries); Dwarf sperm whale (© WÜRTZ-Artescienza 1995); pigmy sperm whale (© WÜRTZ-Artescienza 1995).

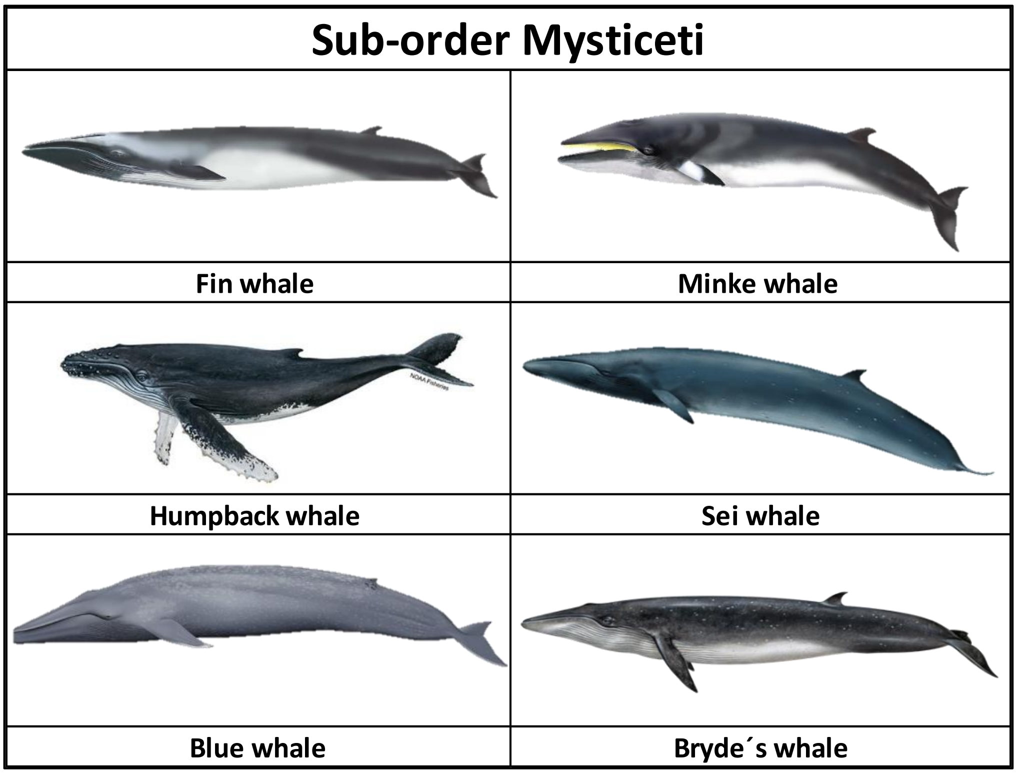


Figure 3. Illustrations of all species recorded on the south coast of Algarve belonging to the sub-order Mysticeti. All illustrations are not in scale. Illustrations source: Fin whale (© Tokio Illustration); Minke whale (© Tokio Illustration); Humpback whale (© NOAA Fisheries); Sei whale (© NOAA Fisheries); Blue whale (© Uko Gorter Illustration); Bryde´s whale (© NOAA Fisheries).

Considering Odontoceti and Mysticeti, whereas the short-beaked common dolphin (*Delphinus delphis*) is the main target Odontoceti species for the whale-watching vessels throughout the coast, the minke whale (*Balaenoptera acutorostrata*) is the most frequently observed Mysticeti species on the Algarve (Castro et al., 2013, 2021; Laborde et al., 2015; Bastos-Santos et al., 2016). The short-beaked common dolphin is a small cetacean species that belongs to class Mammalia, infraorder Cetacea, superfamily Odontoceti and family Delphinidae (WORMS, 2022). This is one the most frequent and widely distributed cetaceans, inhabiting all subtropical, tropical and temperate waters (Evans, 1982), from 40–60°N to 50°S (Bearzi et al., 2003) and it is very abundant in the Iberian coast. *D. delphis* appears generally over the continental shelf, from 100m to 200m depths, or around spots including prominent bottom topographic features (Silva, 1999). Their morphology includes a beak, which is demarcated from the melon, a high and slightly falcated dorsal fin, the presence of a single hourglass colour pattern with a more yellowish thoracic patch. In terms of weight and size, in males, the most common sizes range from 172 to 201cm and in females from 164 to 193cm although older adults can be even larger. About the weight, it can reach 200kg (Evans, 1994; Rice, 1998). Gestation in this species is estimated to be between 10 and 11.7 months and the calf length at birth is 80 to 93cm (Danil & Chivers, 2007). Females reach sexual maturity at around 6-8 years of age and males at 7-12 years. The estimated maximum longevity for both sexes is approximately 30 years (Perrin, 2009). The abundance and distribution between regions around the globe change accordingly with the variations of the oceanographic conditions. For example, around the Mediterranean area, this species favours coastal and upper slope waters (Bearzi et al., 2003). Since *D. delphis* occupies a wide range of habitats, they have a diversified diet and prey mostly upon pelagic species, including cephalopods and small fishes and epipelagic species such as clupeoids and small scombroids (Pusineri et al., 2007). However, individuals are able to adapt their diet depending on the geographical areas and seasonal oscillations in prey distribution and abundance (Castro et al., 2020). Overall, on the Portuguese coast, according to the study of Silva (1999), sardine (*Sardina pilchardus*) was the most significant prey in the sample under study. This species has been seen in association with other cetaceans like pilot whales (*Globicephala spp*.) and other Odontoceti species (e.g., *Stenella coeruleoalba, Lagenorhynchus spp., Grampus griseus*) and Mysticete whales (Perrin, 2009).

The minke whale is the shortest rorqual and the second smallest of the family Balaenopteridae. It has 3 different known populations, in the Southern hemisphere and in the North Pacific and Atlantic (Perrin et al., 2018). This species' length ranges between 7.5 to 8.5 meters and their body mass as adults vary from 6 to 8 tons. Their body is usually white in the ventral zone and blackish in the upperside, with a unique white band on the flippers, and a falcate dorsal fin approximately two-thirds of the distance down the back (Carwardine, 2019). They have between 270–325 fringed baleen plates in each row instead of teeth and the rostrum is V-shaped and narrow, with a single longitudinal ridge. The females reach their sexual maturity between the ages of 6 to 8 years and the males between 5 to 8 years. The gestation time is 10 to 11 months, and the calf is born with a length between 2.2 to 2.8 meters and a weight of 350 to 450kg (Carwardine, 2019). This species feeds on different organisms depending on their availability, season and locality. They range from krill, small schooling fish, and plankton (Perrin et al., 2018). Generally, they are found solitary or in small groups of individuals (Carwardine, 2019). The maximum depth of the dives is between 20 to 40 meters for 3 to 10 minutes and a maximum of 20 minutes. The estimated population number in the area of the Northeast Atlantic is about 81 000 individuals (Perrin et al., 2018).

1.5. Cetacean conservation and threats

At least a quarter of the world's cetaceans have lately been identified as endangered, and the situation could deteriorate further as the status of many others is unknown. The consideration of a species or population status creates, rushes, or otherwise modifies the conservation effort, and the IUCN's 'Red List' is usually considered as the recognized source of such information. There are several categories ranging from 'Critically Endangered' to “Least concern”, as well as a “Data Deficient” category, meaning that there is not sufficient information to classify some species. Depending on the considered cetaceans species distribution range, four species are currently listed as “Critically Endangered,” eleven as “Endangered”, seven as “Vulnerable”, ten as “Near Threatened” and forty-nine as “Least concern”. Also, at least nine species are considered as “Data Deficient” (IUCN, 2021). When looking at the species found on the south coast of the Algarve till now, they have different conservation statuses and one of them (the killer whale from the strait of Gibraltar subpopulation) seems to be critically endangered, according to the IUCN Red List. Two species are listed as “Endangered”, and another two as “Vulnerable” and “Near Threatened”, however most species are classified as “Least concern” (Table I.).

Table I. Species recorded on the south coast of the Algarve distributed by the different categories in which they are listed in the IUCN Red List.

Species	IUCN categories	Distribution	Reference
Balaenoptera borealis	Endangered	Global	Cooke, 2018
Balaenoptera musculus	Endangered	Global	Cooke, 2018
Physeter macrocephalus	Vulnerable	Europe	IUCN SSC Cetacean Specialist Group 2007
Balaenoptera physalus	Near threatened	Europe	IUCN SSC Cetacean Specialist Group 2007
Balaenoptera edeni	Least concern	Global	Cooke & Brownell, 2018
Delphinus delphis	Least concern	Global	Braulik et al., 2021
Tursiops truncatus	Least concern	Global	Wells et al., 2019
Phocoena phocoena	Vulnerable	Europe	IUCN SSC Cetacean Specialist Group 2007
Grampus griseus	Least concern	Global	Kiszka & Braulik, 2018
Stenella coeruleoalba	Least concern	Global	Braulik, 2019

Stenella frontalis	Least concern	Global	Braulik & Jefferson, 2018
Globicephala melas	Least concern	Global	Minton et al., 2018
Globicephala macrorhynchus	Least concern	Global	Minton et al., 2018
Balaenoptera acutorostrata	Least concern	Europe	IUCN SSC Cetacean Specialist Group 2007
Megaptera novaeangliae	Least concern	Europe	IUCN SSC Cetacean Specialist Group 2007
Orcinus orca	Critically Endangered	Strait of Gibraltar subpopulation	Esteban & Foote, 2019
Kogia sima	Least concern	Global	Kiszka & Braulik, 2020
Kogia breviceps	Least concern	Global	Kiszka & Braulik, 2020
Ziphius cavirostris	Least concern	Global	Baird et al., 2020
Mesoplodon bidens	Least concern	Global	Pitman & Brownell Jr, 2020
Pseudorca crassidens	Near threatened	Global	Baird et al., 2018
Mesoplodon mirus	Least concern	Global	Pitman & Brownell Jr, 2020

Marine mammal welfare has been a major issue in recent years when it comes to captive species (De Vere et al., 2018). However, over the years, human activities have caused adverse effects and environmental changes on the marine environment, which have been affecting marine mammal populations in the wild (Garcia-Baron et al., 2019). Welfare can be defined as an animal's coping condition, which includes their health (Broom & Fraser, 2007), pain, suffering status and physiological stress, as well as their exposure to harmful psychological states (De Vere et al., 2018). Cetaceans are more vulnerable to several of these anthropogenic pressures due to their long life spans, late maturity, and high position in the food chain (Fair & Becker, 2000). Furthermore, cetacean's exceptional cognitive and communication abilities (Marino et al., 2007), as well as the strength and quality of their social bonds, indicate that they have a robust and refined sensibility, as well as a potential for distress and pleasure. Among all the threats, IWC has shown a particular concern with entanglement, collisions by ship strikes, strandings, marine contaminants and the possibilities of short and long-term impacts of the whale-watching activity (De Vere et al., 2018). Firstly, approximately 300 000 whales and dolphins die each year as a result of entanglement in fishing gear, with others becoming entangled in various types of marine debris (Nicol et al., 2020).

Bycatch, one of the most serious conflicts between the fishing industry and marine mammals, is the unintended capture of non-target species. Bycatch was estimated to capture over 600 000 marine mammals per year in the 1990s worldwide, with the majority caught and asphyxiated in gill-net fishing (Read et al., 2006).

Marine debris has an impact on about 300 species worldwide, primarily through ingestion and/or entanglement. Exhaustion, malnutrition, asphyxiation, and severe sores and infections can all result from becoming entangled in marine debris, which includes discarded fishing gear and plastic packaging (Baulch & Perry, 2014). In terms of the frequency of occurrence, entanglement in marine debris seems to be a more critical threat than ingestion. Approximately half of all known incidents of cetaceans ingesting debris involved plastic pollution (Baulch & Perry, 2014). Plastic, unlike other forms of pollution, has the potential to harm animals regardless of its concentration in the ecosystem (Laist, 1997), with even little amounts of ingested plastic, which can turn into significant detrimental consequences (Jacobsen et al., 2010). Internal damage, chemical exposure, malnutrition and hunger, sickness, and reproductive failure are all potential consequences in the case of ingesting macroplastics (De Vere et al., 2018). Entanglement-related deaths include choking to death from a plastic packing band around the neck, becoming entangled in fishing nets and suffocating underwater, and dying from emaciation as a result of pulling fishing gear (Kemper & Gibbs, 2001).

Marine mammal-vessel collisions have been documented since the late 1800s, but the number of crashes did not grow significantly until the increase in speed of the boats and the overall number of vessels grew rapidly after 1950s (Laist et al., 2001). Collisions with vessels 80 meters or longer, or vessels travelling at 13 knots or faster, are responsible for the majority of fatalities and serious injuries (Carrillo & Ritter, 2010). Some of the small lesions already verified are scarring, blood loss, small wounds and infections, as major injuries include severe blood loss, shattered bones, deep tissue injury, and full extremity separation that are generally deemed fatal (Campbell-Malone et al., 2008). Apart from collisions, boats can affect species in other ways, via active vessel harassment and passive traffic (Pirotta et al., 2015). This may occur in cetaceans that are exposed to recreational, commercial, and tourism vessel activities. Some of the most predominant short-term effects (already addressed in chapter 1.2) include reduced foraging, socializing, resting and variations in breathing patterns (De Vere et al., 2018).

According to the data on strandings in the Algarve between October of 2020 and October of 2021 from RAAlg (Rede de Arrojamentos do Algarve), there were 72 stranded animals corresponding to 9 different species including the common dolphin presenting the highest frequency of occurrence. In relation to the cause of death, 23% was considered as death from by-catch and 20% as possible by-catch. Followed by 11% of deaths by trauma/collision, 6% by trauma/attack from another cetacean species and 3% as of a disease. However, 37% of stranded animals were not examined or it was not possible to determine their cause of death, suggesting that the percentages described above for each cause of death, may be higher than those mentioned (RAAlg, 2021).

Anthropogenic noise is another major threat to cetaceans. Because marine mammals depend on acoustic communication for a variety of reasons (i.e., location navigation, reproduction, foraging, and social interactions) (Wright et al., 2007), increased anthropogenic noise exposure will have a negative impact on these functions (Clark et al., 2009) because clarity and range of acoustic signals received and sent when communicating, can be reduced (Wright et al., 2007). A growing number of sound sources are being introduced into the ocean, all of which have the potential to influence marine animal species. Some examples are navy sonar, vessel/shipping traffic, pile driving and seismic air gun activity (Merchant et al., 2015). This wide range of interfering noises in the marine environment can contribute to cetaceans modifying their acoustic signals, depending on the sensibility of the different species (De Vere et al., 2018).

