Quantification of the exposure of cetacean individuals to whale-watching vessels through the photo-identification technique in the South coast of Madeira Island (Portugal)

Research Study for the Environmental Sciences Degree

by

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I want to express my gratitude to all who, one way or another contributed to this study:
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Abstract

The fast growing of the whale-watching tourism in the world as in the study site, is the cause of the urgent need of developing whale-watching impact studies. The exposure of cetacean individuals to whale-watching vessels in the south coast of Madeira Island was quantified using data collected during August, September and October 2011. 9 species were sighted and seasonality and occurrence were consistent with precedent studies. *Tursiops truncatus* was the more frequent species with the 36% of the sightings, followed by *Globicephala macrorhynchus* with the 27% and *Stenella frontalis* 16%. Individuals were identified through the photo-identification technique using natural marks. Only 27 (34,62%) identified individuals of *G. macrorhynchus* out of 78 identified individuals, were seen more than once, being 4 the maximum number of captures. From the 98 identified individuals of *T. Truncatus,* a total of 26 (26,53%) individuals were recaptured, with a maximum of 5 captures. For *S. Frontalis* only 2 (4,17%) individuals were recaptured out of 48 and only once. For *Balaenoptera brydei* only 2 individuals were identified and one was recaptured. It was calculated the success probability of sighting cetaceans, during the study period, of whale-watching boats that operates from Funchal port and collaborates with the Madeira Whale Museum, resulting in general the 81,7% with a mean of sightings per trip of 1,25. Any pattern of seasonality nor residentially was extracted because of the shortness of the study period, being impossible to distinguish the residents which may be more vulnerable to cumulative exposure vessel. Also any data about population size is available to relativize these individual quantifications. Collaborative studies are suggested at least between Macaronesian Archipelagos and moreover, to the assessors of whale-watching activity which are determining the carrying capacity and the actuation area, acoustic measures were recommended to be effectuated to whale-watching boats. Finally, the creation of a Marine Protected Area as part of an Atlantic network may be decisive as a conservation measure.

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1. General Introduction

This study is developed in the context of the collaboration between the University of Murcia (Spain) and Madeira Whale Museum (Portugal) through the university exchange programme "Erasmus Placement 2010/2011". The objective was to accomplish practical experience and its concretisation in a research study to achieve the Environmental Science degree.

Other essential partnership for the accomplishment of this study is the one between Madeira Whale Museum and the whale watching touristic operators of Madeira Island. By the LIFE+ Project "Cetáceos-MadeiraII", it is established a collaboration protocol with this relevant stakeholder, aspiring to the sustainable development of this activity by the conservation of the wildlife resources of Madeira Archipelago.

The aim of this study was the application of the photo-identification technique in cetaceans for a quantification of the exposure of individuals of cetaceans to whale-watching vessels. It tries to be a contribution to the whale-watching impact studies in a sector that is growing fast (O'Connor *et al*. 2009) and a proper management will provide environmental, social and economic benefits. Specifically, in this region these studies are need because any official management measure is being implemented, only a Voluntary Code of Conduct, and its growing follows the rhythm of the global scene.

1.1. Ecological role of cetaceans

Taxonomically, the Order Cetacea is divided into two Sub-orders: Mysticetes (or baleen whales) and Odontocetes (or toothed whales). The 85 known species of cetacean recognized to date (Rice, 1998 and IWC, 2001) are spread worldwide in oceans, rivers and seas. Their ecological role in marine ecosystems is explained by various interactions. It is thought they influence as predators, as prey and as detritus.

As predators, the most of them are in the apex in the food web of marine ecosystems. The consumption of significant quantities of prey is the main way they impact marine ecosystems as they affect their distribution and abundance (Croll *et al.* 1998). In addition, cetaceans may serve to structure marine ecosystems through the regulation of mainly krill-based and squid-based food webs. Moreover, some large cetaceans provoke consumer-induced effects, in concrete, while foraging by the reduction of the local invertebrate biomass and the re-suspension of large quantities of sediment and nutrients.

As a prey, some large whales represent a valuable nutritional resource for both human and animal consumers, namely industrial whaling and killer whales respectively. The reasons are their large size, great abundance and high energy density.

As detritus, dead cetaceans that are not immediately consumed, either washed ashore or sink to the sea floor. In this last situation, the carcass is equivalent to several thousand years of organic carbon input for that area in a single pulse, feeding in some cases about 370 species. When stranding, they provide important nutritional resources to various terrestrial vertebrates (Estes, 2008).

Admitting this, the role of cetaceans in ecosystem dynamics is still poorly understood. This is particularly true in offshore systems, due to the difficulty of collecting data on cetacean

distribution, abundance, habitat and resource use, at relevant spatial and temporal scales. Moreover, logistical constraints of attempting to study highly mobile, oceanic animals that spend nearly all of their lives underwater, and the political and legal constraints of working on protected species, which include most cetaceans, are some reasons that make the study of this group a great challenge (Ballance, 2008).

1.1.1. North Atlantic populations of cetaceans

Both mysticets and odontocets are represented in the North region of the Atlantic Ocean. They respond to species-specific ranges and non-uniform distribution patterns occupying all North Atlantic marine regimes (Gordon *et al*. 2008).

Furthermore, North Atlantic cetacean populations have been impacted significantly by human interactions (Reeves *et al.* 2003). Harvested for subsistence, commercial use and for their cultural value, some species have been overexploitated resulting in extinction or in significant population declines. It has also probably caused substantial ecological changes like the reduction of top predators and competitive interactions (Kraus *et al.* 2007).

These populations are also characterized by the impact of numerous species by indirect mortality, mainly due to fishery bycatch and pollution (Hall *et al*. 2002). Climate change is also affecting North Atlantic cetacean populations, especially species that live in the cold temperate to polar seas (Learmonth *et al*. 2006).

1.1.2. Macaronesia populations of cetaceans

In the North East Atlantic Ocean is located the Biogeographic Region of the Macaronesia. It is composed by the archipelagos of Cape Verde, Canary Islands, Azores and Madeira and a portion of the African continent called “African Macaronesia Enclave” (Figure 1.1). This region presents unique geological and biological characteristics.

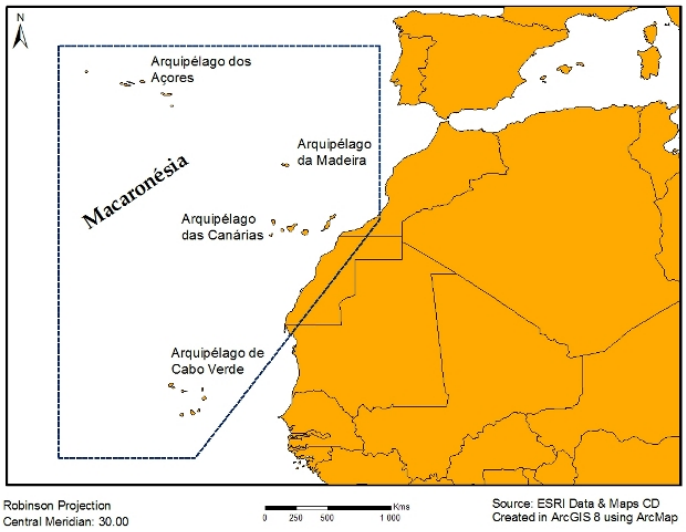

Figure 1.1: Biogeographic Region of the Macaronesia. From EMECETUS project website (http://www.emecetus.com/)

In oceanic islands and seamounts, local processes that cause a high biological productivity are generated, representing important discontinuity structures in the open ocean. Specifically, the topographic disturbance by an island of the oceanic flow may cause warm wakes, eddies and small-scale upwelling features, increasing, into the euphotic layer, the supply of nutrients. This fact leads to the enhancement of the primary productivity (Caldeira *et al.* 2002). According to this, due to the low production characteristic of offshore waters, the waters around these oceanic islands

are considered as “oasis”. They own a high diversity of cetaceans and some species are only seen in these waters.
Concerning the cetacean populations of the macaronesian archipelagos, it is known the presence of resident populations of *Globicephala macrorhynchus* in Canary Island waters and *T. truncatus* in Azores and Canary Island waters. Furthermore, it should be recognized the study of Sophie Quérouil called “*High gene flow in oceanic bottlenose dolphins (Tursiops truncatus) of the North* Atlantic” where it is suggested the existence of a unique oceanic population of *T. truncatus* in the template latitudes of the North Atlantic Ocean pelagic waters. Therefore, they concluded that this large size and high genetic diversity population should be handled as a management unit from the conservation point of view.

1.1.3. Madeira Archipelago populations of cetaceans

In the case of Madeira Archipelago, its oligotrophic waters are influenced by the Azores current and the Canary current, that derive from the Southern branch of the Gulf Stream. Its underwater topography does not present continental shelf, so that, high depths are reached from little miles from coast. Therefore, these variables explain the presence of a great variety of cetaceans in the waters of Madeira Archipelago, in addition to the before referred nutrient rich water masses that flow to the surface increasing the primary production. From one side, the lack of continental shelf provokes that oceanic cetaceans that inhabit deep waters, get closer to the coast. And from the other side, it has to be added the food availability plus the suitable conditions for resting, socialization, mating, birth and survivorship of calves. Furthermore, belonging to the macaronesian chain of “oasis”, Madeira Archipelago probably operates as reference spot for the migratory cetacean orientation (Freitas *et al.* 2004).

In Appendix 1 it is presented the List of cetacean species in Madeira Archipelago waters (Freitas *et al*. *in prep*). A total of 28 species have been cited with different occurrence and seasonality.

Migratory species, like some whales pass by during its migrations to the north in spring and to the south in autumn. Regarding to dolphins, species like Common Dolphin, Spotted Dolphin or Stripped Dolphin being migratory species, they are quite abundant in some seasons and apparently absent in others (Freitas *et al*. 2004). And referring to the Bottlenose Dolphin (*Tursiops truncatus*), it is an evidence the existence of resident individuals in the waters of Madeira Archipelago during consecutive seasons and years (Freitas *et al.* 2002).

Besides, through the photo-identification technique for the verification of the existence of resident groups of *T. truncatus*, two different forms of this species, a coastal resident one and other oceanic transient were recognized (Freitas *et al*. 2002). Studies of the Madeira Whale Museum, still in process, are also trying to find out the existence of resident groups of other species, the short-finned pilot whale (*G. macrorhynchus*).

1.2. Threats and Conservation Status.

In the past, many species and populations of cetaceans were exploited by humans and still they are affected but indirectly by several activities. They included commercial fisheries, coastal development, coastal and offshore drilling, dredging and dumping, military exercises, tourism development and scientific research among others (Hofman, 1995; Hooker and Gerber, 2004).

As an action of the Madeira Whale Museum LIFE Project “Projecto para a Conservação de Cetáceos no Arquipélago da Madeira (2000-2004)” (Project Life99 NAT/P/006432), were identified the threats for cetaceans in Madeira Archipelago waters coinciding with those mentioned already.

Moreover, some potential impacts were recognised as aviation, aquiculture, discharge of organic wastes, land clearance, heavy metals, hydrocarbons and underwater prospection and demolition. Even the specific threats of whale watching to cetacean populations were identified. They are the uncompliance of the Voluntary Code of Conduct, the unsuitability of some touristic boats and the quick increase of the activity.

During the course of that cited project, it was considered the assessment of the UICN (International Conservation Union) conservation status for the species of cetaceans in Madeira archipelago waters at regional and global level. The results followed the UICN criteria and categories were compiled in the document "Estatutos de conservação dos cetáceos no Arquipélago da Madeira" ("Conservation status of cetaceans of Madeira Archipelago") and are presented in Appendix 1, updated from the UICN website. It is an important tool for consulting in the definition of management and conservation policies of these species.

So that, to protect vulnerable species and ecosystems, between other ecological and social reason, has been set up the conservation figure of Marine Protected Areas (MPAs) (Hooker and Gerber, 2004). When it is set up around cetaceans or marine mammals in general, as a result of their function as umbrella species, usually positive effects occur to other species (Simberloff, 1998; Hoyt, 2005). Nonetheless, from the cetaceans conservation point of view, Marine Protected Areas happen to be too small, too few in number, and too weak in terms of protection (Hoyt, 2005). However, those inconvenients could be compensated. Erich Hoyt, in its article about MPAs in the second edition of Marine Mammals Encyclopedia, comments that the creation of networks of MPAs can be fundamental for an effective conservation plan for these wide-ranging species and for marine ecosystems on the whole.

In the Madeira Archipelago, studies are being carried out with the aim of the establishment of a Marine Protected Area. It is one of the goals of the LIFE+ Project "Cetáceos-MadeiraII", the continuation of the project cited before. The creation of this area would also reinforce the ecological coherence and connectivity of the marine areas of the Natura 2000 Network in the Atlantic.

1.3. Whaling industry

Aboriginal whaling was the hunting for subsistence of coastal communities from distant times and still today whale products play an important role in the nutritional and cultural life of native peoples. Some examples are the Eskimos in Greenland and Alaska, and Bequians in the Grenadines (Ellis, 2008).

Industrial whaling appeared in the 17th century, for the demand of whale oil firstly and after for margarine and meat, leading to the whale harvesting in the first half of the 20th century. Peoples strongly linked to whaling in that period were the Basques and the Azoreans. In 1982, the IWC banned commercial whaling so that negligent practices and controversy began, as whaling with scientific-research basis by Japan and pirate practices by Soviets (Clapham *et al*. 2008).

The whaling activity in Madeira Archipelago was developed between 1940 and 1981. It was founded by Azorean whalers in 1940 installing the first whaling factory in the North coast of the island in Ribeira da Janela.
The second processing station in the south coast in Calhau do Garajau 1942, contributed for the abandonment of the first one after some years. In the lates 40´s, Caniçal whaling factory was installed in the eastern extreme of the South coast with a higher efficiency due to the

modernization of the equipments. This one replaced the Garajau factory, achieving its production peak during the 50's and 60's.

A network of eight outlooks above high coastal spots was the basis of the success of this activity allowing the integral coverage of Madeira Island coastal waters and the partial ones of Desertas and Porto Santo.
The international movement for whales protection increased in the 70's forbidding, in some countries like United States, England and France, the commercialization of products extracted from these animals. Until then, those countries were the main purchasers of the Madeira production, leading to the voluntary end of this activity in Madeira Archipelago in 1981. Marine Mammals protection law was implemented in 1986.

1.4. Whale-watching tourism

The switch from whale-killing to whale-watching shows other kind of exploiting the region's cetacean resources. In coastal communities, whale-watching can be perceived as a positive alternative to the enhancement of the ecological and economical sustainability (Hoyt, 2001).

On the one hand, whalewatching contributes with a crucial educational role. It is increased the public awareness about the difficult situation of the oceans in general (Hoyt, 2001) and particularly about conservation issues relating to cetaceans (Forestell, 1993).

On the other hand, its revenues are locally significant and in some areas can be also important at a national level (Hoyt, 2001). From the beginning of the activity, numbers of revenues and participants have expanded and the activity has spread to other countries. Namely, for 2008, based on the substantial growth in the precedent years, there is a minimum world estimate of 13 million whale watchers in 119 countries worldwide, generating $2.1 billion in total (IFAW, 2009).

The wild cetacean observation in the Madeira Archipelago has increased in the last years as it happens in the rest of the world. It was calculated an annual estimation for 2007 indicating its economic relevance. The study of Rita Ferreira, "Characterization of the cetacean observation activity in Madeira Archipelago" estimates an annual revenue of 1,5 million euro, corresponding to 58 thousand tourists approximately.

Due to such explosive growth, management problems have appeared. The presence of many boats in a limited area, too many close approaches and collisions with cetaceans require any kind of regulations. The most of these guidelines have been suggested by researchers or NGO's, however, even operators have organized themselves in associations to formulate their self-imposed ones (Carlson, 2004).

The Madeira Whale Museum designed whalewatching guidelines in a Voluntary Code of Conduct in 2002. The most of the boats adhered it and an assessment of the compliance done in 2007 showed a large compliance of the code in general, independently of having joined to the voluntary code of conduct (Ferreira *et al*. 2007).

1.5. Research on whale-watching impact on cetaceans

Researchers on whale-watching impact on cetaceans, since the lates 90´s, are investigating if observed short-term effects on cetaceans can lead to long-term negative impacts. Namely, examples of short-term effects are the approach or avoidance of boats, the augmentation of the diving time and generally the interruption of natural behaviour. Habitat displacement and

reduction of population parameters like survival rate or reproductive success are some kinds of long-term negative impacts. This sort of studies have been focus in mating, calving, feeding, and resting areas, in the time and boats approaching to the same group of cetaceans and in intensive whale watching of rare species (Hoyt, 2008).

Attention is given to the way in which disturbance responses, especially to acoustic stimuli, can affect cetacean populations. Since cetaceans use sound for a series of vital processes including communication, navigation and detection of prey and predator (Au, 1993) they may be affected by anthropogenic underwater noise from motorized vessels. These contribute to the ambient noise level coinciding with the communication frequencies used by many cetaceans (Haviland-Howell *et al*. 2007) and could cause behavioural or physical changes or impede the transmission or acquirement of information acoustically (Richardson *et al*. 1995).

Some studies have accentuated the sensitivity of small dolphin of inshore populations in restricted areas. Their recurrent exposure to whale watching vessels is leading to long-term impacts, specifically, in Shark Bay, West Australia, where *T. Truncatus* resident population is decreasing. An experiment about behavioural responses to vessel approaches were moderated for residents individuals comparing with those out of the impact site. These facts suggest that sensitive individuals of the resident population already may have died, moved out of the area or been habituated (Bejder *et al*. 2006).

The research in this area is been guided mainly by the global body responsible for the conservation of cetaceans, the International Whaling Commission. The subject of whale watching was considered since 1975 including scientific, legal, socioeconomic and educational aspects.
In its frequent reports, the more representative studies and new ideas from the scientific activity in this topic are discussed. Also they promote and recommend certain lines of work for future studies for an identification, assessment and increase of knowledge about the potential impact of that activity on cetaceans.
In addition, the IWC organize workshops, for example in 2004 “Science for Sustainable Whalewatching” and, in 2010, the “Workshop of whalewatching” in Argentina. Moreover, nowadays “A Five Years Strategic Plan for whalewatching (2011-2016)” is being carried out.