In comparison to the other anthropogenic impacts outlined above, the effects of climate change on cetaceans have received less attention from researchers and the general public. Perhaps this is since climate change causes a variety of modifications that vary by geographic area and can have a wide range of effects on different species. Climate change could cause changes in trophic interactions, prey abundance and distributions, migration range and timing, survival, community structure, and reproductive success according to the researchers (Simmonds & Eliott, 2009). Prey availability is particularly important in controlling the distribution of marine mammals (Learmonth et al., 2006). Climate changes lead to shifts in prey availability and distribution, which bring in consequence nutritional deficiencies and sometimes starvation for some species (Leaper et al., 2006). Rises in sea surface temperatures (SSTs) and ice cap melting can result in a variety of problems, including strandings, poor health, enhanced vulnerability to diseases, malnutrition, and overall increased susceptibility to human threats (Ragen et al., 2008).

1.6. Ecotourism: sustainability and local communities

A well-managed whale-watching activity implies a government policy that protects cetaceans and their environment, as well as the enforcement and a regulatory system that controls the number of operators involved in the industry of marine tourism, the number of vessels on the water, the number of hours spent with the cetaceans and also the proximity of their approach (Higham et al., 2014; Hoyt, 2012). To minimize the possibility of adverse impacts, Hoyt (2018) suggested measures such as to reduce by one-third the area dedicated and make one-third of the daylight hours off from every tourism activity. Also, the pressure generated by multiple small boats with outboard engines can be reduced by watching whales from a large, relatively silent ship. To ensure that this activity remains sustainable it is also essential that managers promote education about the oceans and cetaceans not only to all operators but also to passengers and recreational boat operators. The role of biologists and naturalists, who are the face of whale-watching tours, is critical to teaching, particularly aboard tour boats (Hoyt, 2012). Whale-watching tourism must follow the ideals of watching without disrupting the natural behaviour of the animals and leaving the smallest footprint, which is seen in land-based watching, like birdwatching (Hoyt, 2018).

Whale-watching is frequently described as a form of “ecotourism”, but not all the whale-watching activities could be classified as ecotourism. According to Fennell (1999), “Ecotourism is a sustainable form of natural resource-based tourism that focuses primarily on experiencing and learning about nature, and which is ethically managed to be low-impact, non-consumptive, and locally oriented (control, benefits, and scale). It typically occurs in natural areas and should contribute to the conservation or preservation of such areas.” Given this definition, ecotourism is defined as a type of tourism that is deliberately geared to lessen its environmental impacts, encourages conservation and includes the participation and involvement of the local population. “Whale ecotourism”, according to the IWC (International Whaling Commission), is a commercial whale-watching operator that tries to reduce its environmental impact as much as possible; follows whale-watching guidelines or regulations for the area; gives to the clients accurate and educational lectures about the cetaceans seen and their habitat; contribute to the conservation of the marine environment on a regular basis, by helping research groups or permitting scientists to use their boats as platforms of opportunity and benefit the local host community in some way, by supporting other local businesses or projects and providing employment to locals (Parsons et al., 2006). Although these features were designed for commercial whale-watching in a vessel, they can easily be applied to land-based whale-watching or cetacean-themed museums. Encouraging all the commercial whale-watching businesses to become whale-ecotourism companies, to minimize the impact of whale-watching on cetaceans and increase the economic benefits at a local level, will ultimately support the industry's sustainability (Hoyt & Parsons, 2014). Whale-watching has a lot to offer in terms of scientific research, conservation, education and financial profit, but it can only have a long-term future in Europe if it is done responsibly and sustainably (Hoyt, 2018).

1.7. Objectives

This work was developed under the “Chapter 6. - Evaluation of whale-watching” of the project META (Marine mammal and Ecosystem: Anthropogenic Threat Assessment). This is a two-year project funded by the Portuguese Republic through Fundo Azul, coordinated by the Madeira Whale Museum (MWM), and with partners in Azores from the Institute of Marine Research (IMAR), Lisbon from Instituto Gulbenkian de Ciência (IGC) and Sagres from Mar Ilimitado. The objective of META is to study how human threats affect populations of resident cetaceans, so that proper management measures can be applied.

The overall goal of the present work was to describe the operation, analyse its evolution, and to estimate the direct income of the activity to provide the first insights into the socioeconomic impact of WW in the Algarve. To achieve that goal, the following specific objectives were defined:

1. gather as much information as possible about departing harbours, the number of registered boats and the fleet characteristics between the years 2008 and 2021 and try to understand the seasonality of the operations;
2. gather information on the number of tours, passengers and sightings per year to determine which species are observed by the whale-watchers and which are more prevalent on the coast and also estimate the direct income of the activity in this area;
3. to identify the data still lacking to establish, in the future, a framework to advise on the evaluation of the carrying capacity for the Algarve in order to guarantee a sustainable level of the activity in the region.

2. Methodology

2.1. Characterization of the study site

The south coast of Portugal, better known as the Algarve, contains around 160 km of coast, from Sagres to the Guadiana river mouth (Dias, 1988) (see Fig.4). It has 16 municipalities but only 11 municipalities are in contact with the shore and the sea. The resident population of Algarve is 438 864 inhabitants (Statistics Portugal, 2018). Tourism is a major economic activity of income. In the year 2018, almost 5 million tourists visited Algarve making almost 21 million overnight stays in total (Statistics Portugal, 2018), turning this into a major popular tourist destination in Portugal and even in Europe (Frank, 2014). A part of this tourism is considered ecotourism, which is very predominant, being that whale-watching is one of the many activities that take place in the Algarve (Laborde et al., 2012).

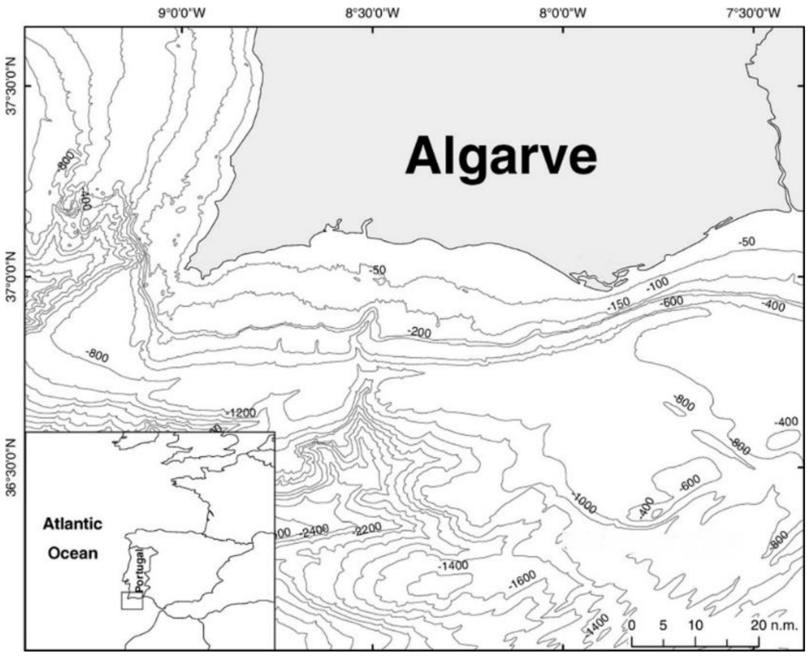


Figure 4. Map of the south coast of Portugal (Algarve).
Source: Veiga et al. (2011).

The Algarve is distinguished by two different types of coastline: the western (Barlavento/Windward) with cliffs along the coastline, and the eastern (Sotavento/Leeward) with sandy beaches (Dias, 1988). The windward area contains the coastal strip of the municipalities of Vila do Bispo, Lagos, Portimão, Lagoa, Silves, and Albufeira and the leeward comprises the municipalities of Loulé, Faro, Olhão, Tavira and Vila Real de Santo António (see Fig.5). There are discrepancies in the species abundances and diversity of the two locations, which are related to the two different types of bottom (Dias, 1988). In addition, the two Algarve regions have differing wind patterns in terms of direction and frequency. The southwest winds are predominant in these regions, both in terms of frequency and speed, while the southeast and northwest winds are of moderate strength (Borges et al., 1997).

Figure 5. Map of the south coast of Portugal (Algarve), divided in windward and leeward. Source: https://opontodepartida.com/algarve-o-que-visitar/

Some characteristics of the south coast of Portugal are the low variations in the water pH and salinity, the presence of a very short continental platform and weak currents overall (Magalhães, 2001). Another characteristic is the presence of oceanic trenches and submarine canyons (Lopes & Cunha, 2010), where the most relevant ones are present in Lagos, Portimão, Albufeira and the Cape São Vicente (Castro, 2010). Although this coast is situated in the Atlantic ocean, the climate around here is the semi-Mediterranean type with a hot long summer and a short, moderated winter (Da Costa, 2015). The average temperature in the winter season is 12ºC and 25ºC in the summer and the average around all year is 18ºC (Frank, 2014). Specifically, in the study area, there are two marine protected areas included in the National Network of Protected Areas, that belong to the Rede Natura 2000 (Da Cunha Simões, 2018). One of them is Sudoeste Alentejano e Costa Vicentina Natural Park which begins in São Torpes and ends in Burgau near Vila do Bispo and therefore still belongs to the study area (ICNF,2022). Another area is the Natura 2000 site SCI Costa Sudoeste (Sites designated under the Habitats Directive) code PTCON0012. The Ria Formosa Natural Park and the Ria Formosa/Castro Marim Natura 2000 SCI (PTCON0013), that include a wetland with very abundant biodiversity and wildlife, intersecting five municipalities (Olhão, Tavira, Faro, Loulé and Vila Real de Santo António) (Amaral, 2009).

With all the features mentioned above about the south coast, it is possible to perceive that this area has extremely rich ecosystems with unique biodiversity, which attracts even more tourists and nature enthusiasts every year.

2.2. Data collection

2.2.1. ICNF data

As a starting point, all historical data available from licensed whale-watching operators was compiled to understand the evolution and characterize the whale-watching activity in Algarve between 2008 and 2021. These records were requested to the Instituto da Conservação da Natureza e das Florestas (ICNF). All the whale-watching companies in Portugal have to apply for licenses to ICNF to make touristic observations of cetaceans in the sea. When approved, these licenses last for 3 years and after that, they have to be renewed if they want to continue with the activity. The data gathered included departing harbours, the number of registered boats and the fleet characteristics between the years 2008 and 2021 on the south coast of Algarve. Both licence requests and yearly reports delivered by whale-watching companies were analysed to understand the seasonality of the operations, the number of tours, passengers and sightings per year, species observed by the whale-watchers, and which are more prevalent on the coast.

Regarding the characterization of the recreational fleet of WW boats operating nowadays in the Algarve, it was evaluated the overall lengths, passenger capacity, location/presence of a motor and the type of classification (Fiberglass catamaran, Fiberglass single-hull, Semi-rigid single-hull, Sailing catamaran and Sailing single-hull) of all the vessels. Data to classify all the vessels, was retrieved from the documentation and licenses approvals of each, which were also provided by the ICNF. However, the ICNF did not have all the documents of the vessels in its possession and therefore some of the information collected for this part of the project was taken from photographs on the companies' websites and social networks although some information was still lacking.

2.2.2. Surveys to whale-watching companies

Since information on several parameters had not been reported to the ICNF by whale-watching companies it was not possible to determine all the direct income of the whale-watching activity in the Algarve. To overcome this gap, a survey was designed for all companies operating between 2018 and 2021 aiming at assessing the direct income from the activity. Surveys are one of the most used techniques in tourism research (Da Costa, 2015). A survey was initially planned to cover the period between 2008 and 2021. However, since a lot of information had not been reported to the ICNF and many companies are no longer operating or do not have data from earlier years, we tried to simplify in order to get the highest adhesion possible, and the questionnaires focused on a more recent period, between 2018 and 2021. This shorter but recent period allowed estimating the direct income from the activity and enabled companies to provide more accurate information.

Although initially planned to make in person, due to the covid19 pandemic restrictions, the survey for the companies was conducted online. An email was sent to all companies, explaining what the project consisted of and for what the information was required. There was the option to answer the survey anonymously and confidentially by uploading their answers to a folder on Google Drive or by responding directly to the email sent with the document attached (see annex A).

2.3. Data analysis

Firstly, the data regarding licenses were analysed, to try to understand how many companies there were operating from the year 2008 to 2021 and how many each year. As well as the number of vessels presents in each company, per year. Next, a distinction was also made between the number of companies present in each municipality along the Algarve coast to try to understand in which areas this activity is more present. Finally, concerning the data of the licenses, it was also made the distinction of the number of companies present in the Barlavento and Sotavento zones of Portugal. Together with the licences' information, documents about the vessels of each company concerning the hull type, vessel type, propulsion, length and passenger capacity were also analysed. Unfortunately, there were some data about some vessels that were not present in these documents, so the analysis was made based on what was known.

With all the compiled information from the reports (number of WW registered boats, number of trips, number of passengers, ticket price) and with the answers to the surveys, the goal was to estimate the direct income of the activity. However, in addition to the lack of data from the reports as mentioned before, only 4 companies answered the survey and so the situation remained the same. So, it was only possible to estimate the direct income of the companies that actually sent the report or answered the survey for the period between 2018 and 2021 (2018 - 13 companies, 2019 – 9 companies, 2020 – 7 companies and 2021 – 5 companies). None of the companies reported the average price ticket per year for adults and children. These values were crucial to assess the activity's direct income. According to O'Connor et al. (2009), in the year 2008 the average price of these trips per adult was 41 dollars in Portugal mainland, which is approximately 41 euros. Therefore, we used the same value to calculate the activity's direct income. Although this value corresponded to the estimated average price for the year 2008, it is still quite similar to what is currently practiced prices.

3. Results

3.1. Evaluation and characterization of the whale-watching activity in the Algarve

The total number of whale-watching companies and the number of boats registered during the period between 2008 and 2021 in the Algarve are expressed in Fig.6. The number of companies and the number of vessels operating in the Algarve increased consistently throughout the years. In 2008 there were only 7 companies of WW with 12 vessels, and in 2021 registers revealed 59 companies and 139 vessels. Looking at the trend lines and r values, the pattern for both the number of companies and number of boats reveals an increase in this period of time.

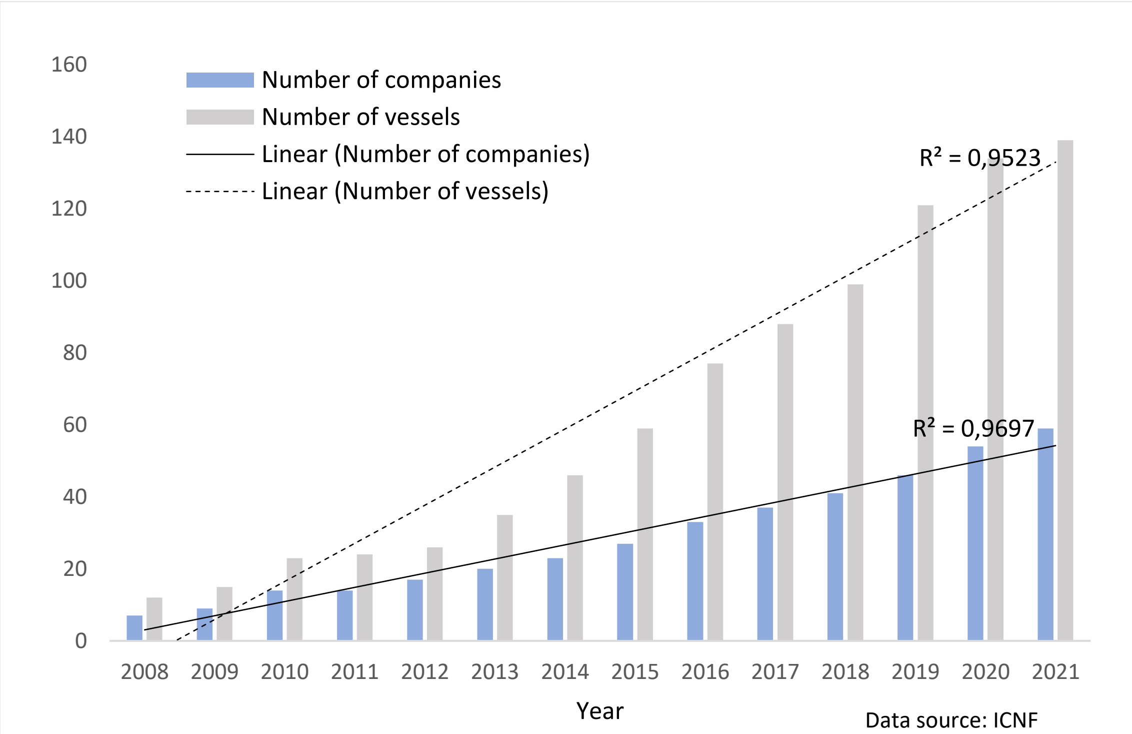


Figure 6. Number of licensed whale-watching companies and vessels in each year, from 2008 to 2021, on the southern coast of the Algarve. Data source: ICNF

Along the south coast of the Algarve there are infrastructures and departing harbours in all municipalities, where the companies are based and operating near that area. Municipalities with recreational boating facilities include Albufeira, Faro, Lagoa, Lagos, Loulé, Olhão, Portimão, Silves, Tavira and Vila do Bispo, with a total of 4 marinas e 7 harbours/docks, along with other small nautical support facilities (DSDR, 2008). The number of whale-watching companies and vessels licenced in 2008 and 2021 were distributed between the municipalities where the companies have their head office and operations. As shown in Table II, in the year 2008 there were 7 companies in the Algarve divided only into 3 municipalities and in 2021 there were 59 companies spread through 10 municipalities.

Table II. Total number of whale-watching companies and vessels in 2008 and 2021, in the Municipalities of Algarve. Data source: ICNF

	Municipalities	Number of companies	Number of vessels
2008	Albufeira	1	1
	Lagos	3	5
	Loulé	3	6
	Total	7	12
2021	Albufeira	8	27
	Faro	4	5
	Lagoa	3	7
	Lagos	12	20
	Loulé	6	17
	Olhão	10	28
	Portimão	4	8
	Silves	4	6
	Tavira	3	9
	Vila do Bispo	5	12
	Total	59	139

In 2008, WW companies concentrated in Lagos and Loulé municipalities with 43% each, while Albufeira had only 14% (see Fig.7A). To this day, in 2021 the reality is completely different because the number of companies increased and is more evenly distributed in all the municipalities of the Algarve. The regions with higher percentage of companies are Lagos (20%), Olhão (17%), Albufeira (14%) and Loulé (10%) and with the lower percentage are Portimão (7%), Faro (7%), Silves (7%), Tavira (5%) and Lagoa (5%) (see Fig.7B).

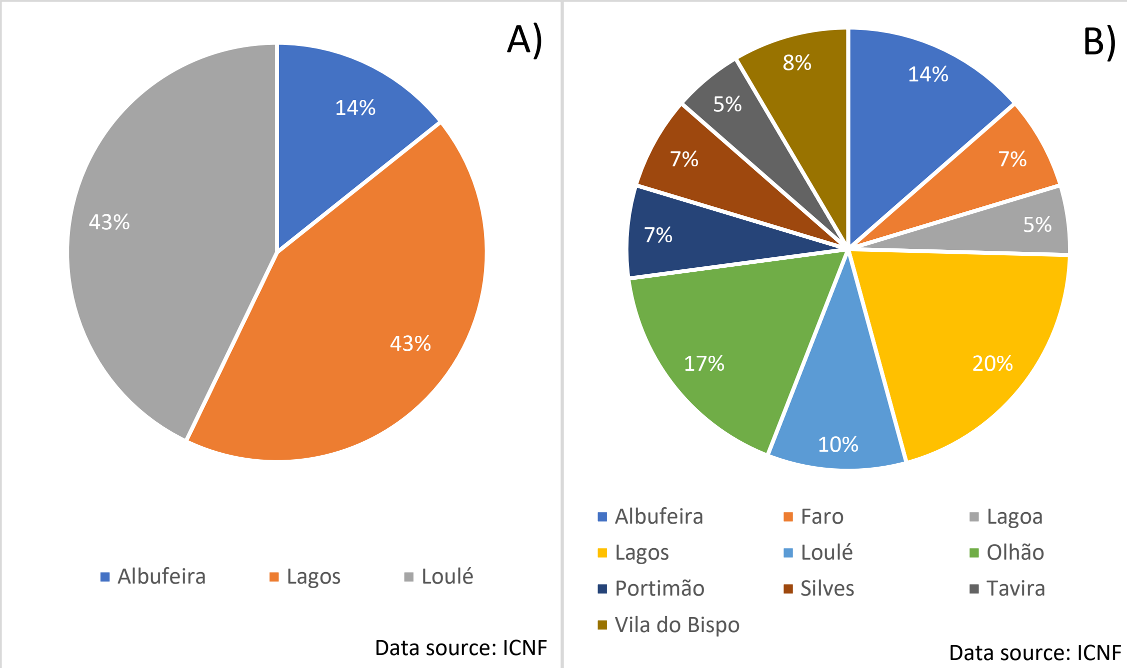


Figure 7. A) Distribution of the companies licenced in the year 2008 by municipality on the south coast of Algarve. B) Distribution of the companies licenced in the year 2021 by municipality on the south coast of Algarve. Data source: ICNF

In 2021, there were 36 companies in the windward area with a total of 80 vessels and 23 companies with 59 vessels in the leeward area. The results evidence that there are more companies and consequently vessels in the windward region of the Algarve, however, the difference is not substantial (see Fig.8).

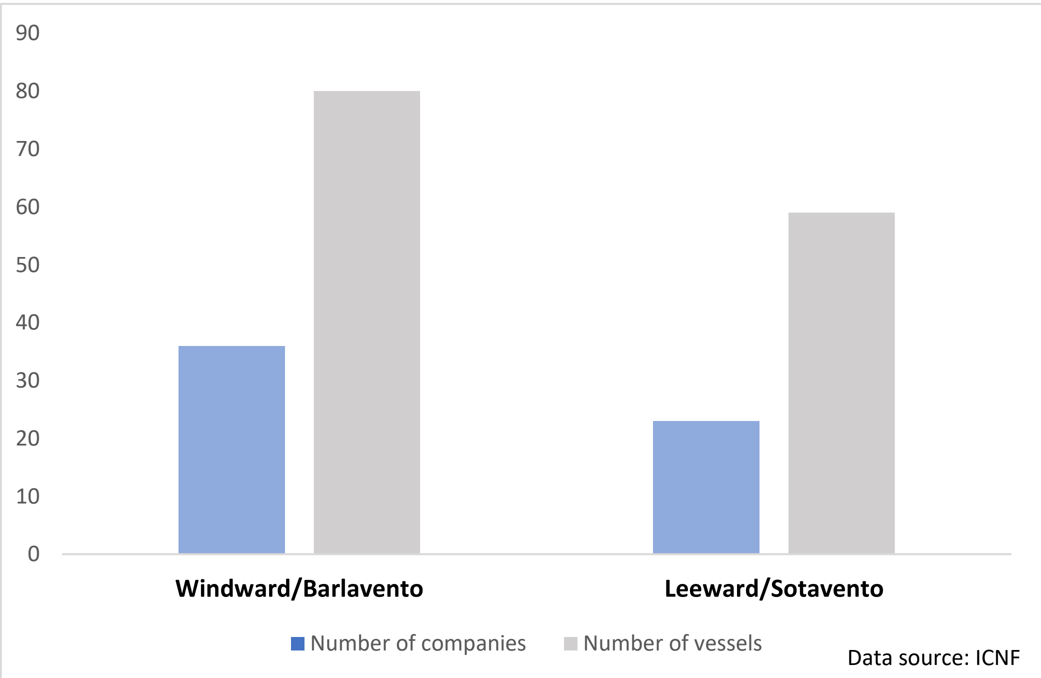


Figure 8. Distribution of the number of companies and vessels according to wind direction (Windward/Barlavento and Leeward/Sotavento) in 2021. Data source: ICNF

Comparing the number of companies present nowadays on the south coast of the Algarve and the rest of Portugal's mainland, the Algarve has the majority of them (59 companies), followed by Setúbal (20), Leiria (8) and Lisbon (5). Thus, there are 92 whale-watching companies registered in Portugal's mainland in 2021 (see Fig.9).

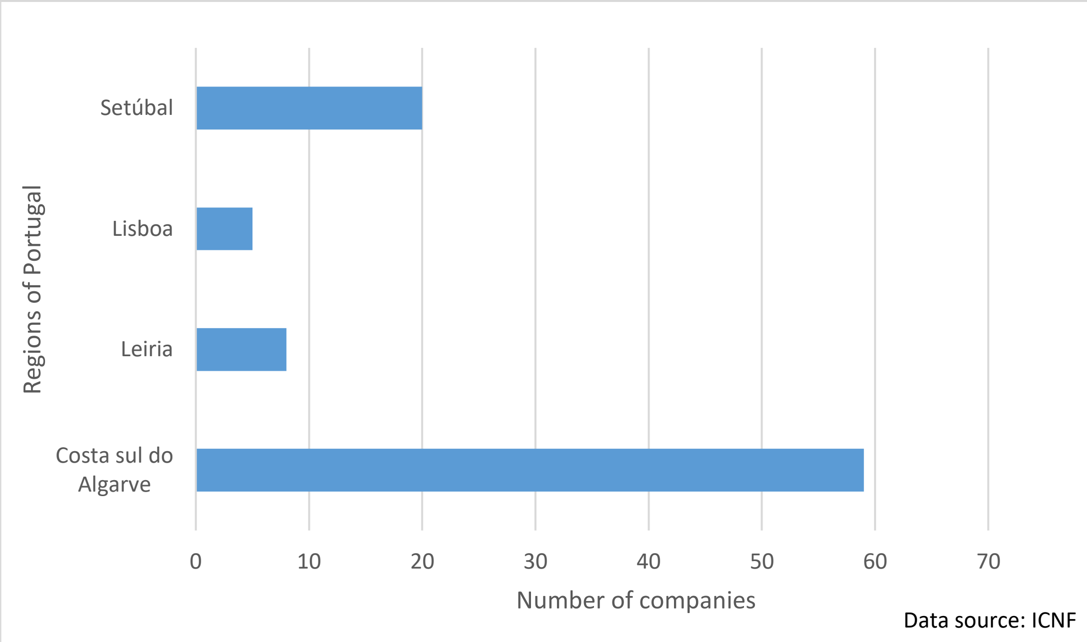


Figure 9. Distribution of all the companies that do whale-watching tours in 2021 by regions in Portugal (n=92). Data source: ICNF

Considering the total of 139 whale-watching vessels in 2021 in the Municipalities of Algarve, boat length data was available for 124 vessels, passenger capacity was available for 120 vessels, the classification by type was available for 101 vessels, and the location and/or presence of the motor was available for only 117 vessels. According to the evaluation, most of the boats have a single hull, and the majority (45 boats) are RHIB (Rigid-hulled Inflatable Boat). Followed by single fibreglass hull boats (35 vessels). Only a minority of vessels have a double hull (catamarans) accounting for only 19 vessels. Two other types of vessels (sailing catamaran and sailing single hull) were considered because they mostly navigate in the form of sailing (despite having a power engine), and only one of each type is currently operating (see Fig.10).

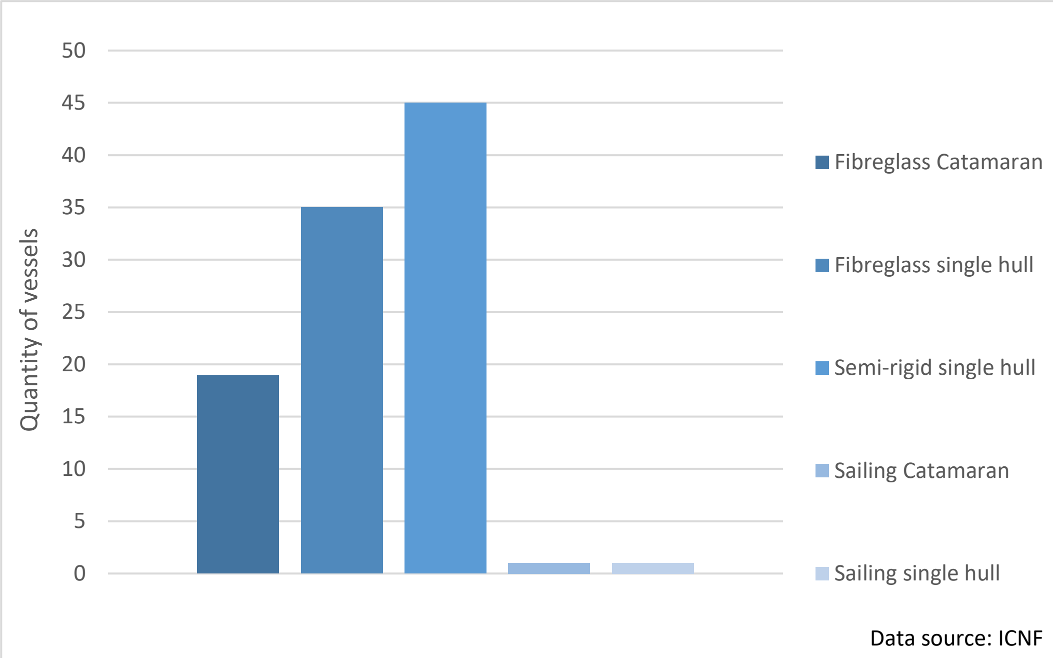


Figure 10. Distribution of the number of vessels according to the different hull types (n=101), doing whale-watching trips in 2021 in Algarve. Data source: ICNF

In terms of the location of the motor on the boat (considering data for 117 vessels), 2 are sailing boats and do not use the motor to navigate, however, they still have one on board in case it is needed. The rest of the vessels function with a power engine, in some cases using an outboard motor (60 vessels) and in other cases an inboard motor (55 vessels) (see Fig.11).