As the responsible in the assessment of the whale watching activity in the Madeira Archipelago is the Madeira Whale Museum, previous research on the whale watching tourism has been developed by this institution. Its scientific activity in cetaceans started in 1996 and enshrined in several projects, it has contributed to the assessment and evaluation of this touristic activity. As part of the LIFE Project “Projecto para a Conservação de Cetáceos no Arquipélago da Madeira” (Project Life99 NAT/P/006432, “Project for the Conservation of Cetaceans in Madeira Archipelago”), it was designed, in 2002, a Voluntary Code of Conduct for whale-watching vessels for the reduction of the potential impact of this activity on cetaceans. Also as part of that project, it was characterized the activity in the document ”Documento J - Relatório da caracterização da actividade de WW e avaliação dos seus impactos” (“Report of the Characterization of the Whale-watching Activity and Impact Assessment on Cetaceans”). Moreover, a proposal for legislation was effectuated to the Regional Government through the document called “Documento I - Plano de Gestão e Regulamentação de actividades de observação de Cetáceos na RAM” (“Management Plan for the regulation of the cetacean observation activities in the Autonomic Region of Madeira”).

Some research studies in collaboration with the University of Lisbon have been also developed, namely, the master thesis of Rita Ferreira, in 2007, called "Monitorização da actividade de observação de cetáceos no Archipielago da Madeira, Portugal" ("Monitoring of the activity of cetacean observation in Madeira Archipelago, Portugal"). This study is composed by "Caracterização da Actividade de Observação de Cetáceos no Arquipélago da Madeira" ("Characterization of whale-watching activity in Madeira Archipelago") where questionnaires and observations, using land-based theodolite tracking and whale watching boats, were accomplished to describe the presence of boats in the area. Characteristics of the touristic vessels were compiled and moreover, estimates of tourists and revenues were calculated. In addition, this thesis was also composed by the study "Avaliação dos Impactos das Embarcações de Observação de Cetáceos no Arquipélago da Madeira" ("Impact assessment of whale-watching boats on cetaceans in Madeira Archipelago") were behavioural analysis of cetaceans response to vessels approach and the compliance of the Voluntary Code of Conduct were measured too from land-based theodolite tracking and whale watching boats.

Nowadays, a LIFE+ Project called "Cetáceos-MadeiraII" (LIFE07 NAT/P/000646, 2009-2013), continuation of the precedent LIFE Project, is being developing the objective 2 consisting in "*Define areas of operation for the whale-watching boats in Madeira archipelago waters and establish the respective carrying capacity*" through nautical surveys, photo-identification technique, characterization of vessels and routes and boardings of volunteers for checking the compliance of the Voluntary Code of Conduct.

1.6. Mark-recapture technique and photo-identification

The capture-recapture method, or mark-recapture, is an individual-based study that was early applied in ecology to estimate abundances of a determined species in an area where all individuals cannot be counted. It consists, essentially, in capturing individuals to mark them, and after that, they are released into the population. In next occasions, the proportion of new and already marked individual captures gives the abundance estimation.

Capture-recapture studies in cetacean populations are based on the use of natural markings like nicks and notches on dorsal fins, pigmentation patterns, markings on tail flukes and callosity patterns (Hammond *et al*. 1990). These distinctive features must be sufficiently long lasting, slow changing and unique to be recognized in subsequent sightings (Hammond, 1986).

So that, photo-identification technique consists in using photographs of distinctive, naturally occurred markings to identify individual animals. It is one of the best and least intrusive methods used for collecting information about cetacean societies in the wild. For example, it has been applied to bottlenose dolphins (*Tursiops truncatus*) by Würsig and Würsig (1977), to sperm whales (*Physeter macrocephalus*) by Whitehead (1990) and blue whales (*Balaenoptera musculus*) by Calambokidis and Barlow (2004).

Furthermore, based on individual re-sightings, capture histories can be used to register short-term movement patterns and migrations (Würsig and Harris, 1990), for life history and ecology of individuals (mortality, fecundity, immigration and emigration rates) and also for abundance estimates (Whitehead *et al*. 2000). In this case, when estimating the population size in wild cetacean societies, the population must be defined as either open or closed even allowing to estimation of births, deaths, immigration and emigration parameters (Wilson *et al*. 1999).

In Madeira Archipelago photo-ID studies are being developed by the Madeira Whale Museum for a long time specifically with *T.truncatus* and *G.macrorhynchus* as target species reaching to the evidence of a resident group of the first one (Freitas *et al*. 2002). Also photo identification is done with baleen whales, sperm whales and beaked whales. Moreover, some of the whale-watching boats crew collaborate with their images.

1.7. Objectives

Cumulative boat exposure induces long-term effects in cetacean individuals, particularly in resident individuals of small dolphins in a small area frequented by whale watching vessels (Bedjer *et al*. 2006). This study tries to quantify the cetacean individuals that are being approached repeatedly by the whale watching boats, identifying them through the photo-identification technique, in a region were in spite of the fast growing of the activity, any management of the resource is being implemented. Presumably, frequencies obtained will provide complementary information for the characterization of this activity in the South coast of Madeira Island.

The main objective of this study aimed:

To provide additional information to the institutions responsible of the cetacean conservation, in the world, the Sub-Committee on Whalewatching of the International Whaling Commission, and in the Autonomic Region of Madeira, Madeira Whale Museum, for the management of the increased cetacean-focused tourism industry in Madeira Island. An accurate determination of the operation area of the activity and the carrying capacity of the resource is needed for reaching an environmentally sustainable economic activity. The calculation some statistics about each vessel and encounters with cetaceans will provide valuable information for the characterization of the activity.

And the specific objectives are:

- The determination of the number of times that each identified individual is exposed to whale-watching boats.
- The determination of the most exposed species to whale-watching boats.
- The calculation of success probability of each touristic operator of encountering any cetacean and the success probability of encountering any cetacean in general as a characterization of the activity.

2. Methodology

2.1. Data collection

2.1.1. Survey Area

The Madeira Archipelago is located in the Southeast of the North of the Atlantic Ocean between 33º 07' N and 32º 24' N latitude and 16º 17' W and 17º 16' W longitude (Caldeira and Lekou, 2000). It is a volcanic island, with a remarkably mountainous topography, sited in the oceanic crust along the African Plate, with a distance of approximately 400 km. from the Northwest of the African Continent.

The meteorological factors are determined mainly by the Azores subtropical anticyclone, responsible of the Northeast trade winds predominance. Affected by them, the superficial oceanic currents existing in Madeira Archipelago are integrated in the North Atlantic current system general circulation (I.H. 1979).

The Madeira Archipelago comprises two inhabited islands, the main islands of Madeira and Porto Santo, and two uninhabited sub-archipelagos: the Desertas Islands and the Selvagens Islands (Figure 2.1).

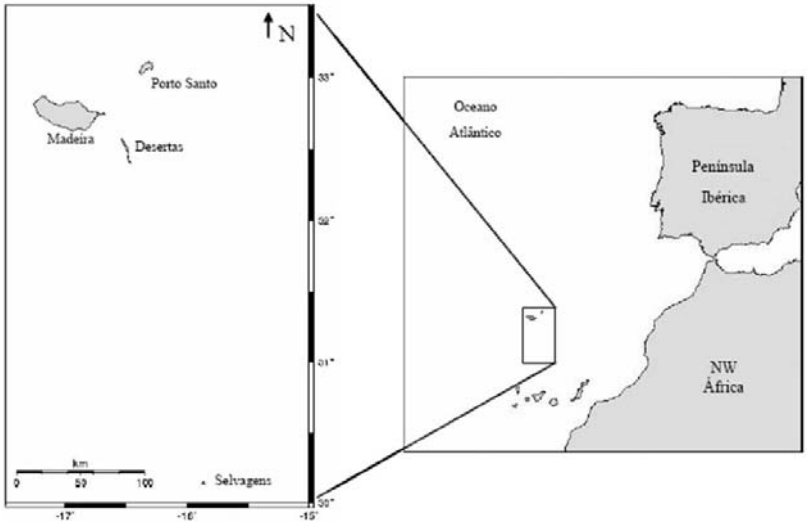

Figure 2.1: Madeira Archipelago location. Museu da Baleia da Madeira

As an oceanic volcanic archipelago, the waters of Madeira Archipelago are considered a productive area contrasting with the oligotrophic ocean waters around. Its marine topography characterized by a lacking continental platform permit to reach high depths in short distances from shore. Those features allow the presence of a variety of cetacean species typically oceanic that approach quite close to the coast (Freitas *et al*. 2004), being identified 28 different species in this region (Freitas *et al*. *in prep*).

As tourism is an important sector in the region's economy since it contributes 20% to the region's GDP (Gross Domestic Product), Madeira Archipelago's nature, is one of tourists' main reasons to visit it (Eurostat, 2012).
Concerning the cetacean observation activity, an annual estimation for 2007 indicates its economic relevance. The study of Rita Ferreira, "Characterization of the cetacean observation activity in Madeira Archipelago" estimates an annual capital of 1,5 million euro, corresponding 58 thousand tourists approximately.

The study area consisted of the waters of the South Coast of Madeira Island where the vessel-based tourism activities mainly operate. In this coast, is located Funchal, the capital city where exists the main port of the island. This maritime zone is sheltered from the predominant winds, Northeast trade winds, having good sea conditions the most of the days.

It is the home port for fishing boats, recreational boats and touristic vessels dedicated to activities like “Big Game Fishing”, whale watching and other wildlife viewing. Additionally, ferry boats and transatlantic cruisers frequent this port. Again referring to the precedent study about the “Characterization of the cetacean observation activity in Madeira Archipelago” in 2007, 7 different kinds of boats were counted in the study area and the mean of boats opening at the same time during daytime is 8.

There are some more facts that characterized the study area important to underline. The presence of the Garajau Marine Reserve, with a coast extension of approximately 6 miles and a area of 376 ha.; the Cabo Girão sea cliff, one of the highest in Europe with 589 meters, a productive fish ground in front of Cabo Girão, in addition to the Municipal Organic Waste Station with a discharge pipe and a coastal Industrial Plant of Cement that includes a small port for maritime transport (Figure 2.2).

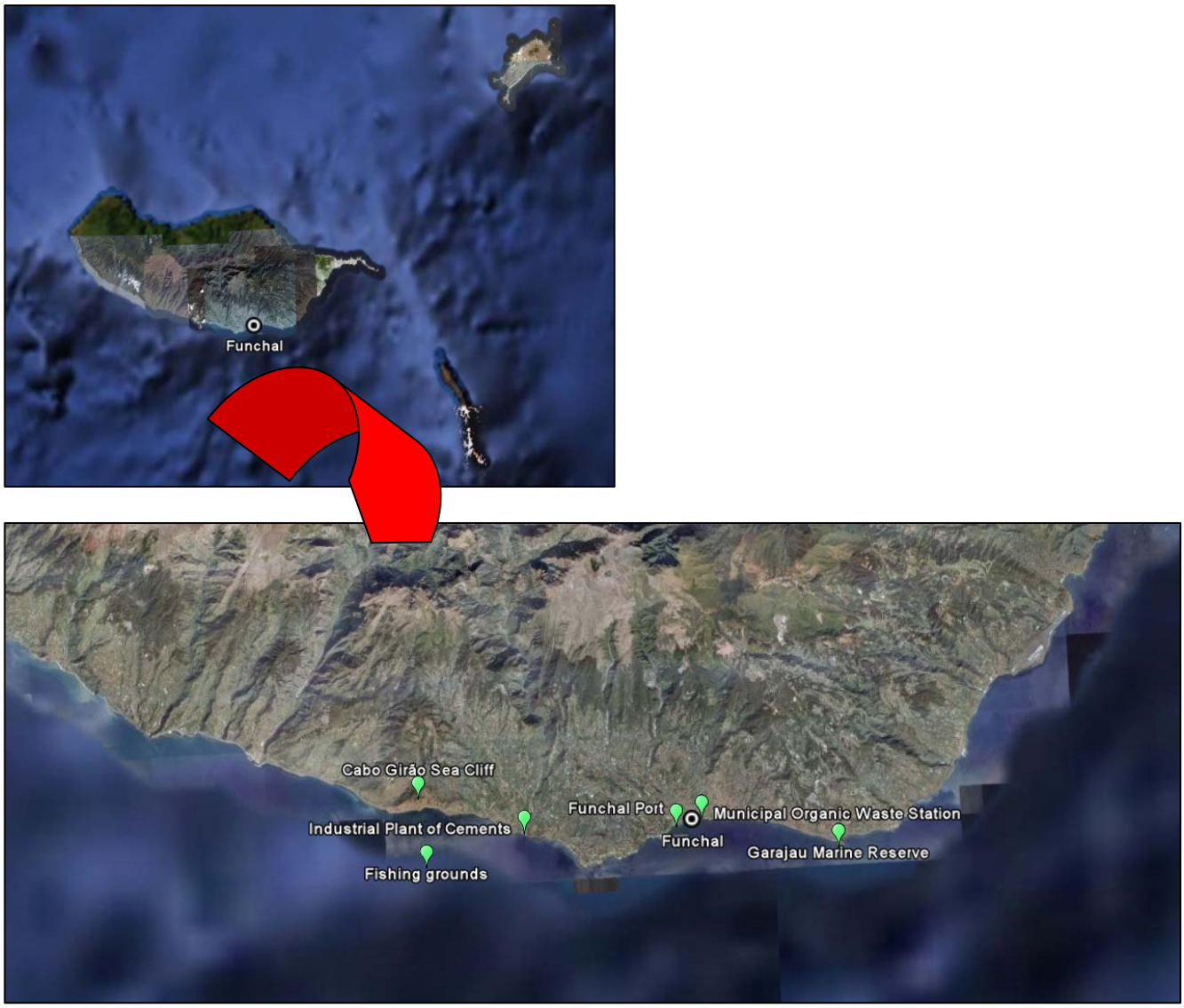

Figure 2.2: Study area characterization. Google Earth.

Diverse activities were encompassed in the study area during the study period, like professional, recreational and touristic fishing, wildlife viewing, pleasure sailing, sportive competition, deposit of inert materials, scientific research and industrial and passenger transport (Figure 2.3).

a. Pleasure Sailing.

b. Deposit of Inert Materials.

c. Scientific Research.

d. Sportive Competition.

e. Whale-watching Tourism.

f. Commercial Fishing.

Figure 2.3: Pictures of some of the activities in the study area during the study period.

2.1.2. Field studies

Survey effort

Systematic boat surveys were carried out by an observer over a 13-week period from the 3rd of August to the 29th of October 2011. The fieldwork frequency was planned to be at least 4 days a week with two trips per day, but no schedule was programmed because of the dependence on boats and personal availability.

Observation platforms

The observation platforms were the 11 commercial vessels of cetacean observation that belongs to 7 companies and operate from Funchal. They collaborate with the Madeira Whale Museum through the European LIFE+ Project "Cetáceos-MadeiraII". This partnership between science and commercial whale watching was established for the achievement of the project goal number 2 "*Define areas of operation for the whale-watching boats in Madeira Archipelago waters and establish the respective carrying capacity*".

Surveys were carried out aboard the vessels "Sea Born I", "Sea Born II" (they belong to the company "Sea Born"), "Sea the Best", "Sea Pleasure" (they belong to the company "Sea Pleasure"), "Ventura do Mar", "Gavião", "Bonita da Madeira", "Cetáceos", "Cetáceos I", "Cetáceos II" (these last three belong to the company "Rota dos Cetáceos") and "ZonaCat" (Figure 2.4). The last one do not collaborate officially with the project but allowed the boardings.

a. Sea the Best


b. Ventura


c. Sea Pleasure

d. ZonaCat

e. Gavião

f. Rota dos Cetáceos

g. Bonita da Madeira

h. Sea Born II

g. Sea Born I

Figure 2.4: Whale-watching vessels

Each company had a varied availability for boarding causing the incapacity of planning the trips and boarding the same number of times in each whale-watching touristic operator. “Bonita da Madeira” only operates from Funchal Wednesdays and Sundays, “Gavião” and “Ventura do Mar” operates in the South coast if they have enough passenger and if they have not contract any trip to Desertas Island. In addition, “ZonaCat” only works with hotel customers and commit a low dedication to animals. That is why it was supposed to be discarded but finally it was decided that it is still valuable information.

They are quite varied vessel regarding to size, passengers capacity, engine power and speed. These characteristics were collected from the crew, updating and completing the table resumed by Rita Ferreira in her study of 2007 “Characterization of the cetacean observation activity in Madeira Archipelago” (Table 2.1).

Table 2.1: Whale-watching vessels characterization. Data from Ferreira (2007) and this study."n.a.": not available

Touristic Company	Sea Born		Sea Pleasure		Terras de Aventura	Horizonte Atlántico (Ventura Nature Emotions)	Gavião Madeira	Bonita da Madeira	Rota dos Cetáceos		
Vessel	Sea BornI	Sea BornII	Sea Pleasure	Sea the Best	ZonaCat	Ventura do Mar	Gavião	Bonita da Madeira	CetáceosI	CetáceosII	Cetáceos
Tipe	Catamaran	Catamaran	Catamaran	Catamaran	Catamaran	Sail boat	Sail boat	Sail boat	Semirigid (Sea RIBs MT 860)	Semirigid (Sea RIBs MT 860)	Semirigid (Setamar 8.30)
Length (m)	22,86	22,86	19,5	22,86	18,15	15,6	13,1	22,6	8,6	8,6	8,35
Width (m)	10,5	10,5	10	10,5	9,07	4,6	3,66	6,2	2,95	2,95	2,7
Capacity (P+T)	100+3	103+3	70+3	98+4	60+3	16+2	20+2	50+3	2+12	2+12	2+12
Engine: Year	2003	2006	2008	2008	2011	1963	1997	1996	2007	2007	2010
Model	4LHA-HTTP	BY-1	n.a.	D3/160	N60	MD58	4LH	3206	n.a.	n.a.	n.a.
Brand	YANMAR	YANMAR	NANNI	VOLVO PENTA	NANNI	VOLVO PENTA	YANMAR	CATERPILLAR	SUZUKI	SUZUKI	HONDA
Power (HP/rpm)	160 / 3.300	150 / 3.600	62	160	62	96	130 / 3.300	355 / 1.800	150	150	200
Number	2	2	2	2	2	1	1	1	2	2	1
Tipe	Inboard	Inboard	Inboard	Inboard	Inboard	Inboard	Inboard	Inboard	Outboards	Outboards	Outboard
Construction date	2004	2008	1998	2008	2003	1965	1997	1996	2007	2007	n.a.
Activity beginning	2004	2008	2004	2008	2004	2003	2003	2003	2007	2007	2011

Whale watching trips

Generally, the trip frequency consists of 2 trips a day at the same hour with trip duration of 3 hours. The most of the times, they navigate in west direction to the touristically interesting Cabo Girão and make a stop for a swimming (Figure 2.5).