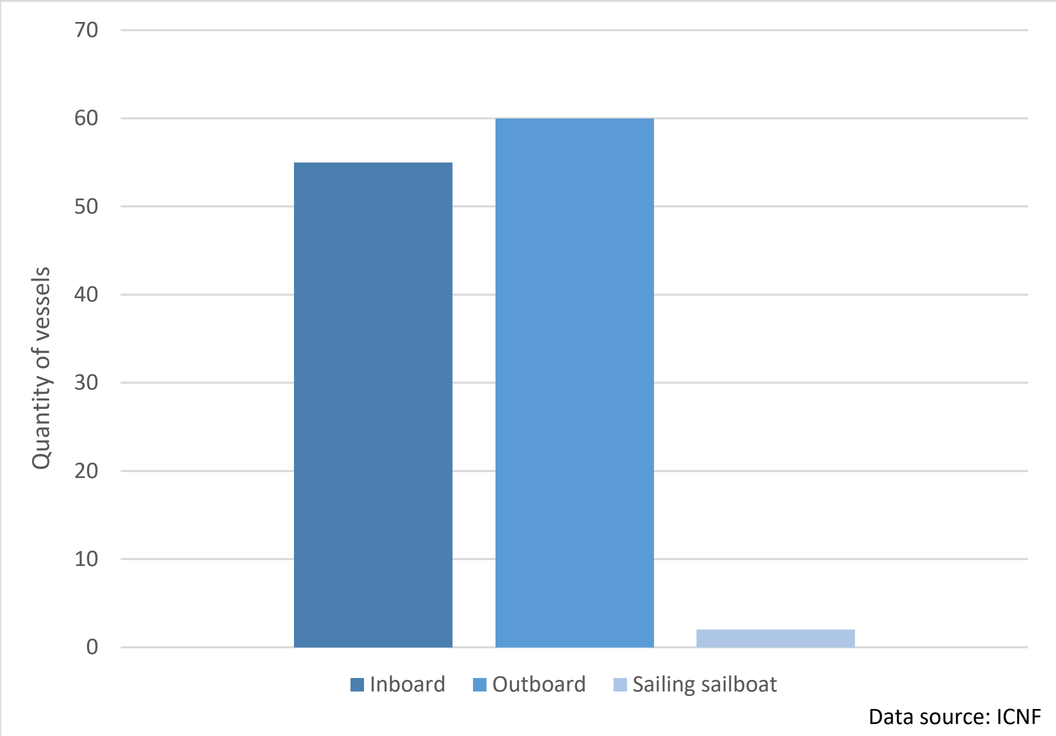


Figure 11. Distribution of the number of vessels according to engine location (n=117) (Inboard; Outboard and Sailing sailboat), doing whale-watching trips in 2021. Data source: ICNF.

Regarding the size of the boats, the majority measure between 5 and 9.99 metres in length, with 89 boats. Next, there are 26 boats with overall lengths between 10 and 14.99 metres, 8 between 15 and 19.99 metres, and only one boat in the 20 to 24.99 metres length class (see Fig.12).

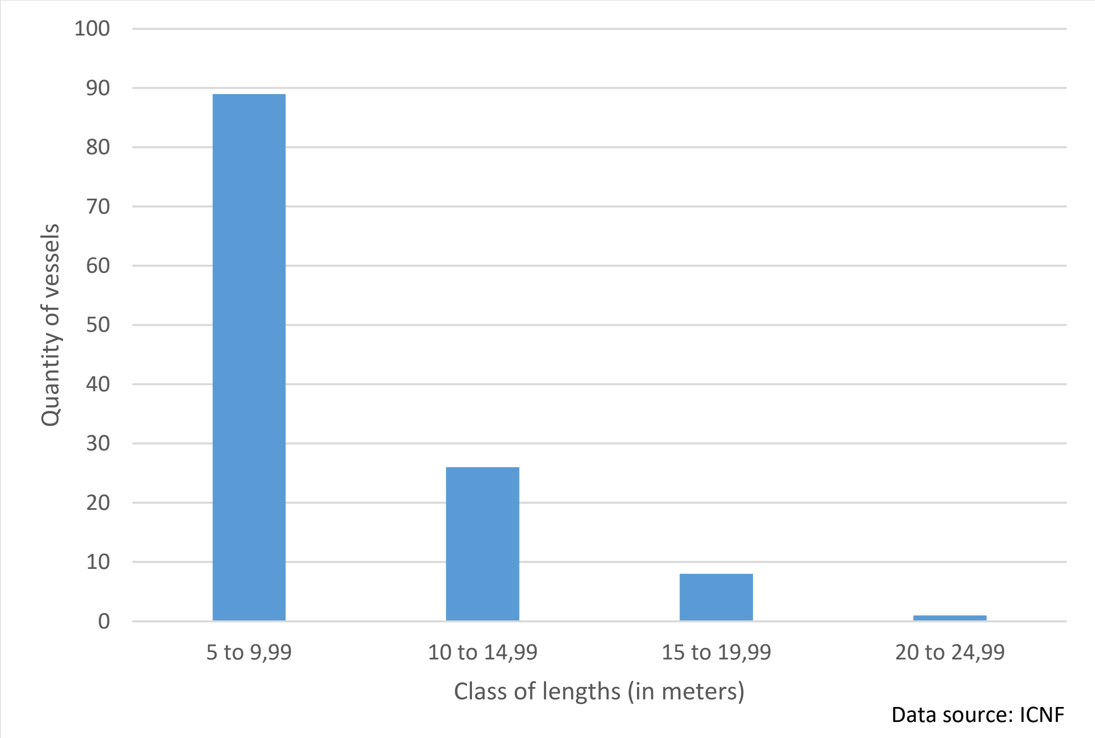


Figure 12. Classification of all boats according to different size classes (n=124) (classes: 5 to 9.99 meters; 10 to 14.99 meters; 15 to 19.99 meters and 20 to 24.99 meters), to undertake whale-watching trips in 2021. Data source: ICNF.

With respect to the passenger capacity of the whale-watching boats currently operating in the Algarve, most of the boats have a capacity of between 10 and 16 people whereas a minority presents higher capacities, with only 8 boats with a capacity between 45 and 80 and 3 with a capacity between 100 and 120 people. There are 20 vessels with a capacity between 18 to 30 persons and only 11 with smaller capacities, carrying 1 to 8 people (see Fig.13).

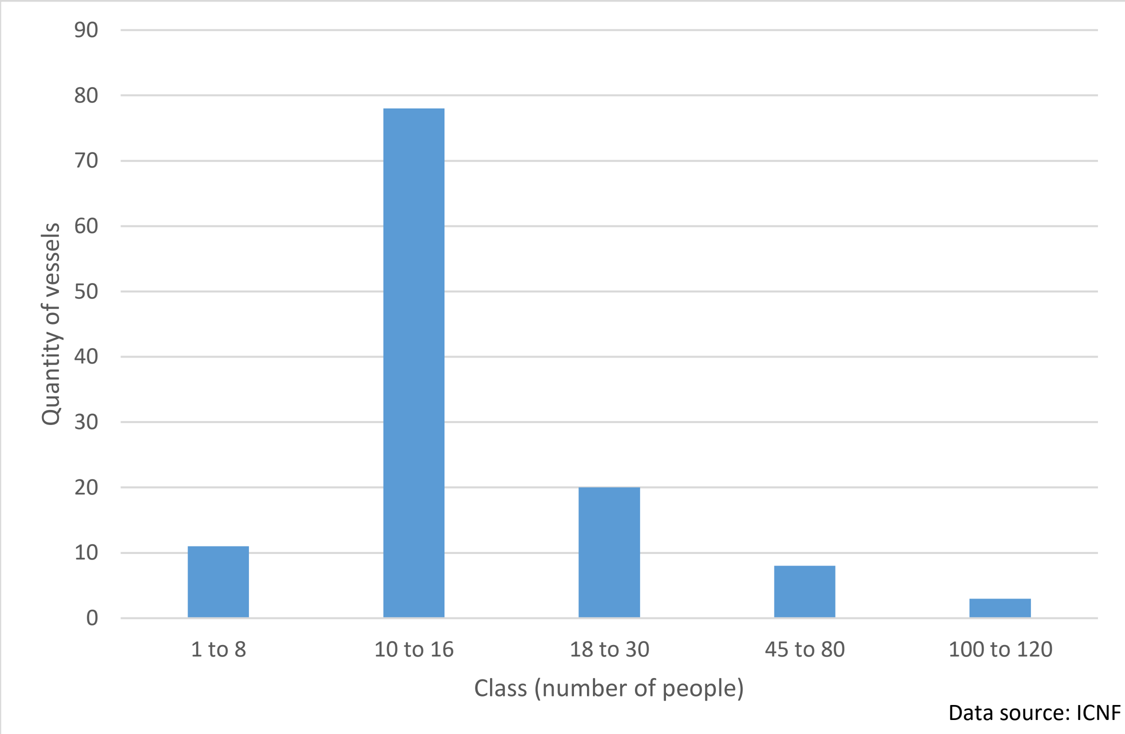


Figure 13. Characterization of the distribution of the passenger capacity of all vessels (n=120), according to different classes (1 to 8 people; 10 to 16 people; 18 to 30 people; 45 to 80 people and 100 to 120 people), undertaking whale-watching trips in 2021. Data source: ICNF

3.2. Data of the sighted species in the Algarve

By law, all the companies of whale-watching in Portugal have to send to the ICNF an annual report on the number of species sighted, number of departures and number of passengers. However, when analysing the data provided by the ICNF, it was possible to see a lack of data, meaning that not all companies send in their report every year whereas others send in incomplete reports. According to data from 2007 to 2021, even though 403 licenses were issued, only 92 reports were presented by the WW companies, representing a much lower number of reports than expected. Since a lot of data was not available (unreported by the WW companies), only some of the foresee parameters were estimated, including the number of departures, passengers and species sighted over the years.

The total number of sightings made by the WW operators between 2007 and 2021 included in the 92 reports adds up to 20 805 sightings of 17 different cetacean species, meaning that of the 22 species already described for this area, 17 have been spotted by WW companies in this period of time. Odontoceti individuals accounted for 20 176 sightings from 2008 till 2021 whereas Mysticeti individuals accounted for 566 sightings in the same period. Apart from these sightings of identified species, some individuals sighted over the years were not identified but count as sightings and in total, there are about 63 sightings corresponding to unidentified species (see Table III and Table IV). Besides the total number of sightings of all the cetacean species observed on the Algarve coast, the average annual value and standard deviation is also presented.

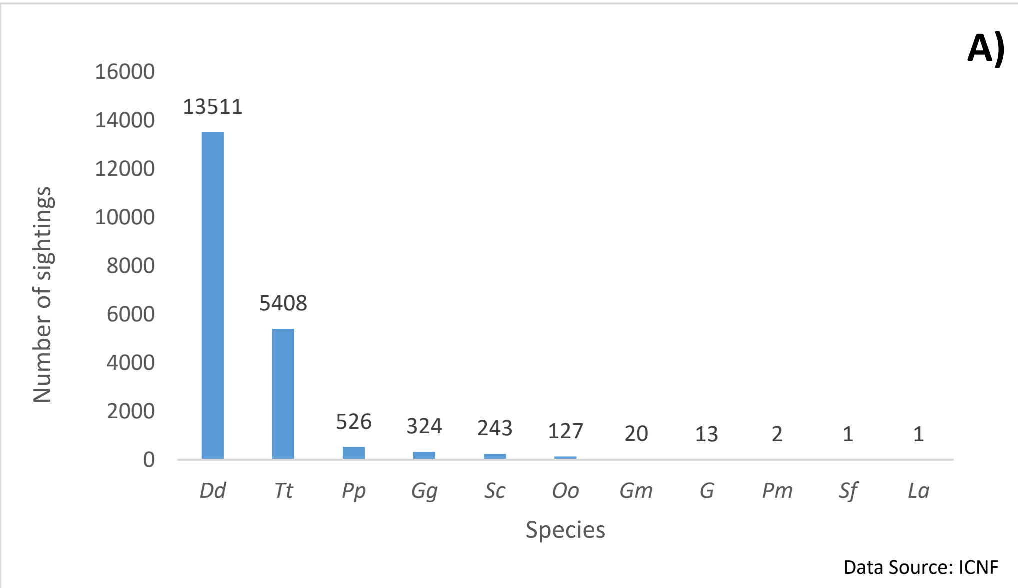
Table III. Sightings of the Odontoceti suborder over the years (2007 to 2021) on the south coast of Algarve by whale-watching companies. n = Number of reports. Data source: ICNF