Figure 2.5: Standard trip. MapSource.

Semirrigids are an exception because they do not have neither a fixed hour nor route. In addition, they have 2 lookouts searching from high coastal points and offer to swim with cetaceans.

Data registration

During the fieldwork of this study, extra information was collected filling out 4 forms (Form 1: Departure Form; Form 2: Sighting Form; Form 3: Observation Event Form and Form 4: Code of Conduct Compliance Form) as voluntary observers do for checking the compliance of the voluntary code of conduct designed by the MWM and, in general, for the characterization of the activity.

These forms are part of the protocol for the establishment of the operation areas and carrying capacity for the whale-watching activity in Madeira Archipelago, objective 2 of the LIFE+ Project "Cetáceos-MadeiraII".

The geo-referentiation of vessel routes was effectuated with a portable Global Positioning System (GPS). It registered automatically also other parameters such as the vessel speed, route length and covered area.

2.1.3. Equipment

The equipment was provided by the Madeira Whale Museum:

- Digital single-lens reflex camera (DSLR) Nikon D2H;
- Lens AF Nikkor 80-200mm 1:2.8 D;
- Memory card SanDisk Compact flash ™ 8 GB;
- GPS Garmin 60.

a. GPS Garmin 60

b. Digital single-lens reflex camera (DSLR) Nikon D2H with Lens AF Nikkon 80-200mm 1:2.8 D

Figure 2.6: Equipment pictures

Photographic equipment adjustment:

It is the same as the described in the photo-identification protocol for the bottlenose dolphin for the accomplishment of the Objective 1 of the LIFE+ Project "Cetáceos-MadeiraII":

- Quality: JPEG Fine;
- Image Size: Large;
- Film speed: 200 ISO;
- Shooting: Continuous/High speed (CH);
- Focus mode: Continuous servo autofocus (C);
- Autofocus area: Dynamic-area;
- Mode: Programmed automatic (P);
- Other menus are not changed;

Forms:

Only data from *Form 2: Sighting Form* was used (Appendix 2 : Form 2-Sighting form), namely the following data:

- Boat (Embarcação);
- Date (Data);
- Trip number (Viagem nº): the first or the second trip of the day;
- Sighting number (Avistamento nº): cumulative in each trip;
- Species (Espécie): Classification of the sighted animals until the more accurate specific level with total certainty;
- School size: the average of the number of individuals that compose the school. If it is a mixed group, individuals of each species are counted separately.

In Appendix 3 it is shown a list of abbreviations used in the research studies of the MWM that was applied in this study as well and used hereafter.

2.1.4. Photo-identification

Cetaceans distinctive natural features, which appear above the surface of the water during the respiratory cycle, usually are the most useful. For individual identification, the more frequently used are heads, backs and dorsal fins because of their variations in coloured patterns, skin patches, body scarring, and nicks and notches along fin edges (Hammond *et al.* 1990).

For all the species found during the fieldwork, the main objective while photographing was the dorsal fin except for the Sperm whale (*Physeter macrocephalus*) that was the caudal fin. The rest of the body and head was also an objective because of the possible presence of marks. Moreover, pictures were taken to the whole animal for species certain identification and principally to the head for the recognition of Bryde's whale (Balaenoptera brydei) and beaked whales. In the case of short-finned pilot whales, it ocurred the possibility of taken pictures to the pectoral fin which is a complementary information.

For this study, because of its 3 months duration, also temporal marks as light scratches, scars and external parasites were used. But to corroborate a match, these short term marks were always accompanied by a long term mark.

While taking pictures in the fieldwork there are some clues to account for successful results:

- The most number of individuals possible should be photographed, trying to cover all individuals of the group;
- Photographs should be taken as perpendicular to the body axis as possible and the dorsal fin centred for a right focus;
- If possible, the sun would be behind the photographer. If it is taken against the light, the dorsal fin would appear as a silhouette, obscuring any markings, such as identifying scratches or lesions.

It was not considered necessary to capture both left and right dorsal fins of individuals, so long as each individual was photographed on at least one side.

2.2. Data treatment

2.2.1. GPS tracks and form data

GPS tracks were downloaded through MapSource Gamin software version 6.15.11. saving tracks individually with the date (yyyy-mm-dd) and name of the boat, for example "2011-08-03 (CetaceosII).gdb".
Form data were processed by the software Microsoft Office Excel 2003 (Microsoft Corporation).

2.2.2. Photo-ID procedure

Photographs storage

Photographs were sorted by encounter in a memory device, each sighting in a different file folder, showing the date (yyyy-mm-dd), trip number (V1 or V2), sighting number (A1, A2,...) and the species abbreviation, for example "2011-08-03 V1 A1 (Sf)". All the sighting folders from the same species were placed in a folder named the species abbreviation.

For image storage and analysis exist varied techniques and established protocols across research situations. There are also some software programs for photo-identification data management such as "Discovery: Photo-Identification Data Management Software System".

As digital images facilitate computer-assisted automated analysis, photo sorting and matching software (for example Darwin, ACDSee Pro v. 2.0 and 2.5) can search thousands of images in a

very short time to produce a limited set of potential matches. Then, the researcher can make the final match using the exceptional capabilities of the human eye. For difficult final identifications, additional rigor should be incorporated using multiple judges.

Experienced researchers in cetacean photo-identification from the Madeira Whale Museum suggested me how to sort data in tables in relation to the study demands. Photographic matches were made through the individual comparison by eye of the image of interest to all possible matches in the catalogue of distinctive individuals. At the end of the process, each dorsal fin match was confirmed by an experienced matcher (someone with more than two years experience with cetacean photo-identification matching).

For each sighting was followed the same procedure. Firstly, it was created an Excel file for each species from which there were enough quality photographs to get the identification of individuals, namely, Gma, Tt, Sf and Bb. These files contain 3 worksheets:

- "Sp sightings": the data from the form only for this species (confidential data of Madeira Whale Museum).
- "Sp individual-sighting": for registering the identified individuals (example in Appendix 4).
- "Sp capture-recapture": capture history of each identified individual (Table for Gma, Tt, Sf and Bb in Appendix 5, 6, 7 and 8 respectively).

<u>Capture and recapture evidence images compilation</u>

Capture and recapture evidence images will be compiled in the folder "Captures" containing a folder for each species, and this last to other folders:

- "Sp catalogue": contains the best images of each captured individual in assorted categories in folders Tt catalogue-CAT 1&2 and Tt catalogue-CAT 3. Files have this format name "Sp_nnn.jpg". "nnn" is the id-code.
- "Sp captures": contains the capture and recapture evidence images in assorted categories in folders Tt captures-CAT 1&2 and Tt captures-CAT 3. Files have this format name "Sp_MT_nnn.jpg". "nnn" is the consecutive number of the last file of this folder.
- "Sp recaptures": contains the compilation of all the images of recaptured individuals in assorted categories in folders Tt recaptures-CAT 1&2 and Tt recaptures-CAT 3. Files have this format name: Sp_nnn_Ra.jpg. "nnn" is the id-code, "R" is the number of recapture (0, 1, 2,...) and if there is more than one, a letter will be added (a,b,c,..), for example Tt_005_0a, Tt_005_0b, Tt_005_1.

Indifferently, it is chosen a species to start with. In the worksheet "Sp sightings", in its corresponding Excel file, it is checked if there are photographs of the sightings chronologically. If any photograph was taken, the next event will be checked. Otherwise, the rest of registered data will be read and after this the corresponding folder with the pictures of that encounter will be opened. All of them will be seen successively to have an initial idea. The photography image viewer and editor software used is Windows Live Photo Gallery 2009 of Microsoft Corporation.

The next step is to delete the photographs that do not bring information: sea, sky, out of focus, far distance... and it follows searching for the best or bests photographs of each individual. It is possible that it does not exist a good enough one individually, but between some of them together, like a puzzle, a capture can be obtained. To amplify them, it was used the tool called "Actual size" that zooms to its original size.

Categorization of capture evidences

The selected photograph(s) of that individual represent(s) its capture evidence. Identifications were then assigned a distinctiveness rating, ranging from 1 – 3, based on a number of photo qualities, such as focus of the image, distance, and the angle of the dorsal fin relative to the frame:

- Category 1: Photograph, of enough size and focused, of the whole dorsal fin and perpendicular to it where the individual has a naturally marked fin and it is recognisable with certainty from any side, right and left, if it has been captured previously.
  On the contrary, If it has not been captured before, it will be recognised with certainty If , in future encounters, it is get a photograph of it of enough size and focused of the totality of the dorsal fin and perpendicular to it (Gma_040La).

Figure 2.7: Example of category 1

- Category 2: Photograph, of not enough size and/or focused, of the whole dorsal fin but with any natural mark or special shape;
  or of enough size and focus, of a portion of the dorsal fin and perpendicular to it;
  or of enough size and focus, of the whole dorsal fin and an angle different to the perpendicular.
  All of them are enough to recognise with certainty from any side, right and left, an individual captured previously or for recognise it if it appears again in future encounters.
  These photographs will not be excluded in the final counting and will be arranged in the same file folder as category 1, named “Sp captures-cat 1&2” (Gma_107).

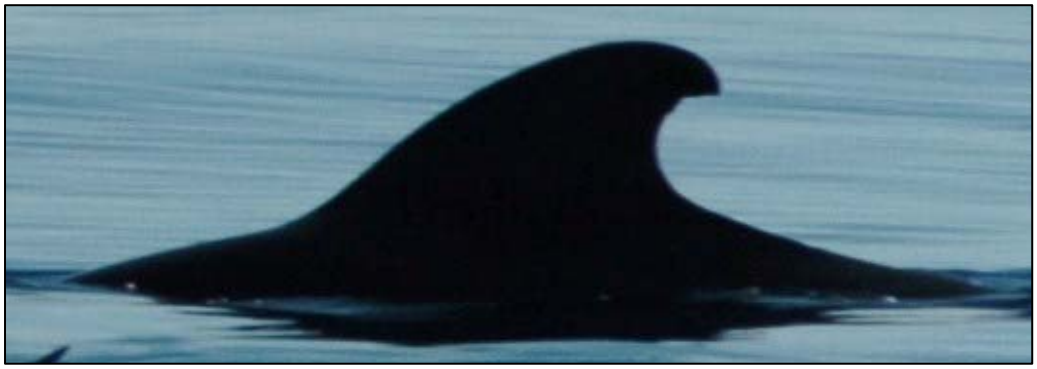

Figure 2.8: Example of category 2

- Category 3: Photograph of an individual without natural markings but enough size and focus, frequently calves or juveniles;
  Or of an individual with a distinctive body mark;
  Or of an individual only recognisable form one side;
  Or in general a photograph of bad quality but with the certainty that it is not an individual captured in that same encounter. For this reason, they are placed to the end of the capture analysis process of each sighting.
  These photographs will be excluded in the final counting and will be arranged in a different file folder as category 3, named "Sp captures-cat 3".
  It is a possibility to have photographs of the same individual in the same encounter with different categories due to its complementary or accessory value, but without any rate as a capture evidence. They will be stored in the same folder as categories 1 and 2. For instance, an out of focus photograph of the opposite side as the one that represent the capture evidence (Tt_MT_006 and Gma_050b).

Figure 2.9: Examples of category 3

After the photograph selection, from the image viewer (Windows Live Photo Gallery 2009 of Microsoft Corporation) it is made a copy in the folder "Sp captures": File-> To make a copy-> To open folder "Sp Captures" (inside folder "Sp" located inside folder "Captures")-> To change the name -> Sp_Mt_nnn.

Image edition

Next, the procedure continue with the image edition to get clearer natural markings providing a easier identification but with the caution for not to distort it. The photographs were trimmed to the dorsal fin incorporing the visible body parts and adjusted some variables of light exposition:
To open file "Sp_Mt_nnn" with the same image viewer and editor (Windows Live Photo Gallery 2009 of Microsoft Corporation) -> Trim -> Exposition Adjustment -> to modify the variables with the tools "Shadow " and "Highlight" adjustment -> File-> Copy.

These data is annotated in the Excel worksheet called "Sp individual-sighting" (in Appendix 4):

- Date.
- Sighting.
- Photograph: number of the photo without been modified.
- Name capture: name of the edited photo "Sp_MT_nnn".

Catalogue matching

The following step consists in matching the catalogue of captures, firstly with the images of the folder of the category 1 and 2. Last capture image is placed in the screen top and down, the catalogue images are slided.

For the viewing of these images it was necessary to use a second image viewer for an accurate distribution of the images in the screen. Moreover, "Windows Live Photo Gallery 2009 of Microsoft Corporation" doesn´t allow opening more than one files at the same time. By this way, the recent capture is opened with the software "Windows Live Photo Gallery 2009 of Microsoft Corporation" and the catalogue images with "Image viewer and fax of Windows of Microsoft Corporation".

If there were not a match (the individual was not found in the catalogue), it means that it was a new captured individual. It was assigned new catalogue identification in the form of "Sp_nnn". The Excel worksheet "Sp individual-sighting" was filled as follows:

- ID CODE: Identification code of the individual correlative to the last one "Sp_nnn".
- CATEGORY: 1, 2 or 3.
- SIDE: picture from right side (R) or left side (L) of the animal.
- CATALOGUE: The image/s will be also used for the capture catalogue and is indicated with the letter "Y".

A copy of this file is copied in the folder "Sp catalogue" in its corresponding category folder: "Sp catalogue-cat 1&2" or "Sp catalogue-cat 3". The name of the file is changed by its Id-code. If there is more than one image for the same individual, it is added "R" or "L" depending on the side and a letter (a,b,c,d,...) when necessary.

In the Excel worksheet "Sp capture-recapture" is introduced the Id-code of the new individual and a cross, "X", in the column of the corresponding encounter. In addition, if the image belongs to category 3, it will be indicated in the column category with the number 3 to facilitate its elimination of the final counts.

If there were a match (the individual was found in the catalogue), it means that it was a recaptured individual. It is filled the Excel worksheet "Sp individual-sighting" inserting a new row under the matched individual row and completing as follows:

- ID CODE: Identification code of the catalogue matched individual.
- CATEGORY: 1, 2 or 3.
- SIDE: picture from right side (R) or left side (L) of the animal.
- CATALOGUE: If the new recapture evidence image is better than the one of the catalogue, it will be changed for this last capture image. If it complements the image of the catalogue, it will be added to the catalogue. Then it will be made a copy of this file in the folder "Sp catalogue" inside of its corresponding category folder "Sp catalogue-cat 1&2" or "Sp catalogue-cat 3". Its name will be changed for its id-code adding "R" or "L" depending on the side and a letter (a,b,c,d,...) when necessary.
- RECAPTURE: the number of the recapture: R1, R2, R3, ...
- RECAPTURE CATEGORY: "D" if the recapture is uncertain. It will be filled in the arrow of the last capture of this individual or in the new recapture depending on which is the doubtful capture.

Storing recapture evidence image

For storing the recapture evidence images there are two cases:

If it is the first recapture, a copy of all the capture and recapture evidence images (in folder "Sp captures") will be compiled in the folder "Sp recaptures" in its corresponding category folder. They will be the images of the first capture and the first recapture. The file name will be changed as indicated before.

If it is not the first recapture, a copy of the evidence images of last recapture will be stored all the folder "Sp recaptures" in its corresponding category folder. The file name will be changed as indicated before (Appendix 5: Examples of all the capture evidences of a re-sighted individual of each studied species).

Nextly, the Excel worksheet called "Sp capture-recapture" is filled with a cross "X" in the arrow of the id-code of the matched individual and under the column of the corresponding encounter. In addition, if the image belongs to category 3, it will be indicated in the column category with the number 3 to facilitate its elimination in the final accounts.

Doubtful recapture

Four scenarios were studied in case of doubtful or uncertain recapture:

- If the capture evidence image is rated category 1 or 2 and the recapture evidence image is rated also category 1 or 2: the recapture evidence image maintain its category 1 or 2. It will be stored in the corresponding folder for that category "Sp capture-cat 1&2" and a copy in the category 1 or 2 catalogue "Sp catalogue-cat 1&2". In the Excel worksheet called "Sp capture-recapture", the cross "X" of this recapture will be in red colour.

- If the capture evidence image is rated category 3 and the recapture evidence image is rated also category 3: the recapture evidence image maintain its category 3 and will be stored in the corresponding folder for that category.

- If the capture evidence image is rated category 1 or 2 and the recapture evidence image is rated category 3: the recapture evidence image will be converted to category 1&2 for avoiding its selection by the Excel filter for category 3. It will be stored in the folder"Sp capture-cat 1&2" and a copy in the category 3 catalogue "Sp catalogue-cat 3". In the Excel worksheet called "Sp capture-recapture", the cross "X" of this recapture will be in red colour.

- If the capture evidence image is rated category 3 and the recapture evidence image is rated category 1 or 2: the recapture evidence image maintain its category 1 or 2 and will be stored in the corresponding folder for that category "Sp capture-cat 1&2". A copy of the first capture evidence remains in the category 3 catalogue "Sp catalogue-cat 3" and a copy of the recapture evidence image will be stored in the category 1 or 2 catalogue "Sp catalogue-cat 1&2". In the Excel worksheet called "Sp capture-recapture", a cross "X" of the first capture will be turned in red colour and the number 3 that indicates the category will be eliminated for avoiding its selection by the Excel filter for category 3.

At the end, when all photographs were analysed, a posterior checking has been executed. Category 3 rated images were not included in the final count as the individuals could not reliably be matched between encounters.

Experienced researchers confirmation

In the end of the matching process, photographic matches were confirmed by researchers of the Madeira Whale Museum. Tt, Sf and Bb matches were corroborate by Ana Dinis (Degree in Marine Biology, University of Algarve, 2002), marine biologist of the objective 1 and 2 of the LIFE+ Project "Cetáceos-Madeira II" being the objective 1 the *Identification of the areas of importance for the bottlenose dolphin in the coastal waters of Madeira archipelago, where* systematic nautical surveys and photo-ID are the main tools used, and the objective 2 consists in "*Define areas of operation for the whale-watching boats in Madeira archipelago waters and establish the respective carrying capacity*". Filipe Alves (Master in Ecology, University of Coimbra, Sciences Department) marine biologist of the objective 3 ("*Surveillance of the conservation status of cetaceans' species in Madeira offshore waters*") and nowadays PhD student in short-finned pilot whales in Madeira Archipelago, that includes photo-identification analysis, confirmed the Gma photographic matches.

After the revision, both scientists suggested the rejection of some captures because of the poor picture quality or not marked enough individuals. Specifically, Ana Dinis recommended the elimination of 3 Tt individuals (Tt_080, Tt_123 and Tt_160), 15 Tt matches and 1 Sf match, and Filipe Alves 4 individuals (Gma_069, Gma_015, Gma_049 and Gma_072). Doubtful matches (with the cross that indicates the capture in red) after the revision, became reliable ones (with the cross in black).

Additional information was obtained from the photographs, including the presence of neonatal and larger calves as well as about additional scars or markings and mother-calf associations. Those comments were recorded but any worth should be given because of the lack of experience.

2.3. Data analysis

2.3.1. Study Area

It was counted the survey days, the number of trips per month and per week, the number of trips carried out by touristic operator boats and the total of hours embarked by the observer.
Moreover, in order to delimit the actuation area of the whale watching activity during fieldwork, it was measured the totality of area covered by all trips and the maximum distant to coast through the recorded GPS tracks. They were unified in a MapSource file obtained the total tracked area.

2.3.2. Species sightings stadistics

Total sighting accounts, sighting frequency of cetacean groups and sighting frequency of each species, during the whole study period and by months, were used to characterize the sightings of the whale watching activity and also the cetacean fauna in the study area.

The sighting frequency of cetacean groups (single and mixed groups) by whale watching vessels was calculated as the proportion of number of sightings of a single species group or a mixed group of two species in relation to the total numbers of sightings from whale watching boats (where a mixed group of two species is counted as a only one sighting). It shows the probability of encountering a group of those characteristics from a whale watching boat. This calculation was done also by month.

The sighting frequency of each species was determined as the relation of the number of encounters of a species with the total number of sightings (where mixed groups were counted as one sighting for each species). By this way, it is indicated the probability of encountering a determined species from a whale-watching boat.

2.3.3. Touristic operators stadistics

It was calculated the number sightings per trip and success probabilities of sighting cetacean of each touristic operator. The sightings per trip of each whale watching operator along study period was determined by the relation of sightings from the boat, where mixed groups are counted as one sighting, with the number of trips carried out in that vessel. A successful trip is that one where a group of cetaceans has been found without minding the species or the number or the duration of the encounter. So that, the success probability will be found out by dividing the number of trips of a determined vessel with any sighting during the boardings in the study period and the number of trips carried out by the observer during the study period.
The mean of both calculations will help to describe the whale-watching activity in the south coast of Madeira Island during the months of August, September and October 2011.

2.3.4. Photo-identification stadistics

Calculations were based on the number of marked individuals of Tt, Gma, Sf and Bb. The capture of marked individuals is the evidence to assess the degree of affectation of cetacean individuals to the exposure to whale-watching vessels in the study area during the study period.

By this way, the actual ratio of captures and recaptures of marked individuals was used to quantify the number of times they are exposed to whale-watching vessels.

It was determined the monthly variability of marked individuals plotted with the number of sighting were any individual was captured.

Furthermore, school size data was used to know the percentage of identified individuals in each school of each event.

In addition, it was plotted the discovery curve. It is the graphic of the cumulative rate of identification of new individuals over time. It indicates how much the population has been marked, illustrating the rate at which new individuals are photographed or discovered per standardised time period, in this case, per sighting, rejecting those were any individual was captured. This graphic is useful to investigate whether the population was open or closed (to immigration, emigration, mortality or birth). If the graphic do not reach a plateau after a sufficient field season, it shows that new individuals continue to be recruited to the population throughout the study period. The new recruits to the population may represent births and immigration into the population indicating that it is an open population. In the other side, when reaching the plateau, no new individuals are encountered because all the population is already identified.
With Sf calculations they may be biased because primarily, this species was discarded from the photo identification study. The reason was their high speed and their big group size that difficult the capture of individuals. Afterwards, they were included but no photographs were taken from 7 Sf encounters.

3. Results

3.1. Field program

Between August and November 2011, a total 71 trips onboard whale watching vessels were carried out on 40 survey days. There was no significant variation in survey effort between months. The mean of trips per month was 23,7 with 21 trips in August, 26 in September and 24 in October as shows the Table 3.1. By week, the mean was 5,5 trips with a minimum of 3 and a maximum of 10 trips in a week (Table 3.2). The proposed planning of 4 days of fieldwork a week with two trips per day was not accomplished. The survey calendar is presented in Appendix 10.

Table 3.1: Nº trips per month.

Month	August	September	October	Mean ± s
No.of trips	21	26	24	**23,7 ± 2,5**

Table 3.2: Nº trips per week

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	Mean ± s
No.of trips	4	6	3	4	6	7	6	9	3	10	5	4	4	**5,5 ± 2,2**

The survey effort totalled 208 hours onboard, shared between 7 touristic operators boats. Although it was planned to survey the same number of times in a vessel of each touristic operator, the availability of boats did not allowed it. The reason was the low frequency of trips in addition to the limited capacity of some of them.

Table 3.3 shows the ranging from 21 to 2 trips. It expresses a bias in survey effort to the catamarans vessels. To Sea Pleasure and Sea Born operators it corresponds the higher number of trips as their vessels navigate everyday and have a large capacity of passengers.

Table 3.3: Nº trips in a vessel of each operator company

Touristic operator	No. of trips
Sea Pleasure	21
Sea Born	15
Rota dos Cetáceos	11
Gavião	8
Ventura do Mar	8
Bonita da Madeira	6
ZonaCat	2
Total	**71**
Mean ± s	**10,1 ± 6,3**

In the case of the ZonaCat vessel, as it works in a different way with a low dedication to search animals, it was supposed to be discarded. Finally, as it is still valuable info, it was included.

The totality of area covered by all trips was approximately 420km^2 with a maximum distant to coast of 13 km (7nm) between the land references of Ponta do Sol in the West and Madeira Airport in the East (Figure 3.1).

Figure 3.1: Area covered by all trips.

3.2. Species sightings

During this study, there were 89 sightings: 78 single-species sightings and 11 mixed-species sightings. There are variations in the number of sightings from the different vessels between months (Table 3.4). There were 36 in August, 32 in September and 21 in October. Bb-NBA and ZD-NZI were decided to be counted together.

Table 3.4: Sightings accounts per month and in the study period

Month	No.sightings	Single species									Mixed species		
		Bb-NBA	Gma	Oo	Pm	Sb	Sc	Sf	Tt	ZD-NZI	Bb-Tt	Gma-Tt	Gma-Pm
Aug	36	1	3	0	0	2	0	9	12	4	2	3	0
Sept	32	2	7	1	1	0	2	3	9	2	0	4	1
Oct	21	0	8	0	1	0	0	4	6	1	0	0	1
Total	89	3	18	1	2	2	2	16	27	7	2	7	2

At least 9 species were identified during the study period: Bb, Gma, Oo, Pm, Sb, Sc, Sf, Tt and ZD. And the association of mixed sightings were Gma-Tt, as the more frequent, and Bb-Tt and Gma-Pm.

If mixed groups are considered as an individual sighting per species, there were made 100 sightings (mixed groups of 2 species here are counted as 2 sightings, in Table 3.5).

Table 3.5: Sightings accounts per species per month and in the study period.

Month	No.sightings	Sighted species								
		Bb-NBA	Gma	Oo	Pm	Sb	Sc	Sf	Tt	ZD-NZI
Aug	41	3	6	0	0	2	0	9	17	4
Sept	37	2	12	1	2	0	2	3	13	2
Oct	22	0	9	0	2	0	0	4	6	1
Total	100	5	27	1	4	2	2	16	36	7

Tt was the more frequent species sighted with 36 per cent of the sightings, followed by Gma with 27 and Sf with 16. By month, in August and September, Tt was the more frequent, and Gma was it in October.

In the next figure (Figure 3.2), it is represented clearly the most sighted species by month, being Tt followed by Gma that surpass it in the month of October.

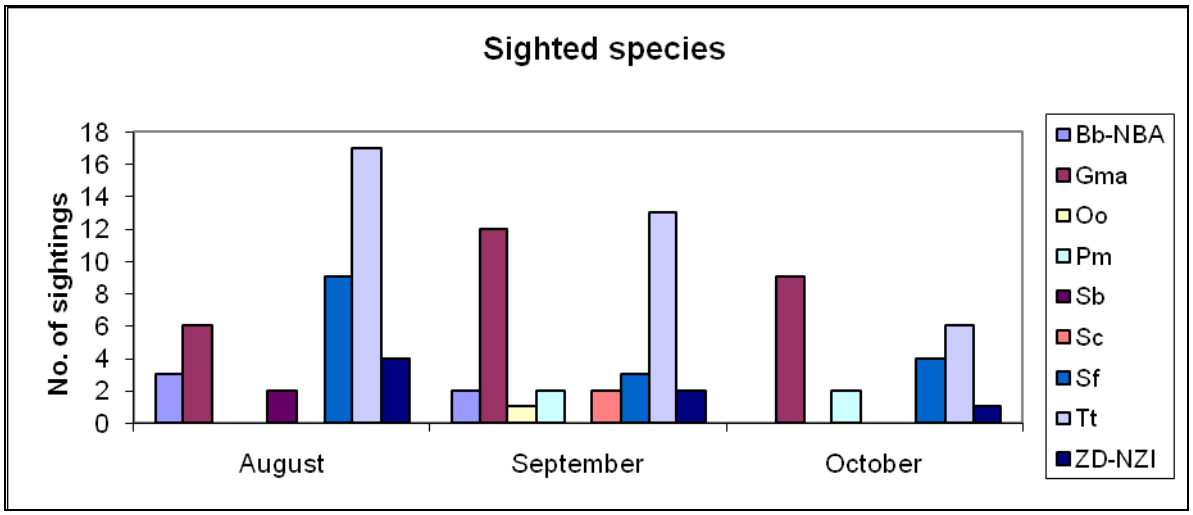

Figure 3.2: Frequency of sighted species from whale watching boats during the survey period. Bb: Balaenoptera brydei; NBA: Balaenopteridae; Gma: Globicephala macrorhynchus; Oo: Orcinus orca; Pm: Physeter macrocephalus; Sb: Steno bredanensis; Sc: Stenella coeruleoalba; Sf: Stenella frontalis; Tt: Tursiops truncatus; ZD: Mesoplodon densirostris; ZDI: beacked whales.

These relative frequencies demonstrate the sighting probability of each species form a whale-watching boat during the study period (Figure 3.3).

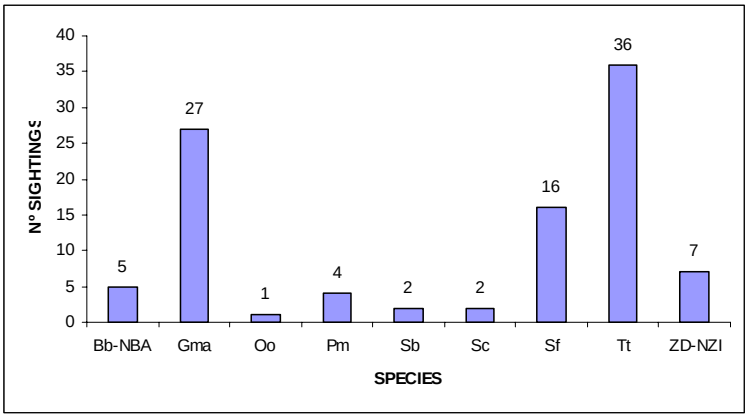

Figure 3.3: Number of sightings of each species

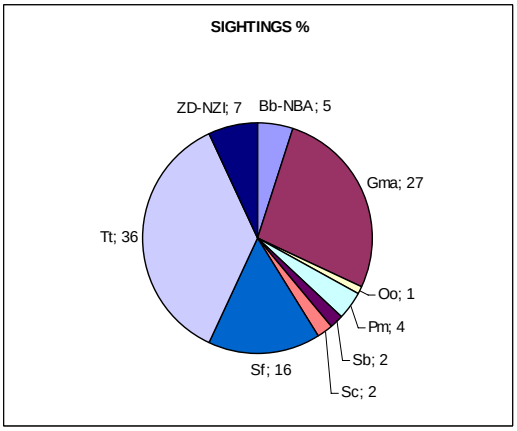

Figure 3.4: Frequency and sighting probability of each species

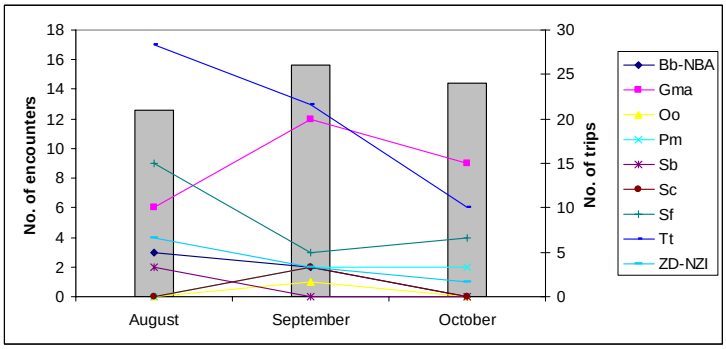

Figure 3.5: Number of sighting of each individual and the number of trips by month during the survey period.

In figure 3.5, it is observed the variation in the number of sightings of each species between months in relation with the number of trips accomplished by month. Tt encounters decreased every month as Gma encounters increase from August to September and decrease in October. For Sf, there is a diminution from August to September followed by a soft increment in October.

3.3. Touristic operators results

Records of sightings achieved from each touristic operator vessels during the boardings in the study period are available in Appendix 11.

Calculations about sightings per trip and success probabilities of sighting cetacean of each touristic operator are indicated in Table 3.6. As the number of trips was different between vessels, relative frequencies will provide a comparison through the success probability and the number of sightings per trip during the study period. Comparison with "ZonaCat" should be discarded because the low number of trips.

The success probability of sighting cetaceans of the total of the whale-watching touristic operators of Funchal port that collaborated in the study was 81,7% with 1,25 sightings per trip during the months of August, September and October 2011.

Individually, "Bonita da Madeira" got a 100% of sighting success, with 1,83 sightings per trip, although only 6 trips were effectuated.

"Rota dos Cetáceos" and "Sea Pleasure" own an elevated sighting success too, with 90,9% and 90,5% respectively, with 11 trips realized abroad the former and 21 abroad the latter.

Moreover, "Rota dos Cetáceos" were the only one vessel in reaching a mean of 2 ,091 sightings per trip. "Gavião" was the boat with less success probability with the 50% and 0,625 sightings per trip.

Table 3.6: Success probability and sightings per trip for each vessel

Touristic operator	No.trips	No.trips with sightings	No.trips without sightings	Success Probability (%)	No. sightings	No.sightings per trip
Rota dos Cetáceos	11	10	1	**90,9**	23	**2,091**
Sea Pleasure	21	19	2	**90,5**	26	1,238
Sea Born	15	12	3	80	15	1,000
Bonita da Madeira	6	6	0	**100**	11	1,833
Gavião	8	4	4	50	5	0,625
Ventura do Mar	8	6	2	75	8	1,000
ZonaCat	2	1	1	50	1	0,500
Total	71	58	13	**81,7**	89	**1,254**

3.4. Photo-Identification results

As Tt and Gma were the more frequent encountered species, lots of photographs of individuals of these species were taken so that they will be mainly the object of this photo-identification study.
Sf encounters were also high frequent. In this case, the lack of pictures in 7 of the 16 encounters in addition to the elevated number of individuals per group caused an extremely low number of recaptures.
Besides, despite of the lower number of sightings of Bb, It was possible to apply the photo-ID technique with this species.

Globicephala macrorhynchus (Gma) Photo-identification Results

During the study period, there were 27 encounters with Gma schools (3 of them without photographs or without identified individuals). From 3914 digital photographs taken to this species, 450 were sorted, analyzed, and archived. An example of all the capture evidences for a re-sighted Gma individual is in Appendix 5, and the table with the capture history of all Gma identified individuals is exhibited in Appendix 6. Moreover, the capture frequencies are shown in Table 3.7.
To sum up, 78 individuals of Gma with distinct dorsal fin were indentified with a recapture rate ranging from 1 to 3, being recaptured a total of 27 individuals, the 34,62% of all the Gma identified individuals.

Table 3.7: Globicephala macrorhynchus (Gma) capture frequencies table

	Gma Identified individuals	
No. of captures	**Absolute freq.**	**Proportion (%)**
1	51	65,38
2	20	25,64
3	4	5,13
4	3	3,85
Total	78	100
Captures >1	27	34,62

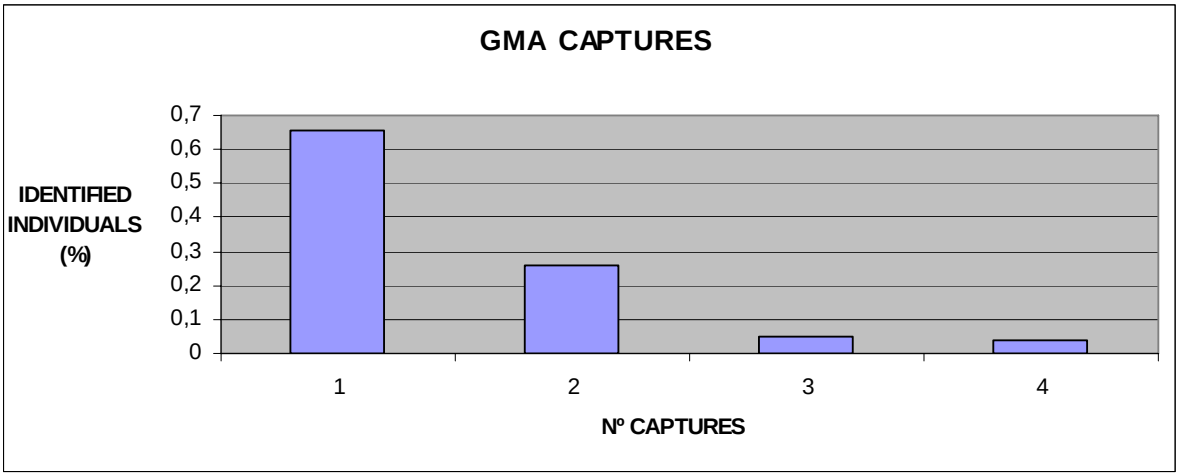

Figure 3.6: Globicephala macrorhynchus (Gma) captures of identified individuals.