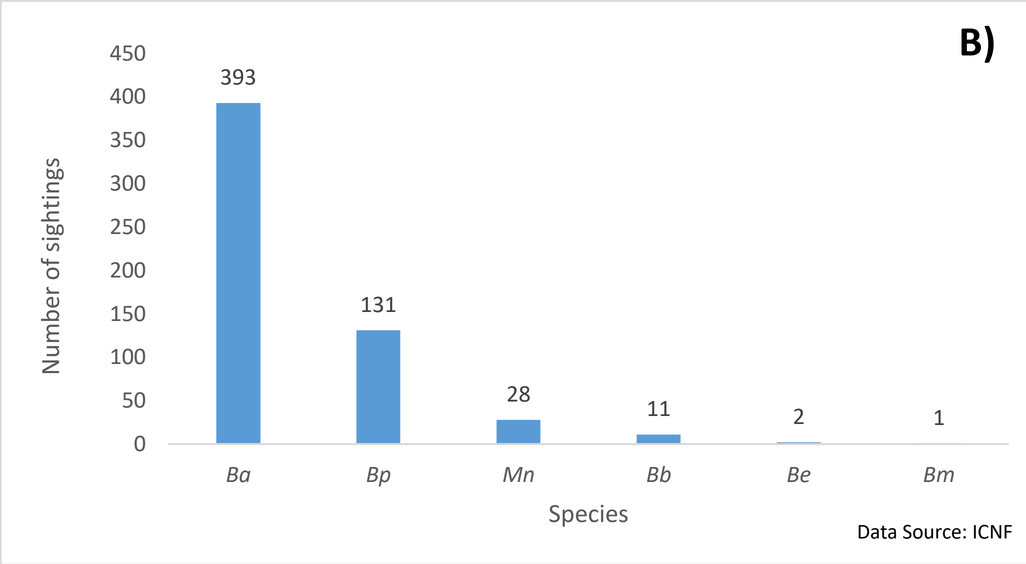
Species/Year	2007 (n=1)	2008 (n=1)	2009 (n=1)	2010 (n=1)	2011 (n=3)	2012 (n=5)	2013 (n=4)	2014 (n=10)	2015 (n=6)	2016 (n=18)	2017 (n=15)	2018 (n=12)	2019 (n=7)	2020 (n=6)	2021 (n=1)	Total	Mean	SD
Delphinus delphis	100	156	8	325	524	503	908	1617	740	2093	2675	1993	1075	500	294	**13511**	**900,7**	**823**
Globicephala macrorhynchus	0	0	0	0	0	0	0	0	1	0	0	12	5	0	2	**20**	**1,33**	**3,24**
Globicephala spp	0	0	0	0	0	0	0	4	1	0	3	3	2	0	0	**13**	**0,86**	**1,41**
Grampus griseus	5	8	1	7	16	14	0	6	4	30	91	74	38	21	9	**324**	**21,6**	**27,1**
Lagenorhynchus albirostris	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**	**-**	**-**
Orcinus orca	2	0	0	1	1	1	4	9	8	12	29	31	22	6	1	**127**	**8,46**	**10,6**
Phocoena phocoena	9	9	0	7	28	28	26	91	36	74	87	82	24	10	15	**526**	**35,07**	**31,9**
Physeter macrocephalus	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	**2**	**-**	**-**
Stenella coeruleoalba	1	0	0	0	5	3	7	31	24	9	28	56	51	24	4	**243**	**16,2**	**18,7**
Stenella frontalis	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**	**-**	**-**
Tursiops truncatus	4	9	2	11	74	124	99	490	253	1125	1305	1170	391	236	115	**5408**	**360,5**	**459**
Unidentified dolphin	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**	**-**	**-**
Unidentified Odontoceti	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	**1**	**-**	**-**
Total	121	182	11	351	649	674	1044	2249	1067	3345	4218	3422	1608	797	440	**20178**	**1345**	**1344**

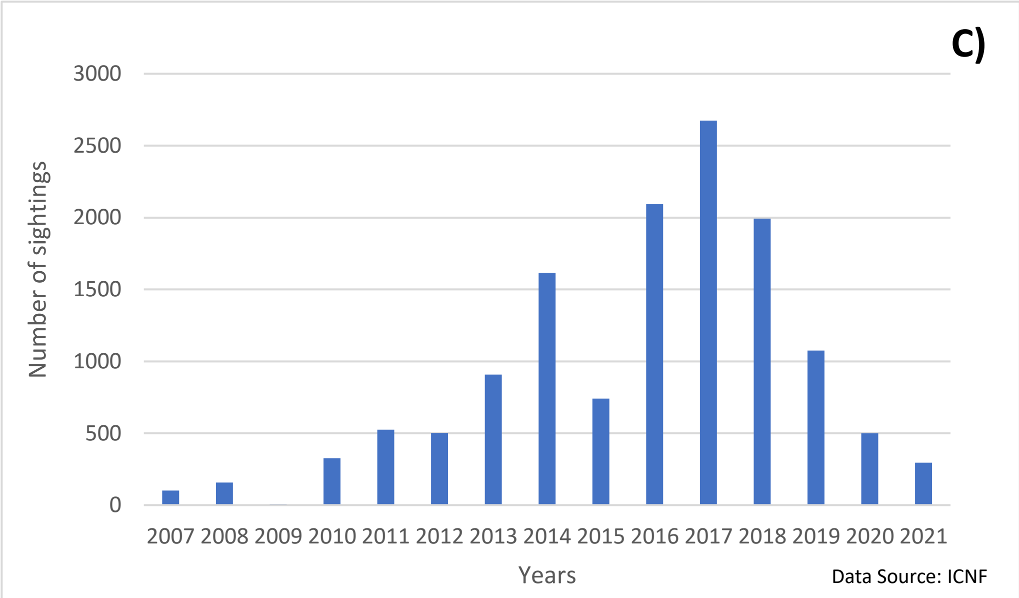
Table IV. Sightings of the Mysticeti suborder over the years (2007 to 2021) on the south coast of Algarve by whale-watching companies. n = Number of reports. Data source: ICNF

Species/Year	2007 (n=1)	2008 (n=1)	2009 (n=1)	2010 (n=1)	2011 (n=3)	2012 (n=5)	2013 (n=4)	2014 (n=10)	2015 (n=6)	2016 (n=18)	2017 (n=15)	2018 (n=12)	2019 (n=7)	2020 (n=6)	2021 (n=1)	Total	Mean	SD
Balaenoptera acutorostrata	2	0	0	2	10	52	12	50	46	38	63	69	27	11	11	**393**	**26,20**	**24,52**
Balaenoptera borealis	0	0	0	1	1	0	0	2	0	3	0	0	0	2	2	**11**	**0,73**	**1,03**
Balaenoptera musculus	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**1**	**-**	**-**
Balaenoptera physalus	0	0	0	0	1	4	1	3	6	9	30	44	20	9	4	**131**	**8,73**	**12,91**
Megaptera novaeangliae	0	0	0	0	0	0	0	0	12	1	13	0	2	0	0	**28**	**1,87**	**4,36**
Balaenoptera edeni	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	**2**	**-**	**-**
Unidentified cetacean	1	3	0	0	0	0	2	8	4	7	2	6	4	0	6	**43**	**2,87**	**2,83**
Unidentified Mysticeti	0	0	0	0	2	3	1	2	0	0	5	5	0	0	0	**18**	**1,20**	**1,82**
Total	3	3	0	3	14	59	16	65	68	58	114	124	53	22	25	**627**	**41,60**	**39,80**

The results from the 92 reports regarding the sighted species show that the most predominant species in this area are the short-beaked common dolphin in the sub-order Odontoceti and the minke whale in the sub-order Mysticeti. And the second most sighted species in both suborders are the bottlenose dolphin (*Tursiops truncatus*) and the fin whale (*Balaenoptera physalus*) (see Fig.14A and B). Considering all the sightings reported of the common dolphin it is possible to see that between 2012 and 2014 the sightings increased and then in 2015 have fallen substantially, but from the 2016 to 2018 the numbers climbed sharply again, with a peak in 2017. In the next years, the reports sent by the companies were only a few of them and in 2020 and 2021 there was also a pandemic, so less trips of whale-watching took place in Algarve, so the data from these years does not demonstrate the true reality of the facts, because if we have less reports there is a discrepancy from the reality of the total number of sightings (see Fig.14C). Till 2012 the sightings of *Balaenoptera acutorostrata* were only a few, but since 2014 they increased in number till 2019, and then the reports as said before were much less and there was also the pandemic, and because of this, the data for these years do not show the reality either (see Fig. 14D).




B)
Number of sightings
450
400
350
300
250
200
150
100
50
0
393
131
28
11
2
1
Ba
Bp
Mn
Bb
Be
Bm
Species
Data Source: ICNF


C)
Number of sightings
3000
2500
2000
1500
1000
500
0
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Years
Data Source: ICNF

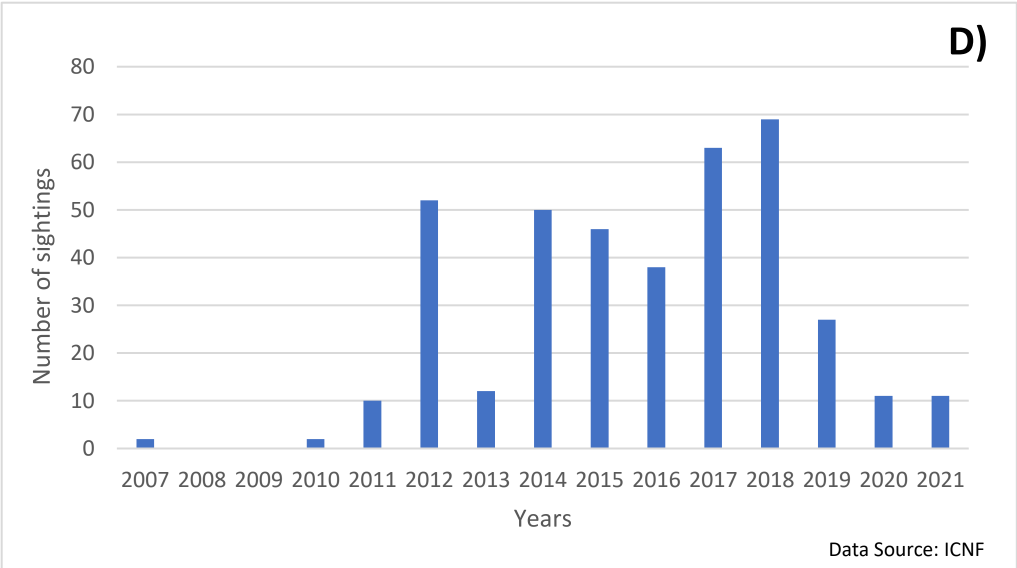
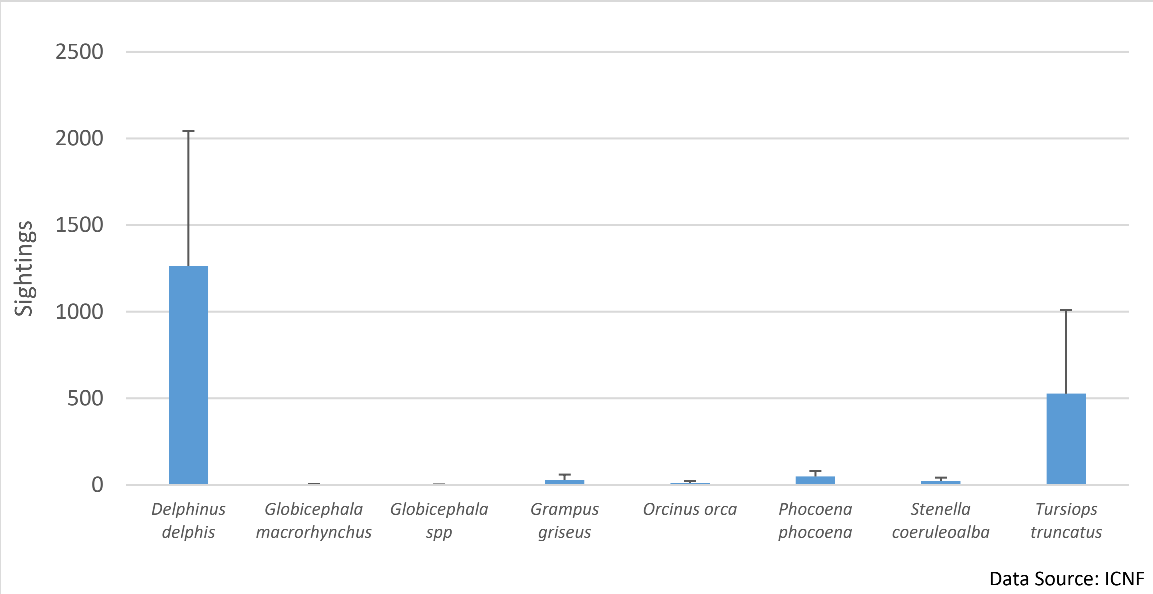

D)
Number of sightings
80
70
60
50
40
30
20
10
0
2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2020 2021
Years
Data Source: ICNF

Figure 14. A) Total sightings of the Odontoceti suborder (*Delphinus delphis* (Dd); *Globicephala macrorhynchus* (Gm); *Globicephala spp* (G); *Grampus griseus* (Gg); *Lagenorhynchus albirostris* (La); *Orcinus orca* (Oo); *Phocoena phocoena* (Pp); *Physeter macrocephalus* (Pm); *Stenella coeruleoalba* (Sc); *Stenella frontalis* (Sf) and *Tursiops truncatus* (Tt) on the south coast of Algarve between 2007 and 2021. B) Total sightings of the Mysticeti suborder (*Balaenoptera acutorostrata* (Ba); *Balaenoptera borealis* (Bb); *Balaenoptera musculus* (Bm); *Balaenoptera physalus* (Bp); *Megaptera novaeangliae* (Mn) and *Balaenoptera edeni* (Be)) on the south coast of Algarve between 2007 and 2021. C) Sightings of *Delphinus delphis* (Dd) between 2007 and 2021, the most sighted species of the Odontoceti suborder. D) Sightings of *Balaenoptera acutorostrata* (Ba) between 2007 and 2021, the most sighted species of the Mysticeti suborder.

Furthermore, several years included in the study period presented less than 3 reports or less than 3 sightings. Excluding these years, the study period is restricted to between the year 2011 and 2020 (see Fig.15). Even excluding years with very few information, the very large deviations of the overall mean for each species (see Fig.15) resulting from the low number of samples (annual reports) and the very discrepant number of observations in each year indicate that values are not very representative and may not be very reliable.