In the next figure (Figure 3.7), it is presented the number of Gma identified individuals and the number of Gma sightings, with any identified individual, by month. August was the month with fewer sightings and identified individuals, in September it occurred the higher number of sightings and October is the month where more individuals were identified.

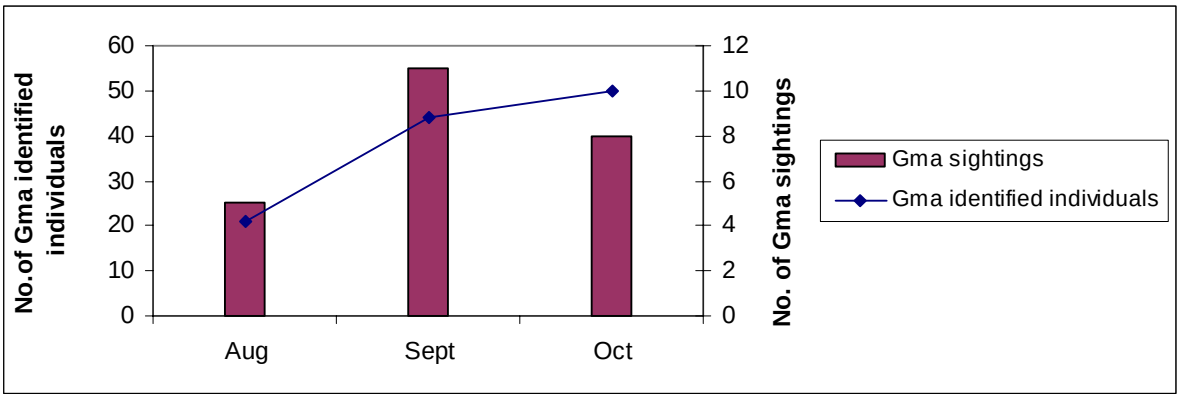

Figure 3.7: Number of Globicephala macrorhynchus (Gma) Identified individuals by month plotted with the number of sightings with identified individuals by month.

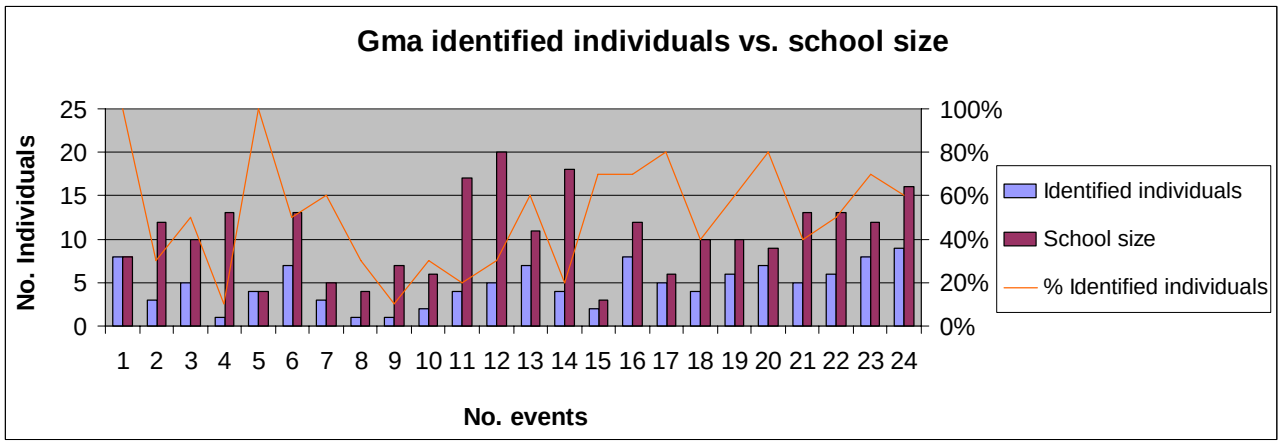

Figure 3.8: Globicephala macrorhynchus (Gma) identified individuals versus school size per event with the percentage of identified individuals in each event.

The Figure 3.9 shows the Gma discovery curve during the study period. Sightings were any individual was capture, were rejected, remaining 24 encounters.

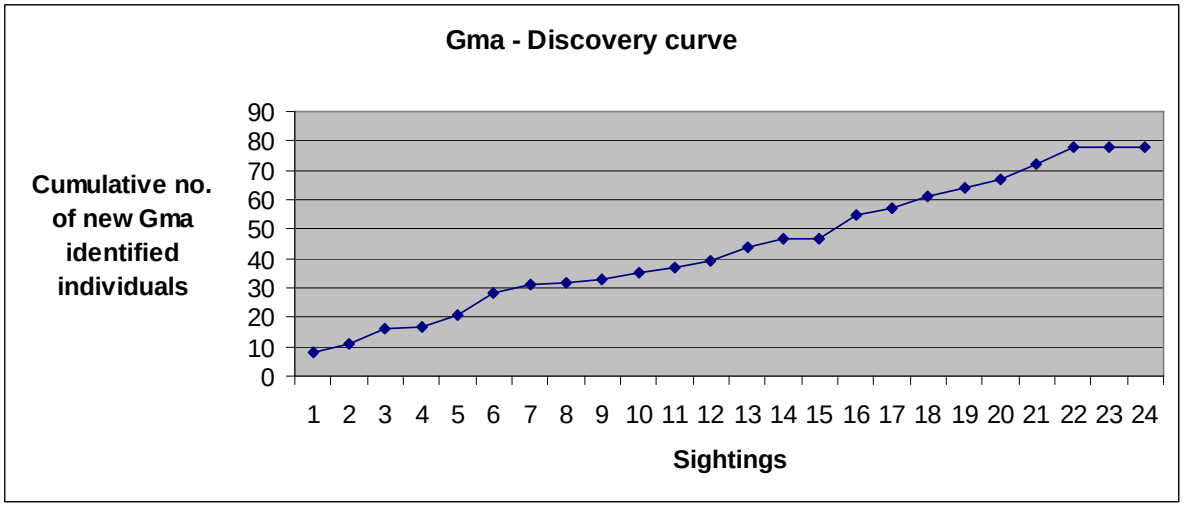

Figure 3.9: Discovery curve of Globicephala macrorhynchus (Gma)in the south coast of Madeira Island from August to October 2011.

The discovery curve for Gma in this study area is still increasing and has not reached its plateau. If it is a closed population, this curve means that the population size is bigger, and when reaching

the plateau all individuals will have been marked. If it is an open population, it will approximate to a crescent logarithmic curve; the plateau will never be reached inclusive if capture occasions are augmented because new immigrants continue entering the population.

Tursiops truncatus (Tt) Photo-identification Results

During the study period, there were 36 encounters with Tt schools (7 of them without photographs or without identified individuals). From 4793 digital photographs taken to this species, 595 were sorted, analyzed, and archived. Tt capture history table is exhibited in Appendix 7 and in table 3.8 the captures frequencies.

98 individuals of Tt with distinct dorsal fin were indentified with a recapture rate ranging from 1 to 4, being recaptured a total of 26 individuals, the 26,53%.

26 of them or the 26,53% of the captured individuals were seen more than once (recaptures) and one individual had the maximum number of captures, 5.

Table 3.8: Tursiops truncatus (Tt) capture frequencies table

	Tt Identified individuals	
No. of captures	**Absolute freq.**	**Proportion (%)**
1	72	73,47
2	17	17,35
3	6	6,12
4	2	2,04
5	1	1,02
Total	98	1
Captures >1	26	26,53

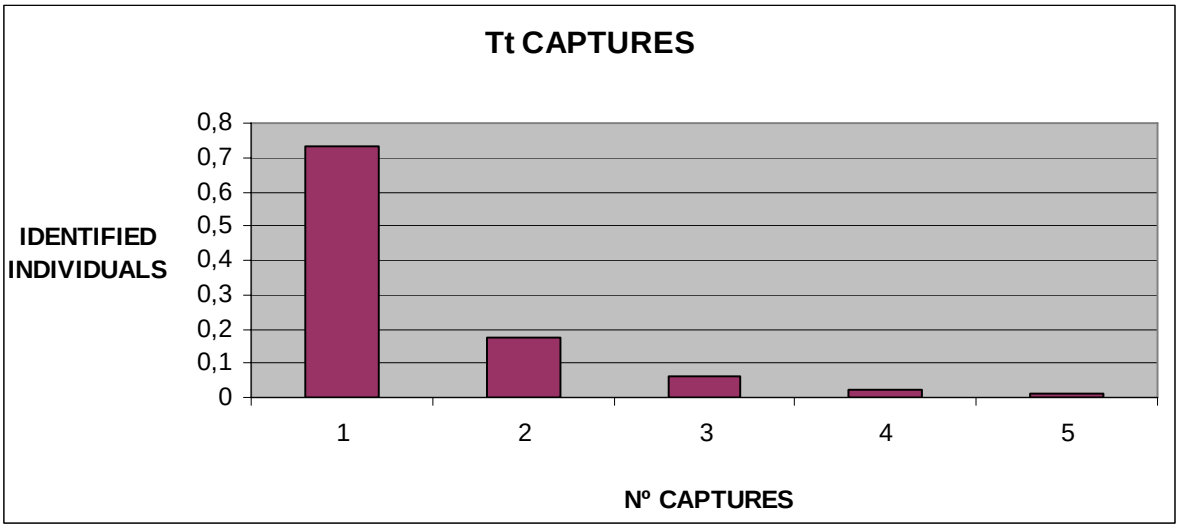

Figure 3.10: Tursiops truncatus (Tt) number of captures of identified individuals.

In the next figure (Figure 3.11) it is presented the number of Tt identified individuals and the number of Tt sightings with any identified individual by month. August was the month with more sightings and identified individuals, in September occurred the lower number of identified individuals and October is the month with fewer sightings and with more identified individuals than September.

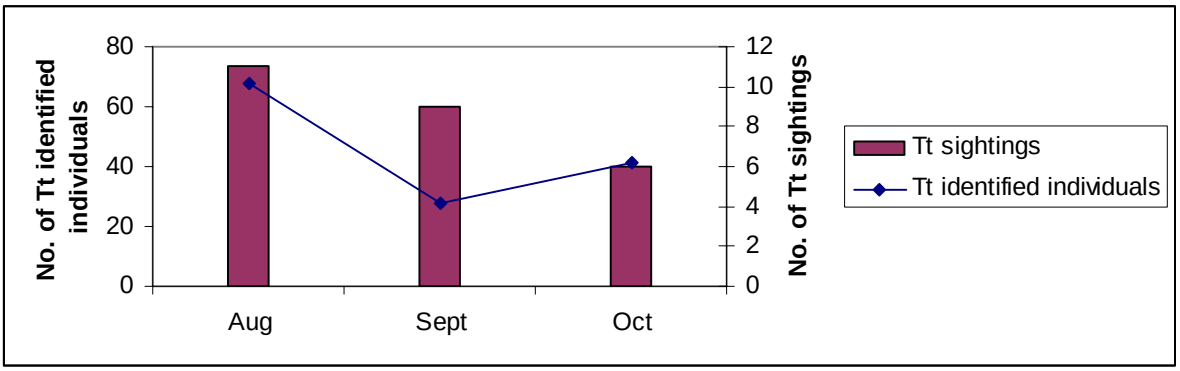

Figure 3.11: Number of Tursiops truncatus (Tt) Identified individuals by month plotted with the number of sightings with identified individuals by month.

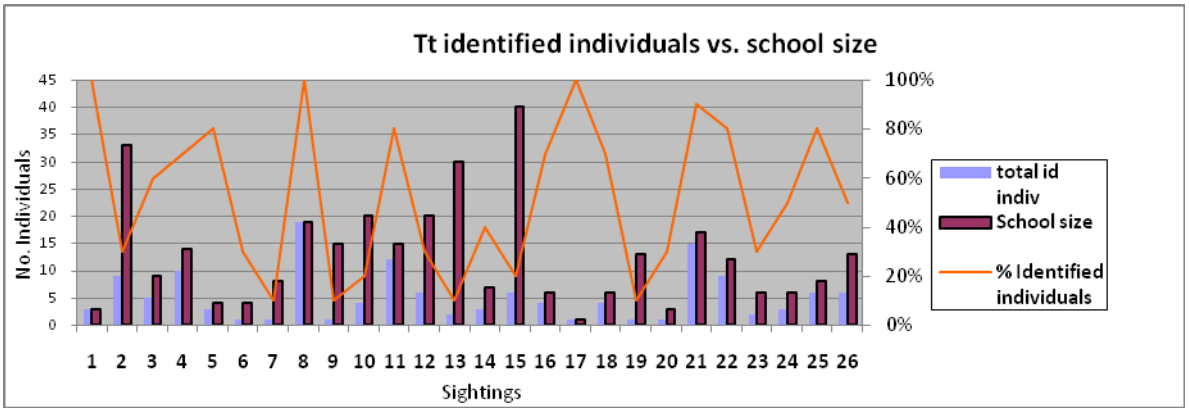

Figure 3.12: Tt identified individuals versus school size per event with the percentage of identified individuals in each event.

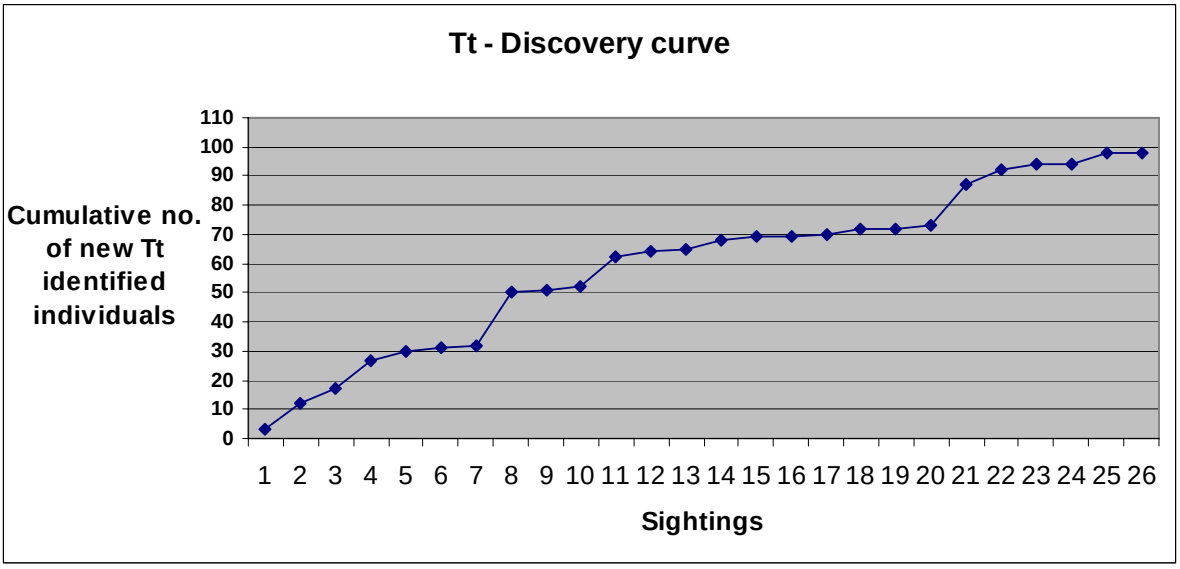

Figure 3.13 : Discovery curve of Tursiops truncatus (Tt) in the south coast of Madeira Island from August to October 2011.

The Figure 3.13 shows the Tt discovery curve during the study period. Sightings were any individual was capture, were rejected, remaining 26 encounters.

As the discovery curve for Gma in this study area, the discovery curve for Tt did not reach a plateau. Also, it is far away to be adapted to a crescent logarithmic curve. It means that capture occasions should be increased.

Stenella frontalis (Sf) Photo-identification Results

During the study period, there were 16 encounters with Sf schools (7 of them without photographs or without identified individuals). From 526 digital photographs taken to this species, 134 were sorted, analyzed, and archived. Sf Capture history table is exhibited in Appendix 8 and in Table 3.9 the capture frequencies. 48 individuals of Sf with distinct dorsal fin were indentified being recaptured a total of 2 individuals, the 4,17%.

Table 3.9: Stenella frontalis (Sf) capture frequencies table

	Sf Identified individuals	
No.of captures	**Absolute freq.**	**Proportion (%)**
1	46	95,83
2	2	4,17
Total	48	100
Captures >1	2	4,17

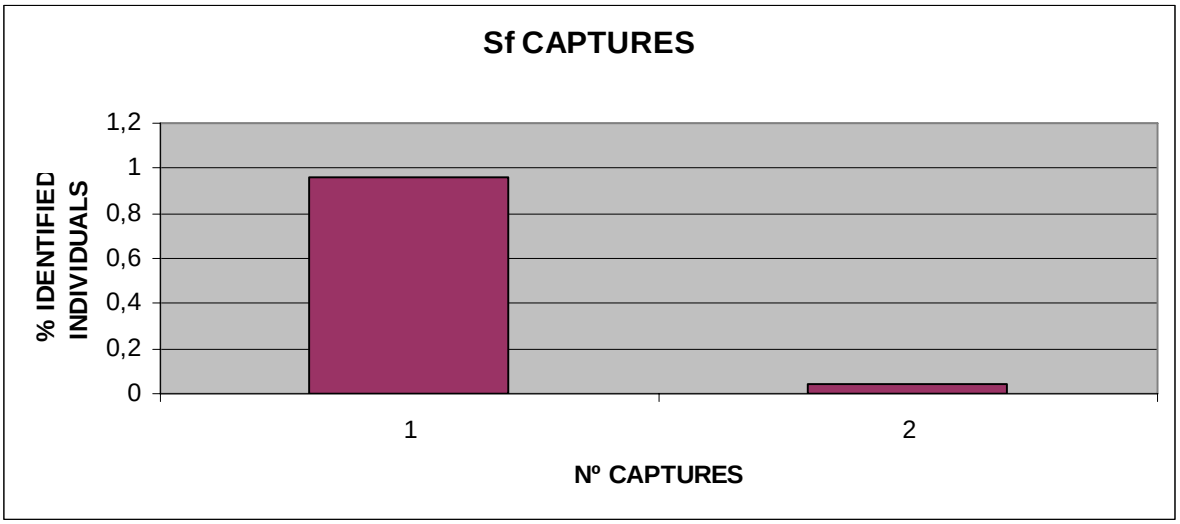

Figure 3.14: Stenella frontalis (Sf) number of captures of identified individuals.

In the next figure, Figure 3.15, it is presented the number of Sf identified individuals and the number of Sf sightings with any identified individual by month. August was the month with fewer sightings and identified individuals, in September it occurred the higher number of sightings and October is the month when more sightings with identified individuals occurred diminishing the number of Sf identified individuals in relation to the preceding month.

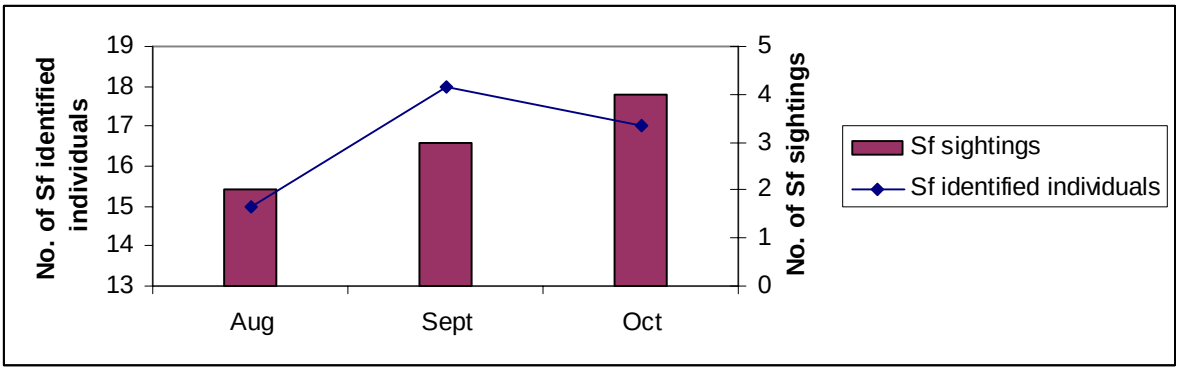

Figure 3.15: Number of Stenella frontalis (Sf) identified individuasl by month plotted with the number of sightings with identified individuals by month

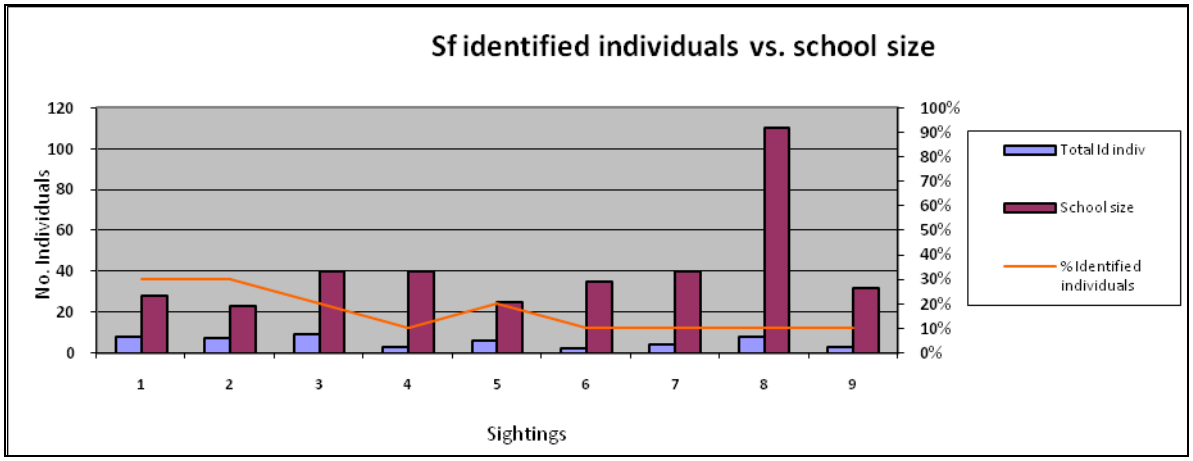

Figure 3.16: Stenella frontalis (Sf) identified individuals versus school size per event with the percentage of identified individuals in each event.

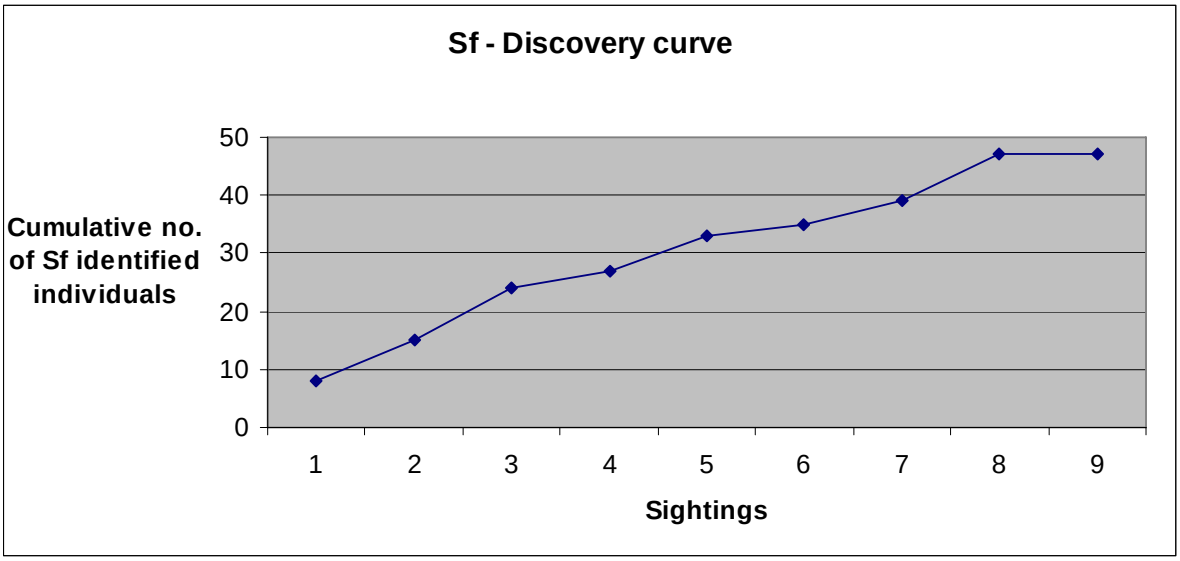

Figure 3.17: Discovery curve of Stenella frontalis (Sf) in the south coast of Madeira Island from August to October 2011.

The Figure 3.17 shows the Sf discovery curve during the study period. Sightings were any individual was captured, were rejected, remaining 9 encounters.

As the discovery curve for Gma and Tt in this study area, the discovery curve for Sf did not reach a plateau. Also, it is far away to be adapted to a crescent logarithmic curve. It means that capture occasions should be increased.

Balaenoptera brydei (Bb) Photo-identification Results

During the study period, there were 5 encounters of Bb and other Balaenopteridae which species was not confirmed (NBA). In three of the encounters no pictures were achived.

As captured individuals were identified as Bb, in this section calculations were done only to the confirmed species as Bb.

From 169 digital photographs taken to this species, 9 were sorted, analyzed, and archived. Bb Capture history table is exhibited in Appendix 9 and in Table 3.10 the capture frequencies. 2 individuals of Bb with distinct dorsal fin were indentified being recaptured only 1 individual, the 50 %.

Table 3.10: Balaenoptera brydei (Bb) capture frequencies table

	Bb Identified individuals	
No.of captures	**Absolute freq.**	**Proportion (%)**
1	1	50
2	1	50
Total	2	100
Captures >1	1	50

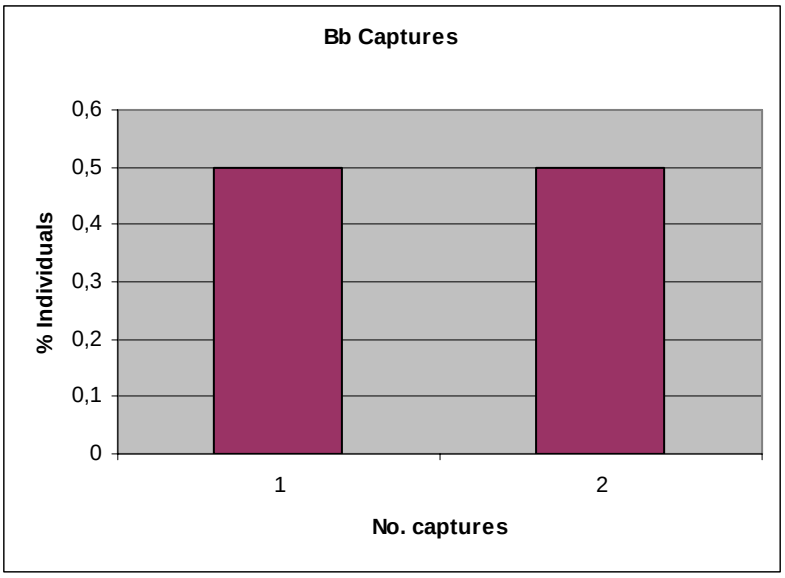

Figure 3.18: Balaenoptera brydei (Bb) number of captures of identified individuals.

In the next figure (Figure 3.19), it is presented the number of Bb identified individuals and the number of Bb sightings with any identified individual by month. August was the month with more sightings and identified individuals. No more sightings with identified individuals were achieved neither in September nor October.

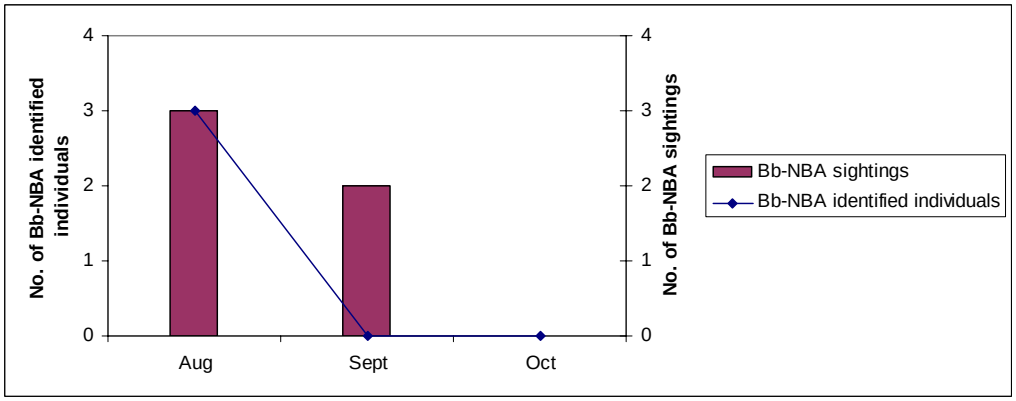

Figure 3.19: Number of Balaenoptera brydei (Bb) identified individuals by month plotted with the number of sightings with identified individuals by month.

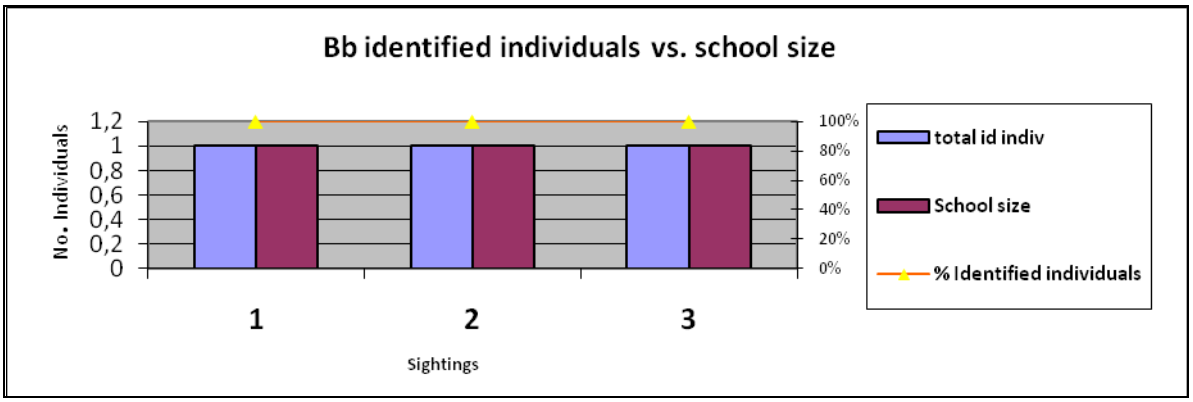

Figure 3.20: Balaenoptera brydei (Bb) identified individuals versus school size per event with the percentage of identified individuals in each event.

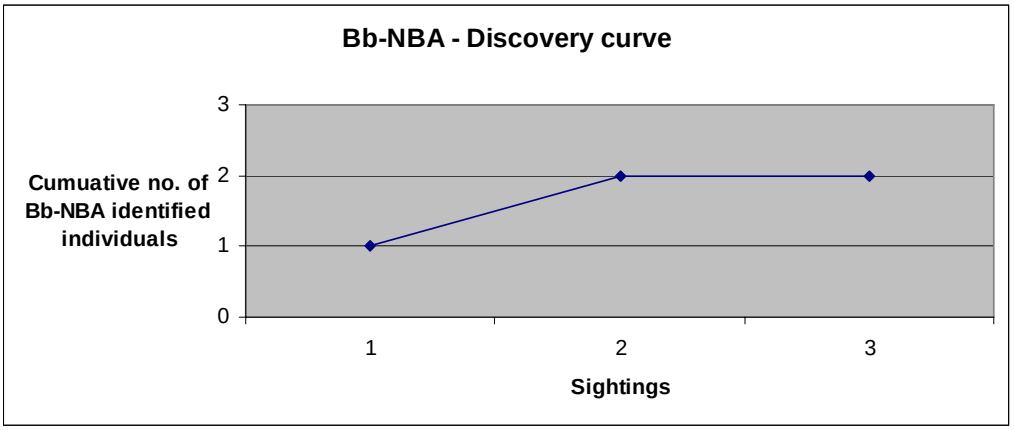

Figure 3.21: Discovery curve of Balaenoptera brydei (Bb) in the south coast of Madeira Island from August to October 2011.

Figure 3.21 shows the Bb discovery curve during the study period. The extremely low numbers of sightings with identified individuals do not allow validating this graphic for this species.

Comparing the cumulative exposure to vessels, Gma the one with the highest percentage of recaptured individuals with the 34, 62 % of the individuals seen more than once (discarding Bb with 50 % of recaptured individual with only 2 identified individuals). I did not exist a big difference with Tt as the 26,53 % of identified individual were re-sighted at least once.

4. Discussion

4.1. Survey effort

The most of the threats and potential impacts for cetacean populations in Madeira Archipelago, identified by the Madeira Whale Museum, are also localized in the study area. To this, we should add the threats related to the whale watching activity. The result is an area, apparently, with high pressure for cetaceans.

Some authors (Bejder *et al.* 2006) define the study site as the impact area. In this study, it is not considered that way since vessels may be audible at greater distances (Richardson *et al*. 1995). So that, it cannot be delimited as the impact area.

4.2. Species sightings

From the 28 species that can be found in Madeira Archipelago, 9 species were sighted during the study period. As the records collected during the vessel trips belong to a determined area with certain oceanographic conditions, distance to the coast and in a specific period of time, sighting probability of each species will be biased. In spite of referring data to the whole archipelago, occurrence of all the species encountered from whale watching boats throughout the study period is consistent with Freitas *et al*. (2004).

The more frequently sighted species during the study period were *Globicephala macrorhynchus* (Gma), *Tursiops truncatus* (Tt) and *Stenella frontalis* (Sf). Both first, occur during all year-round with the evidence of resident groups of Tt (Freitas *et al*. 2004) and it is in process the study to determined whether Gma do it as well. In addition, Tt sightings increase in spring and summer with the arrival of the transient populations, being it registered in the compiled data where they decrease to the half in the number of sightings from summer months of August and September to October. In the case of Gma, being very common every season is declared to have a lower frequency than Tt, as this study presented. The latter, Sf, was described for spring and summer months but can be observed during other parts of the year with less frequency, as it shows the results of 4 sighting of Sf in the month of October.

Referring to the less frequently sighted species, *Balaenoptera bryde* (Bb), *Physeter macrocephalus* (Pm), *Orcinus orca* (Oo), beacked whales (NZI), *Steno bredanensis* (Sb) and *Stenella coeruleoalba* (Sc), also less precise data is available in the study of Freitas *et al*. (2004) but occurrences are also consistent with it. Firstly, Bb individuals of this species were found in the summer months of August and September, corresponding only with data of year 2004 where the seasonal appearance was between June and October. In relation to big odontocets, Pm presence is common without a fixed period along the year-round and about Oo, despite its low frequency, has been seen as well in different seasons of the year.
Concerning to beaked whales, besides the difficulty of identification the different species, the low number of sightings did not allowed to determine any pattern in the referenced study. In relation to small odontocets, Sb low frequent sightings records always occurred during summer, as in the present study where they were observed twice in August. And finally, Sc, being a common species in Madeira Arquipelago waters, its appearance is related to the greater presence of Dd and Sf, in the end of winter and spring, and summer, respectively. Sc sightings during this study are also consistent with Freitas *et al*. (2004) with 2 sightings in the month of September.

In addition, the sighting probability of each species from a whale-watching boat during the study period shows that Tt and Gma are the more probable to be found during the touristic trips. This can be explained by the existence of resident individuals of Tt in the waters of Madeira Archipelago encountered during consecutive seasons and years (Freitas *et al*. 2002) that may be joined by transient groups in spring and summer (Freitas *et al*. 2004). For Gma, the characteristics of the population are not still known, but photo-ID studies are in process by the MWM, trying to find out the existence of a resident group.