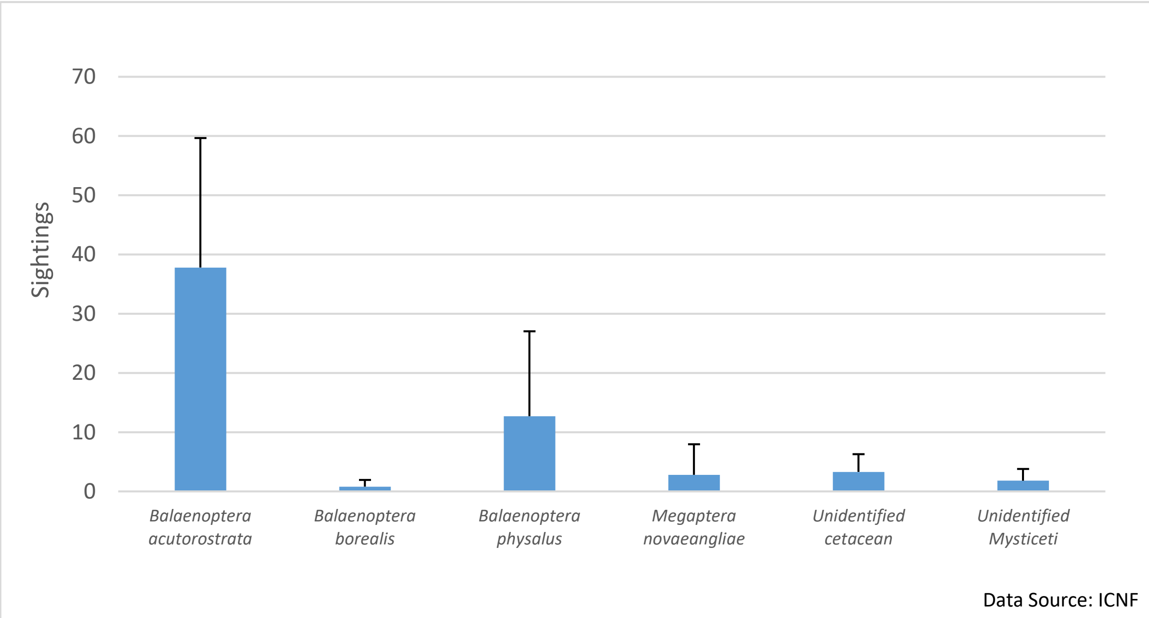


Figure 15. Mean value (± SD) of the Odontoceti and Mysticeti observations in the period from 2011 to 2020. Data source: ICNF

3.3. Socio-economic impact of the whale-watching

To estimate the direct income of the whale-watching activity in the Algarve, the initial plan was to analyse all the reports that were sent by the companies to the ICNF over the years. However, when analysing all the data it was possible to conclude that there was an immense lack of data in most years. For example, in the years 2007, 2008, 2009, 2010, 2013, 2019, 2020 and 2021 less than 20% of all companies sent in their annual report. And the only year in which reports were submitted from more than 50% of companies was in 2016 (see Fig.16). So, with all this lack of data, it becomes difficult to understand the activity's direct income over the years only using the data provided by ICNF. To address this problem, questionnaires were also developed for all companies operating from the year 2018 until 2021, because one of the goals of the project is to understand the current direct income produced.

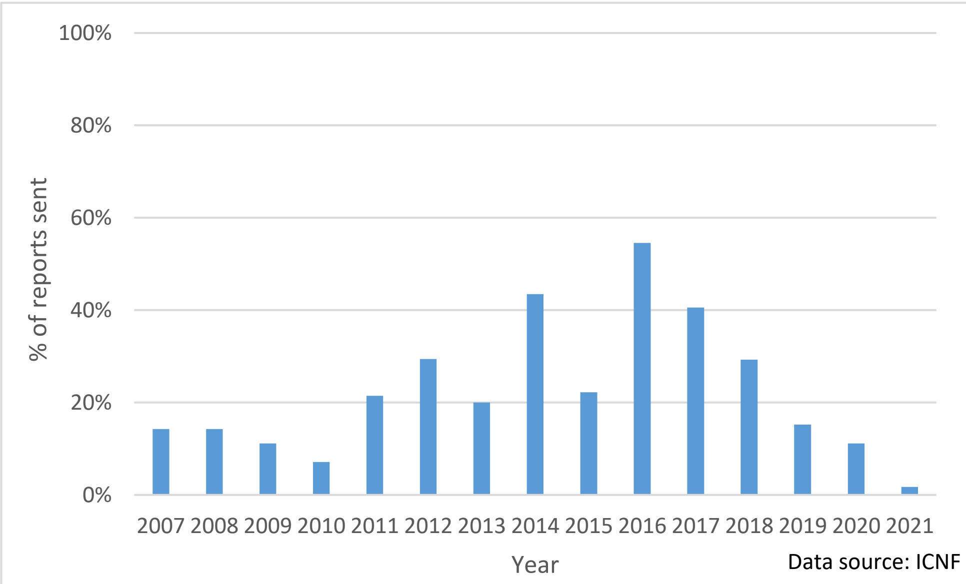


Figure 16. Percentage (%) of reports sent to ICNF over the years (2007 to 2021), in relation to the total number of existing companies in each year. Data source: ICNF

After all the survey questions were set, the survey was sent via email, between March and April of 2022, to all companies that were still in business from 2018 until 2021 (see annexe A). After the poor response from them, a second attempt was made and the same email with the survey was sent to all companies again. However, in total only 4 companies out of 59 that are still active responded. Because of this, it has not yet been possible to estimate the direct income from the activity of all companies in Algarve. Joining the data from the reports available from the year 2018 to 2021 with the data acquired by the surveys, it is possible to produce only an indicative estimate of the direct income of the companies doing whale-watching, bearing in mind that there are some gaps and variables not understood in these values. Most importantly, the activity was very reduced in the years 2020 and 2021 because of the COVID-19 pandemic, so restrictions in economic activities was on force.

The ticket price used for the calculation was 41 euros, in accordance with O'Connor et al. (2009) as explained in the methods section. Because in the majority of the reports sent there is no distinction between the number of adult and child passengers, only prices per adult were considered in the direct income estimate. In 2018, 13 companies with 35 boats made a direct income of 1.905.967,00 euros from 3824 trips with 46487 passengers. In 2019, 9 companies made in total a direct income of 615.779,00 euros, travelling with 15019 tourists that year. In 2020, the year of the pandemic, it is possible to see that the income was much lower than in 2019 because almost the same number of companies did much fewer trips and had a much lower number of passengers as well, making a direct income of only 194.340,00 euros. Lastly, in the year 2021, it can be observed that there was a recovery in the number of departures and visitors that went on whale-watching tours since the value of the direct income increased to 297.660,00 euros (see Table V.). These results are very limited, and only provide a baseline of the possible direct income in the study area for a small part of all companies.

Table V. Data available from the reports and surveys, in order to estimate the direct income from those companies between 2018 and 2021.

Year	Number of departures	Number of passengers	Number of companies	Number of boats	Price per ticket	Direct income
2018	3824	46487	13	35	41,00 €	1 905 967,00 €
2019	1560	15019	9	17	41,00 €	615 779,00 €
2020	589	4740	7	14	41,00 €	194 340,00 €
2021	732	7260	5	10	41,00 €	297 660,00 €

4. Discussion

Since the early 1950s, there has been tremendous expansion and development in the whale-watching industry all around the world (Hoyt, 2018). Despite the risks it may cause to the target species, this business not only offers commercial advantages but also has the potential to be a useful instrument for scientific research on cetaceans (Hoyt, 2012).

Just 3% of Portugal's maritime environment is protected, and only 0.03% of that is thought to constitute no-take areas. Despite the significant anthropogenic pressure in the Algarve, primarily brought on by the enormous influx of visitors, strong fish-based gastronomy, sea-oriented culture, and the bulk of jobs associated with the marine environment, there are only a few protected zones which include marine areas, as mentioned in the methodology section. As a result, there was extensive coastal development and the coastal marine habitats have deteriorated (Da Cunha Simões, 2018). The Algarve's coastal and marine habitats are under pressure from a variety of environmental factors, and one of the most impactful is tourism. The Algarve is regarded as Portugal's top tourist destination, drawing travellers from all over the world who want to take advantage of the region's attractions and Mediterranean environment (INE, 2022). Naturally, a large influx of people evokes worries about the depletion of natural resources and the strain on the environment, particularly given that the Algarve's tourist attractions are mostly marine-based (whale-watching, water sports, sailing, beaches, gastronomy etc.) (Da Cunha Simões, 2018).

The sharp rise in whale-watching activities raised issues in several regions, mostly related to management and also common to other tourism-related firms. What was formerly thought of as a perfectly innocuous activity, especially when contrasted to whaling, was now perceived, in a few places, as being possibly harmful to specific dolphin or whale populations if not properly done and regulated (Hoyt, 2018). To avoid mistakes made in other nations in the past, efforts must be made to establish effective regulatory frameworks in all areas where whale-watching activities are prevalent (Hoyt & Parsons, 2014).

The south coast of the portuguese mainland is the best place in the country to do whale-watching observations (Castro, 2010), with the most sightings of different species of cetaceans, and therefore the largest number of companies are located in this area (see Fig.9). Presently, there are 59 licensed whale-watching companies and 139 boats operating in this area while in 2008 there were only 7 companies with 12 vessels (see Fig.6. and Table II.). In fact, there has been a significant increase in this activity over the years. With the continuous activity development, one of the main questions that arise is "Can the whale-watching industry affect cetacean species?" (Galego et al., 2014). Most nations chose to implement laws only after the issues started to arise, allowing whale-watching to begin with few, if any, control (Hoyt & Parsons, 2014). Portugal is one of the few countries with a law protecting cetaceans from unrestricted and improper whale-watching (Decreto-Lei nº 9/2006 de 6 de Janeiro de 2006).

According to Portuguese law, no more than three platforms can be present in the approach zone. However, the lack of enforcement on Portugal's south coast leads to a high percentage of interactions with more than three boats and the dolphins tend to steer clear of the whale-watching boats in these instances (Galego et al., 2014). It is clear that laws aiming at increasing the sustainability of activity, in this case without negative consequences for cetaceans, need to be actually enforced by informing whale-watching operators and improving surveillance by the relevant authorities (Galego et al., 2014).

An example of a nation that has regulated whale-watching with a permit system and guidelines based on scientific research and prudent management is New Zealand. In this country, there are restrictions on the number of operators doing this activity (through licensing systems) as well as the quantity and total trip duration. Also, on the islands of Portugal (Azores and Madeira archipelago), there are other rules and different guidelines on the legislation when observing dolphins or whales. There is also a limit of the daily trips per boat and duration of the sighting and a limit of licenses given according with the different areas' abundance of cetaceans in the islands (Sequeira, 2018). These Portuguese archipelagos constitute autonomous regions and therefore legislation on the islands is different, including more guidelines regarding whale-watching than on the mainland. This may be also due to the fact that the whale-watching activity in these islands started much earlier (O'Connor et al., 2009). There is a chance now to learn from these positive examples and from these experiences of other places where whale-watching is new or recent and problems got severe due to a lack of regulation. It might be simpler for managers to take proactive measures now rather than attempting to control the problem once whale-watching is well established (Hoyt & Parsons, 2014).

According to the National Statistics Institute of Portugal (INE), in 2021 there was a total of 10.874,000 million overnight stays for 2.725,134 million guests in the Algarve. These values are much lower than in previous years since in the year 2019 there was a peak of 20.900,495 million overnight stays (see Fig.17). The decrease in both the year 2020 and the year 2021 concerning the number of tourists was already expected because of the COVID-19 pandemic. From 2009 to 2019 it is noticeable that the number of overnight stays increased exponentially (INE, 2022). Although there is no data for the year 2008 specifically, it is possible to see that the number of overnight stays in that year was much lower than what would normally occur in the year 2021, if there was no pandemic. Likewise, the number of whale-watching companies has increased since then as a response to tourism demand, explaining the significant expansion of this activity between 2008 (7 companies with 12 boats) and 2021 (59 companies with 139 boats).

In 2008 there were only seven whale-watching companies in three municipalities in the Algarve (Lagos, Albufeira and Loulé). At this time, the availability of accommodations was poorly distributed, with 90% of the accommodations located in the Lagos-Faro coastal strip. Of these, 73.6% were concentrated in the municipalities of Albufeira, Portimão and Loulé, with Albufeira having the largest share, reaching 40% (PROT Algarve, 2004). Due to the poor distribution of the number of accommodations along the Algarve coast, tourists were present in larger numbers in the municipalities with more accommodations, which is a possible explanation for the fact that the whale-watching companies only existed in these 3 municipalities, as they were the ones that attracted the most tourists (see Fig.7A). According to Rosa (2020), in the year 2019, Albufeira, Portimão and Loulé remained the municipalities with the highest number of accommodations. However, the municipalities that were very poor in new accommodation in 2008, currently offer much more accommodation, due to the increase in tourism demand throughout the Algarve coast. Therefore, as the number of accommodations is more distributed throughout the coast, the number of tourists and the activities made available to them, such as whale-watching, are also more spread out. Looking at Figure 7B), it is possible to see that in 2021 although there are many more companies, they are also more distributed by all municipalities.

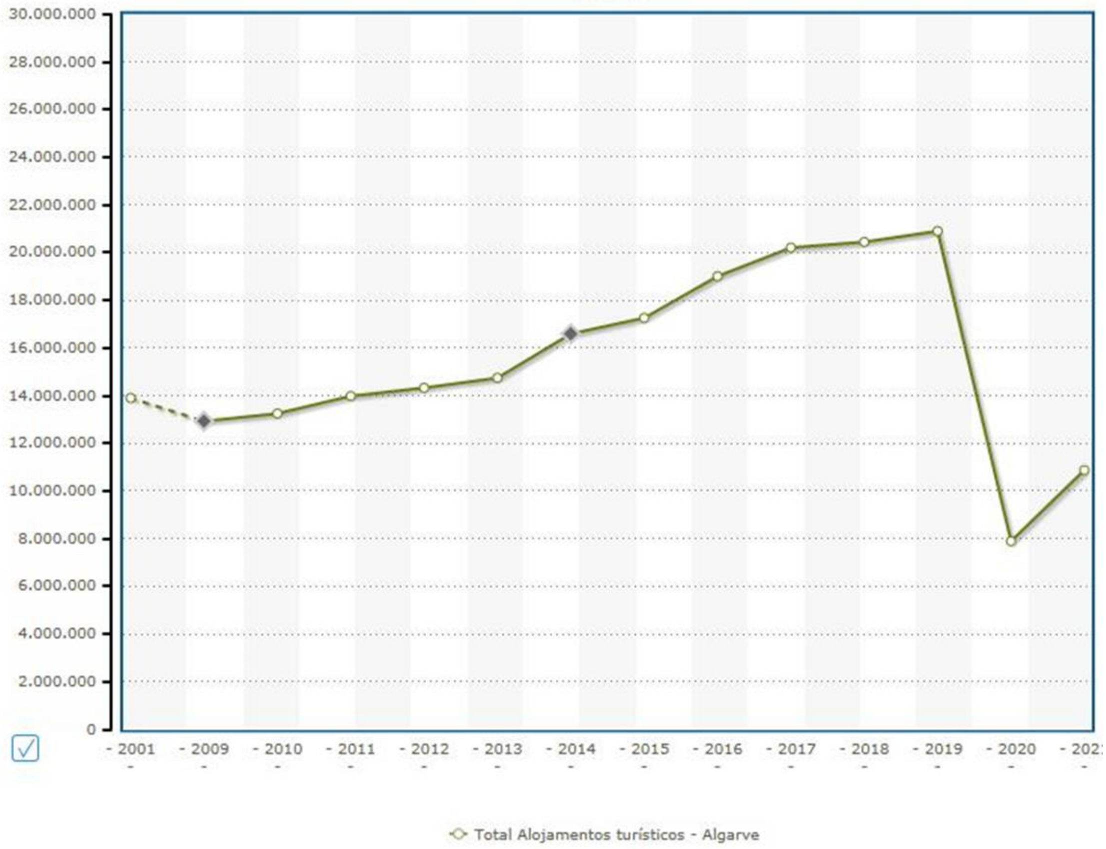


Figure 17. Total overnight stays in all types of accommodations present in the Algarve from 2001 to 2021. Source: INE (2022).