The current conservation status declares that there are no reasons for concern about the status of these populations at a regional and global level. However, these estimates at a regional level were based in data until 2003 as one the objectives carried off by the Project "*Projecto para a Conservação dos Cetáceos no Arquipélago da Madeira"*of the Madeira Whale Museum, consisting in historical abundance data from Madeira Archipelago. Those preliminary estimations will be reinforced by the current studies enshrined in the Project "Cetaceos-MadeiraII" by the same institution, which will be presented presumably next year.

That lack of concern about these species conservation does not mean, however, that certain individuals or groups may not be negatively influenced by localized threats, like the potential disturbance from whale-watching boats. The concentration in a small geographic area of the increasing activity of whale-watching tourism that overlaps at least part of the home range of resident groups, may threaten the welfare of those groups. Bejder *et al.* (2006) documented a long-term decline in the abundance of bottlenose dolphins (*Tursiops* sp.) in Shark Bay related to the whale-watching activity, due, at least partially to the displacement of the more sensitive individuals from the disturbed area.

4.3. Touristic operators

As we can get form the results of the touristic operators statistics, the type of vessel did not influence in the success probability as the highest ones belongs to a sailboat, a semirigid and a catamaran.

The activity of whale-watching touristic operators of Funchal port that collaborates with the MWM resulted to be quite prosperous with a success probability of sighting cetaceans of 81,7% , that means that in the 81,7% of the trips during the months of August, September and October 2011, passengers had at least one encounter with cetaceans.

Limited comparisons can be made between vessels because of their varied characteristics as type, capacity, engine and some other variables that can affect the encountering of cetaceans. Individually, "Bonita da Madeira" was the only one vessel where cetaceans were encountered in all trips, 100% of sighting success despite the low number of trips effectuated. "Rota dos cetáceos" and "Sea Pleasure" own an elevated sighting success too, with 90,9% and 90,5% respectively, with a higher number of trips realized (11 aboard the former and 21 aboard the latter).

Moreover, there was only one touristic operator that reached the mean of 2 sightings per trip being the general mean 1,25. It is also the only operator with semirigid boats, "Rota dos Cetáceos", which has lookouts and reaches higher speeds.

4.4. Photo-identification

Photo-ID analysis from the present study showed that the species with the higher cumulative exposure to vessels was Gma with a percentage of recaptured individuals of the 34,62 %. Tt was the second with the 26,53% of the identified individuals being recaptured at least once and Sf was the third, with the recapture of only 4,17% of the identified individuals. So that, the rest of identified individuals for each species was not captured more than once.
Those analyses did not indicate any determinant results because of the shortness of the study period. Any pattern of seasonality not residentially was extracted being decisive to measure the impact in individuals. It would be interesting to distinguish the captured individuals between residents and transients because long-term vessel activity within a region of tourism has a detrimental effect on resident dolphins (Bejder *et al.* 2006). In that study, where short-term behavioural responses were analysed, it is also suggested that is not that impact-site dolphins had habituated but because those sensitive to vessel disturbance left the region. Concerning transient individuals, it is logical to think that the sensitive individuals will reduce its period in the impact site. Moreover, if in the other regions these transient individuals have also suffered from this kind of pressure, the impact will be accumulated.

These quantifications need also to be relativized with the population size, to determine the relation of individuals encountered by whale watching boats in this study. The impact will depend on the population size because, as population biology theory states, in a negative event, the biggest size and genetic variability populations will have more survival probability.

4.5. Recommendations for further studies

Due to the lack of long term studies for the knowledge of the cetacean populations in the waters of Madeira Archipelago, it is not possible a certain checking of the frequent or occasional occurrence of this species nor their residentially or migration period. As long term data is needed for more accurate estimations, it is recommended that after the completion of the current LIFE+ Project "Cetáceos-MadeiraII" of Madeira Whale Museum which will reveal presumably more precise data, another long-term study starts giving continuity to those analyses.

It is important to know the home range of these individuals to check if it is coincident with the area where the whale-watching boats operate. Nevertheless, that information requires further study, so that it is recommended to carry out this kind of study all year round and during some years. More extensive photo-identification from whale-watching boats is need for more reliable estimates.

Moreover, existing the suggestion of the existence of a unique oceanic population in the North Atlantic of *T.truncatus* (Querouil *et al*. 2007) and the belonging of this archipelago to a chain of "oasis", it is significant the importance of studies in collaboration with the other macaronesian archipelagos. These studies may permit to understand better about some species and specifically about the cumulative pressure suffered from the whale-watching activity along the different islands. Furthermore, this team studies should be also amplified to other distant parts of the North Atlantic Ocean region. Other plan for the future should be the promotion of research studies in areas used by these shared populations and where no research neither management is been effectuating and where they may suffer from any kind pressure.

On the subject of the impact of vessel noise in cetaceans, acoustic measures are recommended by the study of Jensen *et al*. (2009). In this study called "Vessel noise effects on delphinid communication" in the coast of Tenerife (Canary Islands, Spain), it was concluded that because of

the fact that noise emissions of a vessel depend on ship, engine and propeller design, before drawing any conclusion about the impact on cetaceans, those measurements should be done. To give an example, inboard engines generate more intense sounds than outboards, so that, they may have a greater impact on cetaceans (Au and Green, 2000). Those quantifications may help to determine the carrying capacity that is being calculated by the Madeira Whale Museum.

For a sustainable development of the activity throughout the years, it is needed a proper management of the cetacean resource scientifically based. So that, the determination of the carrying capacity and the operation area of the whale-watching tourism activity in the south of the Madeira Island, by the Madeira Whale Museum, is decisive.

In order to protect vulnerable species and ecosystems, between other ecological and social reason, it has been created the conservation figure of Marine Protected Areas (MPAs) (Hooker and Gerber, 2004). When it is set up around cetaceans or marine mammals in general, as a result of their function as umbrella species, usually positive effects occur to other species (Simberloff, 1998; Hoyt, 2005). Nonetheless, from the cetaceans conservation point of view, Marine Protected Areas happen to be too small, too few in number, and too weak in terms of protection (Hoyt, 2005). However, those inconvenients could be compensated. Erich Hoyt, in its article about MPAs in the second edition of Marine Mammals Encyclopedia, comments that the settled up of networks of MPAs can be fundamental for an effective conservation plan for these wide-ranging species and for marine ecosystems on the whole.

Finally, for the implementation of a conservation strategy, it is needed the knowledge of the home range all year round of those populations. Herfindal *et al*. (2005) stated that "successful conservation and management requires scaling protected areas or management units to the biological scales in which species function", a positive horizon from a wildlife conservation perspective contemplates the establishment of a marine area in the waters of Madeira Archipelago, getting ecologically connected with the others Marine Protected Areas of the Natura 2000 Network in the Atlantic. Furthermore, also the whale watching activity threats may be limited by that protection measure, being reduce then the frequency in which each individual is exposed to the vessels, diminishing the negative impact of the activity on the cetacean resource. Those aspects are some of the objectives of the current Project "Cetáceos-MadeiraII" carried out by the MBM.

5. Conclussions

9 species were sighted from whale-watching boats during the study period: *Balaenoptera brydei, Globicephala macrorhynchus, Orcinus orca, Physeter macrocephalus, Steno bredanensis, Stenella coeruleoalba, Stenella frontalis, Tursiops truncatus,* and *Mesoplodon densirostris*.

Tursiops truncatus was the more frequent species with the 36% of the sightings, followed by *Globicephala macrorhynchus* with the 27% and *Stenella frontalis* 16%.

From the identified individuals, 27 (34,62%) identified individuals of *G*. *macrorhynchus* out of 78 identified individuals, were seen more than once, being 4 the maximum number of captures. From the 98 identified individuals of *T. Truncatus,* a total of 26 (26,53%) individuals were recaptured, with a maximum of 5 captures. For *S. Frontalis* only 2 (4,17%) individuals were recaptured out of 48 and only once. For *Balaenoptera brydei* only 2 individuals were identified and one was recaptured.

The success probability of sighting cetaceans, during the study period, of whale-watching boats that operates from Funchal port and collaborates with the Madeira Whale Museum, resulted in general the 81,7% with a mean of sightings per trip of 1,25.

Any pattern of seasonality nor residentially was extracted from photo-identification analysis because of the shortness of the study period, being impossible to distinguish the residents which may be more vulnerable to cumulative exposure vessels.

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Appendices

Appendix 1: List of cetacean species in Madeira Archipelago and conservation status

SUBORDER	Common name	Scientific Name	Presence in Madeira waters	Occurrence during year	Regional status MBM 2003	Global status UICN 2012
MISTICETI	North Atlantic right whale	*Eubalaena glacialis*	Rare	Undefined	Not estimated	Endangered (EN)
	Blue whale	*Balaenoptera musculus*	Rare	Undefined	Not estimated	Endangered (EN)
	Fin whale	*Balaenoptera physalus*	Common	Seasonal defined	Endangered (EN)	Endangered (EN)
	Sei whale	*Balaenoptera borealis*	Occasional	Seasonal defined	Not estimated	Endangered (EN)
	Bryde whale	*Balaenoptera brydei*	Occasional	Undefined	Not applicable	Not estimated
	Humpback whale	*Megaptera novaeangliae*	Rare	Undefined	Not estimated	Low concern (LC)
	Minke whale	*Balaenoptera acutorostrata*	Rare	Undefined	Not estimated	Low concern (LC)
ODONTOCETI	Sperm whale	*Physeter macrocephalus*	Common	Annual periodic	Vulnerable (VU)	Vulnerable (VU)
	Pygmy sperm whale	*Kogia breviceps*	Occasional	Undefined	Data Deficient (DD)	Data Deficient (DD)
	Dwarf sperm whale	*Kogia sima*	Rare	Undefined	Not estimated	Data Deficient (DD)
	Cuvier beaked whale	*Ziphius cavirostris*	Occasional	Undefined	Data Deficient (DD)	Less concern (LC)
	Sowerby beaked whale	*Mesoplodon bidens*	Rare	Undefined	Not estimated	Data Deficient (DD)
	Blainville beaked whale	*Mesoplodon densirostris*	Occasional	Undefined	Not estimated	Data Deficient (DD)
	Gervais beaked whale	*Mesoplodon europaeus*	Rare	Undefined	Not estimated	Data Deficient (DD)
	Northern bottlenose whale	*Hyperoodon ampullatus*	Rare	Undefined	Not estimated	Data Deficient (DD)
	Killer whale	*Orcinus orca*	Occasional	Undefined	Data Deficient (DD)	Data Deficient (DD)
	Short-finned pilot whale	*Globicephala macrorhynchus*	Common	Annual permanent	Least concern (LC)	Data Deficient (DD)
	Long-finned pilot whale	*Globicephala melas*	Rare	Undefined	Not estimated	Data Deficient (DD)
	False killer whale	*Pseudorca crassidens*	Occasional	Seasonal irregular	Not estimated	Data Deficient (DD)
	Risso dolphin	*Grampus griseus*	Occasional	Seasonal irregular	Least concern (LC)	Least concern (LC)
	Bottlenose dolphin	*Tursiops truncatus*	Quite common	Annual permanent	Least concern (LC)	Least concern (LC)
	Rough-toothed dolphin	*Steno bredanensis*	Rare	Seasonal irregular	Data Deficient (DD)	Least concern (LC)
	Short-beaked common dolphin	*Delphinus delphis*	Quite common	Seasonal defined	Least concern (LC)	Least concern (LC)
	Striped dolphin	*Stenella coeruleoalba*	Common	Seasonal irregular	Data Deficient (DD)	Least Concern (LC)
	Atlantic spotted dolphin	*Stenella frontalis*	Quite common	Seasonal defined	Least concern (LC)	Data Deficient (DD)
	Fraser's dolphin	*Lagenodelphis hosei*	Rare	Undefined	Not estimated	Least Concern (LC)
	Melon head dolphin	*Peponocephala electra*	Rare	Undefined	Not estimated	Least Concern (LC)
	Porpoise	*Phocoena phocoena*	Rare	Undefined	Not estimated	Least Concern (LC)

Appendix 2: Form2- Sighting form. Madeira Whale Museum

PROGRAMA DE OBSERVADORES VOLUNTÁRIOS A BORDO DAS EMBARCAÇÕES MARÍTIMO-TURÍSTICAS

FORMULÁRIO Nº 2

FICHA DE AVISTAMENTOS DE BALEIAS E Ggolfinhos

Viagem nº: _____ Embarcação: _____

Data:(dd/mm/aa)	Hora:	Avistamento nº	Local:	Latitude:	Longitude:	Avistado por	Dica	Distância (m)
				. º N	. º W			

Espécie (nível taxonómico mais baixo possível)	Grau de certeza na identificação?	Nº individuos	Nº de crias	Agregação (**marcar com x**)
	Certeza ☐ Provável ☐ Incerto ☐			Animal isolado Grupo coeso Grupo disperso Grupos dispersos

Comportamento dos animais (**fazer círculo**): (não preencher no caso das embarcações já estarem junto dos animais) Repouso Alimentação Deslocação Normal Deslocação em velocidade Saltando Deslocação errática à procura de alimento Socialização Outros:	Direcção dos animais (rumo)	Outras espécies presentes (**marcar com x**) Aves Peixes tartarugas Outros
Condições climatéricas (**fazer círculo**) Escala de Beaufort: 0 1 2 3 4 5+ Visibilidade: Muito boa Boa Média Má Cobertura de nuvens: claro (<10% nuvens) parcialmente coberto (10-50% nuvens) coberto (51-100% nuvens) Meteorologia: Bom (sol) Razoável Neblina Chuvisco Chuva Glare: Forte Médio Fraco Ausente Direcção do vento: Intensidade do vento (nós):	Outras notas/comentários/esquemas:	

Appendix 3: List of abbreviations. Madeira Whale Museum

Abbreviation	Common name	Species
Tt	Bottlenose dolphin	*Tursiops truncatus*
Sf	Atlantic spotted dolphin	*Stenella frontalis*
Dd	Short-beaked common dolphin	*Delphinus delphis*
Sc	Striped dolphin	*Stenella coeruleoalba*
Sb	Rough-toothed dolphin	*Steno bredanensis*
Gm	Pilot whale sp.	*Globicephala sp*
Gma	Short-finned pilot whale	*Globicephala macrorhynchus*
Gg	Risso dolphin	*Grampus griseus*
Pc	False killer whale	*Pseudorca crassidens*
Oo	Killer whale	*Orcinus orca*
pDE	Small dolphin	*Balaenoptera borealis*
gDE	Big dolphin	
nDE	Unidentified dolphin	
Zc	Beaked whale	
ZB	Sowerby beaked whale	*Mesoplodon bidens*
ZD	Blainville beaked whale	*Mesoplodon densirostris*
nM	*Mesoplodon sp.*	*Mesoplodon sp.*
NZI	Beaked whales	
Pm	Sperm whale	*Physeter macrocephalus*
nK	*Kogia sp.*	
Bm	Blue whale	*Balaenoptera musculus*
Bp	Common whale	*Balaenoptera physalus*
Ba	Common minke whale	*Balaenoptera acurostrata*
Bb	Sei whale	*Balaenoptera borealis*
Be	Bryde whale	*Balaenoptera brydei*
Mn	Humpback whale	*Megaptera novaeangliae*
Eg	Balaenidae	
B	Unidentified whale	
NBA	Balaenopteridae	
N	Unidentified	

Appendix 4: Example of table of “Sp individual-sighting” (a portion of the table “Gma individual-sighting”)

RECAPT.CAT	RECAPT.	ID CODE	DATE	SIGHTING	PHOTOGRAPH	NAME CAPTURE	3	2	CATAL.	SIDE
		Gma_001	03/08/2011	V2 A2	171	Gma_MT_001			Y	R
		Gma_001	03/08/2011	V2 A2	128	Gma_MT_402			Y	R
	R1	Gma_001	25/09/2011	V1 A3	308	Gma_MT_153				R
	R2	Gma_001	03/10/2011	V1 A1	23	Gma_MT_208				R
	R3	Gma_001	17/10/2011	V2 A1	422	Gma_MT_394		2		L
	R3	Gma_001	17/10/2011	V2 A1	366	Gma_MT_395		2		L
		Gma_002	03/08/2011	V2 A2	146	Gma_MT_002			Y	R
		Gma_002	03/08/2011	V2 A2	148	Gma_MT_399			Y	R
		Gma_002	03/08/2011	V2 A2	138	Gma_MT_400			Y	R
		Gma_002	03/08/2011	V2 A2	139	Gma_MT_401				R
	R1	Gma_002	03/10/2011	V1 A1	29	Gma_MT_209			Y	R
	R2	Gma_002	17/10/2011	V2 A1	336	Gma_MT_377			Y	L
	R2	Gma_002	17/10/2011	V2 A1	367	Gma_MT_378				L
		Gma_003	03/08/2011	V2 A2	149	Gma_MT_003			Y	R
		Gma_003	03/08/2011	V2 A2	139	Gma_MT_004			Y	R
		Gma_003	03/08/2011	V2 A2	250	Gma_MT_008			Y	L
	R1	Gma_003	17/10/2011	V2 A1	358	Gma_MT_381				L
	R1	Gma_003	17/10/2011	V2 A1	376	Gma_MT_382				L
		Gma_004	03/08/2011	V2 A2	226	Gma_MT_005		2	Y	L
D	R1	Gma_004	03/10/2011	V1 A1	110	Gma_MT_215		2	Y	R
D	R1	Gma_004	03/10/2011	V1 A1	126	Gma_MT_216		2	Y	R
D	R1	Gma_004	03/10/2011	V1 A1	140	Gma_MT_217		2	Y	R
D	R1	Gma_004	03/10/2011	V1 A1	168	Gma_MT_218		2		L
		Gma_005	03/08/2011	V2 A2	233	Gma_MT_006			Y	L
	R1	Gma_005	17/10/2011	V2 A1	428	Gma_MT_385				L
	R1	Gma_005	17/10/2011	V2 A1	344	Gma_MT_386				L

Appendix 5: Examples of all the capture evidences of a re-sighted individual of Gma, Tt, Sf and Bb