Worldwide, whale-watching vessels are growing in size and number, but the noise impact on the observed species depends on the vessel source characteristics, which are still mostly unstudied (Hendrix & Rose, 2014). Because they naturally spend a lot of time close to the targeted cetaceans, these tourism-related activities require extra consideration in the context of vessel noise effects. The effects and noise levels depend on a wide variety of boat characteristics, including hull material and design, size, maintenance of the vessel, propulsion system, horsepower and speed (Erbe, 2002). The probability that animals will be affected will depend not only on the vessel's characteristics, but also on the environmental noise levels, propagation conditions, angle of approach, driving skills, distance from the animals, and duration of the sighting (Arranz et al., 2021). Another critical element is the quantity of vessels in the area. The size and presence of a motor do not always play a significant role in disturbances; frequently, the presence of the boat alone is enough for an animal to respond. The type of boat, however, may have an impact on how strong the reaction is (David, 2002).

For whale-watching excursions, a variety of boats are employed, such as monohulls, sailboats, rigid-hulled inflatable boats (RHIBs), catamarans and wooden boats (Arranz et al., 2021). The companies present on the Algarve coast have all these types of hulls, except those made of wood (see Fig.10). Most of the boats have a single hull, and the majority are RHIBs, followed by fibreglass single-hull boats. Only a minority of vessels have a double hull (catamarans) and there is only one sailing catamaran and one sailing single hull (see Fig.10). According to the recent study by Arranz et al. (2021) based on a limited number of vessels within each category type, the loudest SLs (source levels) for LF (low-frequency), MF (mid-frequency) and HF (high-frequency) were emitted by large catamarans, followed by motor sailing and motor vessels at low levels of speed. In another similar study by Wladichuck et al. (2019), these same results were also proven. These measurements in both publications show that different whale-watching vessels emit highly varied received noise levels around the species for the same speed and distance, and as a result, have variable noise consequences. The size of the boat also proved to be a very important characteristic in both studies and in the case of the Algarve most boats have between 5 and 9.99 metres long. There are only a few boats above 10 meters concerning the total length (see Fig.12). Also looking at the passenger capacity of the vessels operating in this area, the majority can carry between 10 to 16 people, whereas a minority has a bigger capacity (see Fig.13). As mentioned above, most boats do not exceed 10 metres, so fewer large boats can carry more passengers.

Smaller boats with smaller horsepower engines may inherently cause less noise and consequently less disturbance to the targeted species. Therefore, some boats are better suited for whale and dolphin watching activities since they are better in terms of reducing underwater noise emissions (Arranz et al., 2021). Additionally, how cetaceans respond to vessel noise may depend on how they perceive the sounds. The main different three categories of cetacean hearing are low-frequency (present in baleen whales), mid-frequency (in large-toothed whales and the majority of dolphins), and high-frequency (such as porpoises) (Southall et al., 2019). Looking at the characteristics of the whale-watching fleet in the Algarve, it is possible to see that although the boats are mostly single-hulled and fibre or RHIBs, there are still about 20 catamarans out of the total 139 boats. If in the future more authors prove that large catamarans may cause more impact on cetaceans due to the high level of noise they produce, restrictions on licensing this type of vessel could help minimise possible impacts on cetaceans (see Fig.10).

With respect to propulsion, most whale-watching vessels in the Algarve use power engines (60 boats use outboard motors and 55 use inboard motors). This shows that the mode of propulsion used is similarly divided. Only two vessels preferably use the sailing mode, although they also have engines on board (see Fig.11). In Oliveira et al. (2009), it was concluded that there was no obvious difference between the inboard and outboard engine SPL (sound pressure level) values. Furthermore, inboard engines have lower frequencies, but forward/reverse manoeuvres take longer than in outboard vessels. Kruse (1991) reported that killer whales did not react differently to outboard or inboard engines. However, other studies proposed that boats with inboard engines produce less intense sounds, than the ones with outboard motors and that smaller boats with outboard motors produced similar or louder noise levels than larger boats with inboard motors. Propeller cavitation is the main source of underwater noise produced by vessels (Ross, 1989). In comparison to bigger boats with inboard motors, smaller boats with outboard motors have significantly smaller propellers. As a result, compared to larger vessels with inboard motors and bigger propellers, the amount of cavitation produced by an outboard motor may be higher. So according to this, comparing boats with inboard motors, which are quieter, outboard motors will likely create greater noise (Au & Green, 2000). In addition, when accounting for speed, Erbe (2002) discovered that RHIBs were significantly noisier than motorboats. Further research on this topic is needed, particularly to find if this characteristic of the boat makes a difference in the amount and type of noise they produce (Jelinski et al., 2002).

Since hearing is a marine mammal's main sensory modality for navigation, communication, and spot prey and predators, this is particularly significant (Richardson et al., 2013). Considering that whale-watching vessels naturally spend a lot of time close to cetaceans and that there have been reported wide-ranging short- and long-term effects on cetacean species (Senigaglia et al., 2016), lowering vessel noise SLs (Source levels) will help mitigate any negative effects. In whale-watching vessels, noise reduction can be accomplished by slowing down since higher speeds increase propeller cavitation, which raises noise levels (Erbe, 2002), getting farther away from the group of cetaceans (Sprogis et al., 2020) and avoiding gearshifts because they create high-level transients in the sound (Jensen et al., 2009). Noise-reducing methods, such as installing noise-absorbing gear, switching to quieter/electric engines or utilizing larger, slower-moving propellers to avoid cavitation, can be used to permanently lower underwater noise levels in vessels (Arranz et al., 2021). Furthermore, to reduce disturbance to cetaceans it is very important to follow national regulations, guidelines and codes of conduct of the country where the observations are taking place (IWC, 2019). The minimum approaching distance and speed, approach angle, the maximum number of vessels allowed in a given radius around the species and the amount of time that a vessel may stay in this radius are just a few examples of rules or guidelines that vary significantly in different areas (Arranz et al., 2021).

On Portugal's mainland, the Habitats Directive, national law (Decree-Law 263/1981 from 3 September), and other international conventions and agreements (CITES, Bonn, ACCOBAMS and Bern), aim to protect cetacean species. A law designed at controlling whale-watching on the Portuguese mainland was published in January 2006 (Decree-Law number. 9/2006 dated 6 January). It sets a licencing programme and a code of conduct for whale-watching activities that all vessels, including whale-watching businesses and recreational boats, must adhere to while they are close to cetaceans. The law as it stands states that swimming with cetaceans is prohibited and that there is a maximum amount of time per boat (30 minutes) and a maximum number of boats per observation (3) as well as minimum distances that must be maintained when approaching a group of cetaceans. In addition, it is necessary to approach animals slowly, from the back and in a parallel position, granting a 180º free area ahead of them, maintaining the same speed as the cetaceans and avoiding abrupt shifts in the course (see Fig.18) (Sequeira, 2018). Although there are many similarities between the code of conduct and the legislation in Portugal mainland, in the Azores and Madeira, there are some distinctions. One of the main differences between the code of conduct for the mainland and the Azores, is that it is legal to swim with dolphins in the wild, although with some rules.

In the Azores archipelago there are also distinct rules for when observing dolphins or whales. An example is that, when observing dolphins, the approach limit is 300 meters and 500 meters with whales (Sequeira, 2018), because of the different responses, depending on the species, when interacting with boats. Similar rules could be useful in the Portuguese mainland as well, because of the many whale sightings over the years for example in Algarve (see Table IV and Fig.14 B). Looking at the legislation in the Madeira archipelago, established by the Decree 15/2013/M, swimming with cetaceans is not allowed and 10 minutes is the maximum time that a boat can be with the animals. In Madeira there is also a licensing system, although a maximum number of whale-watching boats per area is already established. This number was defined according to the abundance of cetaceans on the area near the different harbours of the archipelago. The regions with higher abundances have permission to issue more licences, and areas with lower abundances can only issue a few licences. Additionally, a limit of three daily trips per vessel has been implemented (Sequeira, 2018). Since the activity is currently expanding in south coast of Portugal (see Fig.6), there is an urgent need to establish a maximum whale-watching boat capacity for the area.

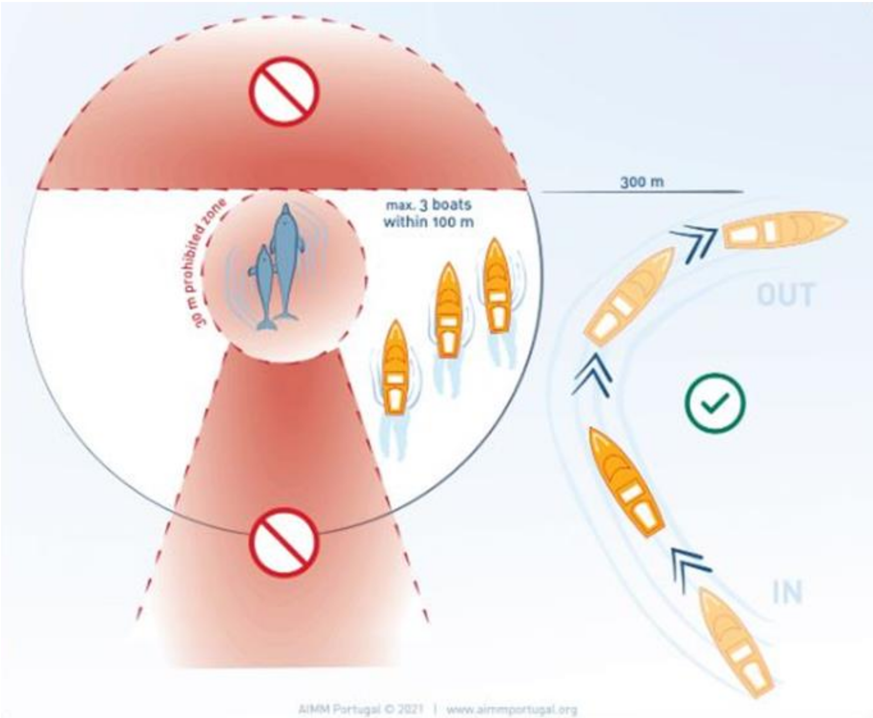


Figure 18. Illustration of the Code of Conduct for dolphin and whale watching in mainland Portugal. Source: © AIMM Portugal, 2021.

Different cetacean species present different reactions to boats. On Evans et al. (1994), the harbour porpoises that were observed tended to react negatively to all types of vessels, however, speedboats in particular, caused them more distress than yachts. According to Green et al. (1999), humpback whales accelerate more noticeably when boats are louder. On the other hand, Liret (2001) found that bottlenose dolphins responded favourably to boats travelling at speeds of more than 5 knots in 87% of the cases and that the distance and duration of the encounter increased if the boat tried to reach the dolphins. Bottlenose dolphins, especially adults, are more drawn to boats with higher speeds. It has been hypothesised that slowly or small moving boats would not elicit a positive response from dolphins, possibly because their wake or stem wave was insufficiently large (David, 2002). With respect to killer whales, Kruse (1991) stated that the type of motor or size of the boat had no bearing on how the killer whales reacted. However, more recently, there have been some reports of interactions with boats, by killer whales around the Iberian Peninsula. The majority of the boats that they engaged with were sailing boats, including monohulls (72%) and catamarans (14%). However, encounters with motor boats (6%), semi-rigid boats (5%), and fishing boats (3%) were also noted (Fernández & Pavo, 2021).

Over the years, various scientists have focused their attention on studying the presence of cetaceans off Portugal's mainland. Although the range and quantity of cetaceans across the Iberian coast were poorly understood in the past (Stephanis et al., 2008), since then, several studies have been made over the years. In fact, some studies have already shown modifications in the acoustic behaviour of bottlenose dolphins in the presence of vessels in the Sado Estuary (Sobreira, 2017). However, long-term and targeted ongoing research on the impact of noise on coastal and oceanic cetaceans has never been undertaken along the mainland shore (Brito et al., 2009). This country has a major coastline with a number of significant topographic and oceanographic features, such as seamounts and underwater canyons, with abundant marine resources in extremely productive areas (Wooster et al., 1976), particularly where coastal upwelling is stronger. Such a dynamic habitat is recognized to promote ecological richness, which explains the presence of cetaceans in high numbers (Brito et al., 2009; Correia et al., 2015). Teixeira (1979) carried out the initial, more thorough research on this topic. The findings showed that common dolphins (*Delphinus delphis*) were the species most frequently observed, followed by striped dolphins (*Stenella coeruleoalba*) (Vieira et al., 2009). Although information on the distribution and abundance of cetaceans throughout the Portuguese coast is available (Vingada & Eira, 2018) information on more geographically restricted areas is still insufficient (Castro et al., 2020; Vieira et al., 2009). The most recent studies have shown 28 species of cetaceans occurring on the coastal waters of Portugal's mainland (Vingada & Eira, 2018). Castro et al. (2013) reported 13 documented sighted cetacean species on the south coast. Looking at the results of this study, the cetacean observation companies in the study site, sighted 17 different species, out of the 22 already reported for this area (see Table III and Table IV.). These findings strongly imply that many cetacean species have a significant presence along Portugal's southern coast and that this area is important for these species.

More recently, in 2020, a bryde's whale was observed for the first time off the coast of the Algarve. This sighting was recorded by the AIMM (Marine Environment Research Association) (Castro et al., 2021). This great discovery adds one more species to the list of cetaceans observed alive in the Algarve. After this occurrence, in the year 2021, this same species was observed twice by the whale-watching companies in this area (see Fig.14B). Sometimes bryde's whale sightings are underestimated because sei whales (*Balaenoptera borealis*) are frequently mistaken for bryde's whales (Freitas et al., 2012). Taking into account that sightings of sei whales by whale-watching companies are relatively more frequent (see Fig.14B), it is possible that bryde's whale have been observed before but were misidentified since some companies may not have employees trained in marine biology (Castro et al., 2021).

Regarding the abundance of cetaceans, according to the previously published bibliography, the most recorded species is the short-beaked common dolphin, followed by the bottlenose dolphin and lastly the striped dolphin. There are also other species like the harbour porpoise, risso's dolphin, long-finned pilot whale and the baleen whales, although in fewer numbers (Sequeira et al., 1996; Brito et al., 2009; Pierce et al., 2010; Vingada et al., 2011; Santos et al., 2012). Accordingly, in the present study, the most sighted species was the common dolphin, and secondly, the bottlenose dolphin (see Table III and Fig.14A) whereas baleen whales were much less sighted (see Table IV and Fig.14B), which agrees with other articles already published (Vieira et al., 2009; Castro, 2010; Laborde et al., 2011; Goetz et al., 2015). In fact, in the Algarve region, the short-beaked common dolphin (*Delphinus delphis*) is the most commonly encountered and abundant species (Brito et al., 2009; Azevedo, 2010; Moura et al., 2012). However, the biology and ecology of these organisms, including their numbers and distribution, are poorly studied in this area. One of the main reasons for their occurrence in larger numbers, is the fact that they are known to be opportunistic feeders and this area is highly productive, with a massive upwelling season that lasts from March to October (Lafuente & Ruiz, 2007). These characteristics confine sardines (*Sardina pilchardus*), one of the common dolphins' primary prey species, to the coastal waters (Silva & Sequeira, 2003). According to Castro et al. (2020), this area is not only important for this species because of its productivity, but possibly it is also a nursery area.

Regarding the bottlenose dolphin, another study carried out with data between 2009 and 2016, made a total of 774 sightings, including a maximum of 170 sightings in 2014 and a minimum of 20 in 2009 (Vieira, 2017). In the present study, a total of 5408 sightings were recorded for this species with the maximum number of observations between 2014 and 2018 (see Table III and Fig.14A). Also, in Vieira (2017), it was reported that this species is closer to the shore in this area of Portugal, and some authors claim that this species prefers the warmer months to be located closer to the coast since these places are crucial for calving and breeding (Lusseau, 2005). Therefore, the Algarve coast is probably very important for bottlenose dolphin reproduction.

In the 2005 SCANS – II (Hammond et al., 2013) and 2016 SCANS – III (Hammond et al., 2021) surveys, aiming at estimating cetacean abundances in European Atlantic waters, there were no harbour porpoise sightings in the South of Portugal. However, there was a total of 526 sightings made by whale-watching companies along 15 years (between 2007 and 2021), although no observations were made in 2009 (see Table III and Figure 14A), but only a few reports were delivered. Therefore, an annual average of 35 porpoise sightings suggests that this area is used by this species (Castro, 2010), being particularly important to a possible porpoise immigration from an even more meridional population (Chehida et al., 2021).

Risso's dolphins are also sighted very frequently in some years. Stekke et al. (2011) concluded that this species is fairly rare in the south of Portugal because between 2001 and 2010 only 19 sightings were made by whale-watching boats. However, the present study revealed a total of 324 sightings between 2007 and 2021, ranging between 0 observations in 2013 and 91 observations in 2017 (see Table III and Fig.14A). These data may indicate an increase in the number of observations of this species. Nonetheless, our data are based on reports from only a fraction of all whale-watching companies, and therefore a more thorough evaluation will only be possible when/if all companies deliver their annual reports.

Considering Mysticeti species, the minke whale has been reported as the most frequently observed in the coast of Portugal (Bencatel et al., 2017). According to the study by Bastos-Santos et al. (2016), the minke whale has been shown to occupy a dispersed distribution, having a superior concentration of sightings close to the coast under the 38ºN. Accordingly, considering a similar period (2010 and 2014) Laborde et al. (2015), showed that this species was also the most sighted on the south coast of Portugal whereas fewer sightings of other species were registered (*B. musculus; B. physalus; M. novaeangliae* and *B. borealis*). These results also go along with the ones gathered in this study (see Fig.14B and Table IV). Until 2010 it was thought that the most common mysticete species on the southern coast of the Algarve was the fin whale (Castro, 2010; Brito et al., 2009). However, according to the records made by the whale-watching companies included in the present study, until 2010 no sightings of fin whale occurred. In this case, it must be considered that observations of Mysticete are bound by their migratory seasonality and by their well-known different preferred bathymetries. In the present study, there were only 2 sightings of minke whales in 2007 and 2 in 2010, although in the following years, there was a relative progression in the number of observations, being 2018 the year with the most sightings of this species (see Fig.14D and Table IV).

Currently in Portugal, specifically in the south coast area, there are no studies regarding the socio-economic impact of whale-watching activities or any estimate of their possible direct or indirect income. Therefore, one of the main objectives of the present study was to estimate the direct income produced by whale-watching. The available reports of the whale-watching companies for a range of years (2007 to 2021) were analysed and it was tried gathering information on the number of trips, the number of onboard passengers (adults and children) and ticket prices. However, when analysing this data provided by the National body (ICNF) responsible for licensing whale-watching companies it became clear that it would be impossible to estimate the historic direct income, as there were many missing reports (see Fig.17) and furthermore, many reports concerning recent years were also not available (see Fig.17). To overcome this difficulty, surveys were sent directly to whale-watching companies requesting information on the necessary parameters. Unfortunately, only four companies responded and therefore it was impossible to estimate the global whale-watching activity direct income in the Algarve. Instead, a less representative estimate was possible based on the relatively small number of companies that sent reports to the ICNF or that responded to surveys (see Table V.). Records of how many departures were made, how many passengers were transported in total per year and the price of the activity of all companies are needed to estimate the activity's direct income.

Presently, it is not possible to know how the activity is proceeding and evolving. Consequently, it becomes difficult to establish the area's carrying capacity for this economic activity and to create efficient management measures to guarantee the activity's sustainability and the least possible impact on target species. It is therefore necessary that the national organizations responsible for this activity in Portugal, act more and demand, as described in the law, the annual submission of reports by all companies. Complete reports in the future may help understand the activity's direct income, as well as changes in cetacean species observations, species occurrence and distribution, among other parameters. In fact, although platforms of opportunity such as whale-watching activities are not the most reliable way to collect representative data, these companies spend many hours daily at sea, in the same areas, close to cetaceans, making this data easily accessible for future studies.

Dedicated, systematic surveys have been made to evaluate the distribution and/or abundance of cetaceans in the Iberian Atlantic waters using airplanes, boats or coastal points (López et al., 2004; Hammond et al., 2013, 2021; Pierce et al., 2010; Santos et al., 2012; Vingada & Eira, 2018). While land-based surveys are only possible on the coastal seas, dedicated ship-based and aircraft surveys are logistically challenging and expensive. So, the use of data gathered by on-board observers from platforms of opportunity, such as passenger ferries (Kiszka et al., 2007), whale-watching vessels (Moura et al., 2012), and fishing boats (Spyrakos et al., 2011), as well as using data from cetacean strandings (López et al., 2002; Silva & Sequeira, 2003), historical records (Brito et al., 2009; Brito & Vieira, 2010), and surveys (Maynou et al., 2011), has become increasingly common among researchers. There are numerous methods for determining the quantity, distribution, and habitat preferences of cetaceans, each with distinct advantages and disadvantages. In the present study, all data about the sighted species over the years was taken from the reports available from whale-watching companies present on the south coast of the Algarve. Due to the low number of available reports, it was not possible to estimate and evaluate changes in the observation rates for the different species over the years. Considering the large variation of observations in the different study years, even after excluding those with very small number of reports and observations (see Fig.15) are not very representative (they may not be very reliable). Therefore, a more in-depth study based on a larger number of reports is necessary in the future so that this type of data can contribute to the characterisation of cetacean occurrence in the Algarve and to understanding the factors that condition their occurrence over time. Despite the high variability in the number of reports available for each year, contributing to a heterogeneous sampling effort, the present study offers new insights into the occurrence of several species. Opportunistic sampling can cover a large region at a relatively low cost and make use of local ecological knowledge to produce information needed for cetacean conservation, but it has some limitations in terms of reliability (Goetz et al., 2015). When compared to data from dedicated surveys, the two most significant limitations are an unsystematic sampling effort possibly leading to biased results (Wall et al., 2006) and unreliable species identification, because of the inexperienced observers gathering data (Hauser et al., 2006). This later inexperience could be improved with the establishment of an educational programme.

Since cetaceans are the target species, and there is a lot of whale-watching activity on Portugal's southern coast, its effects should be taken into account, and further research should be done to better comprehend how these animals use this area (Cid et al., 2013). There are already quite a few companies enrolled in this activity in the Algarve, possibly including unlicensed companies who are able to operate freely due to poor legal enforcement. Additionally, the majority of businesses lack the means and the employees with the necessary training to properly pass on information about the species to the public. Cetacean operators also struggle to keep the public informed about scientific developments on these animals. To effectively connect the general public with science and increase ocean literacy, ecotourism must incorporate elements of environmental awareness, conservation, and education. For efficient long-term management, new regulations for whale/dolphin watching in the south of Portugal are also essential (Vieira, 2017).

Further research on cetaceans in Portugal's mainland coastal waters, including the south coast, is needed. It is fundamental to do more dedicated cetacean scientific surveys and long-term studies to gain a deeper comprehension of cetacean communities. Unfortunately, one of the biggest impediments to this happening more often is the lack of funding (Castro et al., 2021). For a better understanding of the significance of the area and to look at potential residence patterns of the various species, additional research on habitat use, photo identification and behaviour is needed (Castro et al., 2013).

In conclusion, although commercial whale-watching activity is legally regulated in Portugal, proper enforcement is lacking, and further legal obligations are necessary. Finally, the present study allowed defining a series of necessary studies and recommendations that could improve the environmental sustainability of the whale-watching activity in the Algarve.

Future studies:

- estimate the whale-watching carrying capacity for the Algarve, since it is a constantly expanding activity;

- understand the direct income of this activity;

- evaluate impacts on cetacean species and assess which type of boats produce lower impacts.

Future recommendations:

- The AIS (Automatic Identification System) or other tracking systems could be implemented in all cetacean observation vessels to improve understanding of species distribution and knowledge of the operating fleet;

- At least one properly trained skipper/crew member should be on board on every trip, particularly through certified courses on the identification and biology of cetacean species;

- Skipper training should be mandatory on the code of conduct and rules to follow when watching dolphins and whales;

- More enforcement actions should be applied by the competent authorities during the course of the activity;

- On-board observers should be regularly present for better control of the activity;

- All companies should comply with regulations and deliver the mandatory annual report with at least a record of the number of sightings, species, number of passengers and number of trips, or an alternative solution should be found;

- If a company does not respect the code of conduct and/or does not deliver the annual report to the ICNF, legal consequences should be applied, including licence removal;

- A limit on the number of companies and vessels that operate in this area should be established, once the estimated carrying capacity can be estimated.

5. Conclusions

This work provides the first analysis of all the information available in the reports of whale-watching companies operating on the south coast of the Algarve. The contribution of this study is highly relevant because it emphasised the small number of reports in relation to the issued number of licences and the missing information that was being kept out of the reports and licensing forms. Although commercial whale-watching activity is legally regulated in Portugal, proper enforcement is lacking, and further legal obligations are necessary. The establishment of a carrying capacity of the target species is of upmost importance. Furthermore, the present study also revealed that it is necessary to improve the code of conduct, since a low compliance of the code of conduct has already been reported, and the way the licensing system is conducted on Portugal's mainland. It is also very important to do further research to evaluate which types of boats are more impactful and if there are already effects of the increasing activity on the species in this area. All the work carried out in this master thesis will be used later by the other researchers and project partners from the Project META, to establish a framework to evaluate the WW carrying capacity and a protocol to collect data from WW boats, to deal with the lack of information on the reports and propose management measures for this activity in this region of Portugal's mainland.

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7. Annexes

7.1. A – Survey sent to all whale-watching companies operating in Algarve

META

Promotor: museudabaleia

Questionário destinado a operadores de empresas de observação de cetáceos no Algarve

Breve descrição

O projeto META é um projeto financiado pela República Portuguesa através do Fundo Azul coordenado pelo Museu da Baleia da Madeira (MBM) e tendo como parceiros o Instituto do Mar (IMAR) nos Açores, o Instituto Gulbenkian de Ciência (IGC) em Lisboa e a Mar Ilimitado em Sagres. O projeto decorre simultaneamente nas regiões dos Açores, Madeira e no continente. Em relação à região do Algarve, o principal objetivo é avaliar o impacto sócio-económico da atividade comercial de observação de cetáceos. Este questionário é destinado a todos os operadores das empresas de observação de cetáceos no Algarve, de forma a obter algumas respostas em relação ao funcionamento e a evolução desta atividade ao longo dos anos e por fim o seu impacto sócio-económico. Todas as respostas são confidenciais e tratadas de forma anónima. A sua resposta a este questionário é muito importante para a realização deste estudo. Caso não queira responder a alguma das questões abaixo, agradecemos que envie na mesma as suas respostas, mesmo que o questionário esteja apenas respondido parcialmente. Obrigada pela sua atenção e pela sua disponibilidade para responder a estas questões tão importantes para conhecer melhor a atividade.

Questões

1. **Em relação aos anos de 2018, 2019, 2020 e 2021, preencha a tabela com os dados da sua empresa para a atividade de observação de cetáceos apenas.**

Ano	2018	2019	2020	2021
Nº total de barcos				
Soma da Capacidade total dos barcos				
Mês de início da atividade				
Mês de fim da atividade				
Nº total de saídas realizadas				
Nº total de passageiros transportados				
Nº total de avistamentos de cetáceos				
Receitas Brutas (em euros)				

1.1. Foi possível diferenciar os dados de observação de cetáceos das outras atividades da empresa na resposta anterior?

Sim ☐ Não ☐

2. **Em 2018, 2019, 2020 e 2021 qual era o preço de 1 bilhete?**

Preço/Ano	2018	2019	2020	2021
Adulto				
Criança				

3. **Qual(ais) o(s) principal(ais) porto(s) de saída das suas embarcações?**

Cofinanciado por: República Portuguesa, fundoazul

Parceiros: Instituto Gulbenkian de Ciência, imar, Okeanos, mar ilimitado