- **Gma_002**


a. 03/08/2011 (V2 A2)


b. 03/10/2011 (V1 A1)


c. 17/10/2011 (V2 A1)

- **Tt_066**


a. 22/08/2011 (V1 A2)


b. 29/08/2011 (V2 A1)


c. 01/09/2011 (V1 A1)


d. 17/09/2011 (V1 A1)

- **Sf_079**


a. 19/10/2011 (V2 A1)


b. 29/10/2011 (V2 A1)

- **Bb_002**

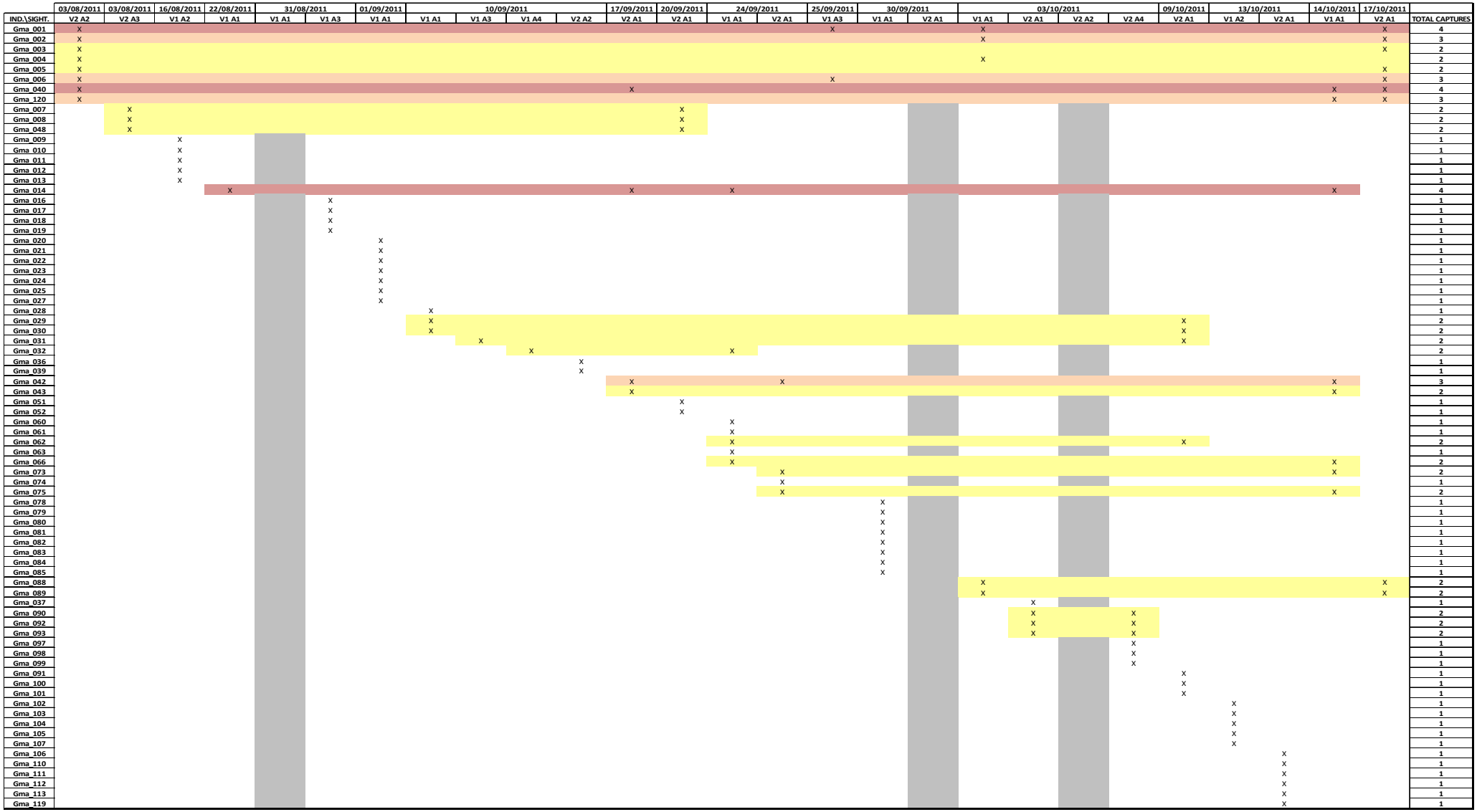


a. 08/08/2011 (V2 A2)


b. 25/08/2011 (V1 A1

Appendix 6: Table of Gma identified individuals capture history

Legend	1 capture	2 captures	3 captures	4 captures



IND.\SIGHT.	03/08/2011 V2 A2	03/08/2011 V2 A3	16/08/2011 V1 A2	22/08/2011 V1 A1	31/08/2011 V1 A1	31/08/2011 V1 A3	01/09/2011 V1 A1	10/09/2011 V1 A1	10/09/2011 V1 A3	10/09/2011 V1 A4	10/09/2011 V2 A2	17/09/2011 V2 A1	20/09/2011 V2 A1	24/09/2011 V1 A1	24/09/2011 V2 A1	25/09/2011 V1 A3	30/09/2011 V1 A1	30/09/2011 V2 A1	03/10/2011 V1 A1	03/10/2011 V2 A1	03/10/2011 V2 A2	03/10/2011 V2 A4	09/10/2011 V2 A1	13/10/2011 V1 A2	13/10/2011 V2 A1	14/10/2011 V1 A1	17/10/2011 V2 A1	TOTAL CAPTURES
Gma_001	X															X			X								X	4
Gma_002	X																		X								X	3
Gma_003	X																										X	2
Gma_004	X																		X									2
Gma_005	X																										X	2
Gma_006	X															X											X	3
Gma_040	X											X														X	X	4
Gma_120	X																									X	X	3
Gma_007		X											X															2
Gma_008		X											X															2
Gma_048		X											X															2
Gma_009			X																									1
Gma_010			X																									1
Gma_011			X																									1
Gma_012			X																									1
Gma_013			X																									1
Gma_014				X								X		X												X		4
Gma_016						X																						1
Gma_017						X																						1
Gma_018						X																						1
Gma_019						X																						1
Gma_020							X																					1
Gma_021							X																					1
Gma_022							X																					1
Gma_023							X																					1
Gma_024							X																					1
Gma_025							X																					1
Gma_027							X																					1
Gma_028								X																				1
Gma_029								X															X					2
Gma_030								X															X					2
Gma_031									X														X					2
Gma_032										X				X														2
Gma_036											X																	1
Gma_039											X																	1
Gma_042												X			X											X		3
Gma_043												X														X		2
Gma_051													X															1
Gma_052													X															1
Gma_060														X														1
Gma_061														X														1
Gma_062														X									X					2
Gma_063														X														1
Gma_066														X												X		2
Gma_073															X											X		2
Gma_074															X													1
Gma_075															X											X		2
Gma_078																	X											1
Gma_079																	X											1
Gma_080																	X											1
Gma_081																	X											1
Gma_082																	X											1
Gma_083																	X											1
Gma_084																	X											1
Gma_085																	X											1
Gma_088																			X								X	2
Gma_089																			X								X	2
Gma_037																				X								1
Gma_090																				X		X						2
Gma_092																				X		X						2
Gma_093																				X		X						2
Gma_097																						X						1
Gma_098																						X						1
Gma_099																						X						1
Gma_091																							X					1
Gma_100																							X					1
Gma_101																							X					1
Gma_102																								X				1
Gma_103																								X				1
Gma_104																								X				1
Gma_105																								X				1
Gma_107																								X				1
Gma_106																									X			1
Gma_110																									X			1
Gma_111																									X			1
Gma_112																									X			1
Gma_113																									X			1
Gma_119																									X			1

Appendix 7: Table of Tt identified individuals capture history

Legend	1 capture	2 captures	3 captures	4 captures	5 captures

	03/08/2011	05/08/2011			08/08/2011		10/08/2011		13/08/2011	16/08/2011	22/08/2011		25/08/2011		29/08/2011	31/08/2011		01/09/2011	05/09/2011		07/09/2011	10/09/2011	12/09/2011	17/09/2011		21/09/2011		24/09/2011		25/09/2011	05/10/2011	06/10/2011	07/10/2011	12/10/2011	17/10/2011	19/10/2011	
IND.\SIGHT.	V2 A2	V1 A1	V1 A2	V2 A2	V1 A3	V2 A2	V2 A2	V2 A3	V2 A1	V1 A2	V1 A1	V2 A2	V1 A1	V2 A1	V2 A1	V1 A4	V2 A1	V1 A1	V1 A1	V2 A1	V2 A1	V1 A4	V1 A1	V1 A1	V2 A1	V1 A1	V2 A1	V1 A2	V2 A1	V1 A1	V1 A1	V1 A1	V1 A1	V1 A1	V1 A1	V1 A1	OTAL CAPTURE
Tt_001	x																																				1
Tt_002	x																																				1
Tt_003	x																																				1
Tt_004			x																																		1
Tt_005			x																																		1
Tt_006			x																																		1
Tt_007			x																																		1
Tt_008			x																																		1
Tt_009			x																																		1
Tt_010			x																																		1
Tt_011			x																																		1
Tt_012			x																																		1
Tt_018				x																																	1
Tt_019				x								x		x																							3
Tt_020				x																																	1
Tt_021				x																																	1
Tt_218				x																																	1
Tt_030								x																												x	2
Tt_031								x																													1
Tt_032								x																													1
Tt_033								x																												x	2
Tt_034								x																								x				x	3
Tt_035								x																												x	2
Tt_036								x																													1
Tt_037								x																													1
Tt_038								x																													1
Tt_039								x																													1
Tt_046									x																												1
Tt_047									x																												1
Tt_048									x																												1
Tt_050										x																					x						2
Tt_056											x																										1
Tt_058												x			x									x													3
Tt_059												x						x					x	x													4
Tt_060												x																									1
Tt_061												x																									1
Tt_062												x																									1
Tt_063												x																									1
Tt_064												x																									1
Tt_065												x											x														2
Tt_066												x			x			x						x													4
Tt_067												x											x														2
Tt_068												x																									1
Tt_069												x																									1
Tt_070												x																									1
Tt_071												x						x			x		x									x					5
Tt_072												x																									1
Tt_073												x																									1
Tt_074												x																									1
Tt_083												x		x				x																			3
Tt_082													x	x																		x					3
Tt_084														x																							1
Tt_088															x																						1
Tt_089															x																						1
Tt_090															x																						1
Tt_091															x																						1
Tt_092															x																						1
Tt_093															x																						1
Tt_094															x																						1
Tt_095															x																						1
Tt_096															x																						1
Tt_098															x																						1
Tt_102																		x																			1
Tt_214																		x								x											2
Tt_122																					x																1
Tt_132																						x															1
Tt_133																						x	x	x													3
Tt_134																						x															1
Tt_139																							x			x											2
Tt_144																									x		x										2
Tt_145																										x											1
Tt_146																										x											1
Tt_159																																x		x			2
Tt_165																														x							1
Tt_167																															x						1
Tt_168																															x						1
Tt_169																															x						1
Tt_170																															x						1
Tt_171																															x						1
Tt_172																															x						1
Tt_173																															x						1
Tt_174																															x						1
Tt_175																															x				x		2
Tt_177																															x						1
Tt_178																															x				x		2
Tt_179																															x					x	2
Tt_183																															x					x	2
Tt_184																															x	x					2
Tt_191																																x		x			2
Tt_192																																x					1
Tt_194																																x					1
Tt_125																																x		x			2
Tt_198																																	x				1
Tt_199																																	x				1
Tt_202																																			x		1
Tt_203																																			x		1
Tt_204																																			x		1
Tt_205																																			x		1

Appendix 8: Table of Sf identified individuals capture history

Legend	1 capture	2 captures

	03/08/2011	05/08/2011	08/08/2011		10/08/2011	16/08/2011	21/08/2011	22/08/2011	29/08/2011	18/09/2011		23/09/2011	06/10/2011	19/10/2011	29/10/2011		
IND.\SIGHT.	V1 A1	V2 A1	V1 A1	V2 A1	V1 A2	V1 A1	V2 A1	V2 A1	V2 A3	V1 A2	V2 A1	V2 A1	V2 A1	V2 A1	V1 A1	V2 A1	TOTAL CAPTURES
Sf_001	X																1
Sf_002	X																1
Sf_003	X																1
Sf_004	X																1
Sf_005	X																1
Sf_006	X																1
Sf_010	X																1
Sf_043	X																1
Sf_011									X								1
Sf_012									X								1
Sf_013									X								1
Sf_014									X								1
Sf_015									X								1
Sf_017									X								1
Sf_047									X								1
Sf_018										X							1
Sf_019										X							1
Sf_020										X							1
Sf_021										X							1
Sf_022										X							1
Sf_023										X							1
Sf_024										X							1
Sf_054										X							1
Sf_055										X							1
Sf_026											X						1
Sf_027											X						1
Sf_028											X						1
Sf_029												X					1
Sf_030												X					1
Sf_031												X					1
Sf_032												X					1
Sf_033												X					1
Sf_071												X					1
Sf_035													X				1
Sf_078													X				1
Sf_036														X			1
Sf_079														X		X	2
Sf_084														X			1
Sf_085														X			1
Sf_037															X		1
Sf_038															X		1
Sf_039															X		1
Sf_046															X		1
Sf_096																X	1
Sf_098															X		1
Sf_099															X	X	2
Sf_100															X		1
Sf_101															X		1

Appendix 9: Table of Bb identified individuals capture history

Legend	1 capture	2 captures

	03/08/2011	08/08/2011	25/08/2011	01/09/2011	18/09/2011	
IND.\SIGHT.	**V2 A1**	**V1 A1**	**V1 A1**	**V2 A1**	**V1 A1**	**TOTAL CAPTURES**
Bb_001	X					1
Bb_002		X	X			2

Appendix 10: Survey Calendar

AUGUST 2011						
1	2	3	4	5	6	7
		CetáceosII		Gavião		
		Sea BornII		Sea the Best		
8	9	10	11	12	13	14
Ventura do Mar		Sea Pleasure			ZonaCat	
CetáceosI		Bonita da Madeira			Sea BornII	
15	16	17	18	19	20	21
	Sea Pleasure					ZonaCat
						Sea BornI
22	23	24	25	26	27	28
Sea Pleasure			Sea Pleasure			
CetáceosII			Sea BornI			
29	30	31				
Sea BornII		Bonita da Madeira				
Cetáceos		Ventura do Mar				

SEPTEMBER 2011						
			1	2	3	4
			Sea the Best			
			Sea BornII			
5	6	7	8	9	10	11
Sea the Best		Ventura do Mar			CetáceosI	Sea BornII
Sea BornII		Bonita da Madeira			Sea the Best	
12	13	14	15	16	17	18
Ventura do Mar					Sea the Best	Sea BornII
Sea the Best					Gavião	Bonita da Madeira
19	20	21	22	23	24	25
	Gavião	CetáceosII		Gavião	Sea the Best	CetáceosI
	Sea the Best	Sea the Best		Sea BornII	Sea Pleasure	
26	27	28	29	30		
				Gavião		
				Sea BornI		

OCTOBER 2011						
					1	2
					Sea Pleasure	
3	4	5	6	7	8	9
Ventura do Mar		Sea the Best	Sea BornII	Gavião	Gavião	Sea the Best
CetáceosI			Ventura do Mar	CetáceosI		Sea BornII
10	11	12	13	14	15	16
		Bonita da Madeira	Sea Pleasure			
		Sea BornI	Sea the Best	Cetáceos		
17	18	19	20	21	22	23
Sea the Best		Bonita da Madeira				
Ventura do Mar		Sea BornII				
24	25	26	27	28	29	30
					CetáceosI	
	Gavião		Ventura do Mar		Sea the Best	
31						

Appendix 11: Vessel sightings during boardings in the study period

ROTA DOS CETÁCEOS														
			SINGLE SPECIES									MIXED SPECIES		
Nº TRIP	DATE	SIGHTING	Bb-NBA	Gma	Oo	Pm	Sb	Sc	Sf	Tt	ZD-NZI	Bb-Tt	Gma-Tt	Gma-Pm
1	03-08-2011	1							1					
2	08-08-2011	1							1					
		2										1		
3	22-08-2011	1							1					
		2								1				
4	29-08-2011	1								1				
		2									1			
		3							1					
5	10-09-2011	1		1										
		2						1						
		3		1										
		4											1	
6	21-09-2011	1								1				
7	25-09-2011	1								1				
		2						1						
		3												1
		4				1								
8	03-10-2011	1		1										
		2												1
		3				1								
		4		1										
9	07-10-2011	0												
10	14-10-2011	1		1										
11	29-10-2011	1							1					
TOTAL		**23**	**0**	**5**	**0**	**2**	**0**	**2**	**5**	**4**	**1**	**1**	**1**	**2**

BONITA DA MADEIRA														
			SINGLE SPECIES									MIXED SPECIES		
Nº TRIP	DATE	SIGHTING	Bb-NBA	Gma	Oo	Pm	Sb	Sc	Sf	Tt	ZD-NZI	Bb-Tt	Gma-Tt	Gma-Pm
1	10-08-2011	1									1			
		2								1				
		3								1				
2	31-08-2011	1		1										
		2					1							
		3		1										
		4								1				
3	07-09-2011	1								1				
4	18-09-2011	1							1					
5	12-10-2011	1								1				
6	19-10-2011	1								1				
TOTAL		**11**	**0**	**2**	**0**	**0**	**1**	**0**	**1**	**6**	**1**	**0**	**0**	**0**

ZONA CAT														
			SINGLE SPECIES									MIXED SPECIES		
Nº TRIP	DATE	SIGHTING	Bb-NBA	Gma	Oo	Pm	Sb	Sc	Sf	Tt	ZD-NZI	Bb-Tt	Gma-Tt	Gma-Pm
1	13-08-2011	1									1			
2	21-08-2011	0												
TOTAL		**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**

SEA THE BEST / SEA PLEASURE														
			SINGLE SPECIES									MIXED SPECIES		
Nº TRIP	DATE	SIGHTING	Bb-NBA	Gma	Oo	Pm	Sb	Sc	Sf	Tt	ZD-NZI	Bb-Tt	Gma-Tt	Gma-Pm
1	05-08-2011	1							1					
		2								1				
2	10-08-2011	1					1							
		2							1					
3	16-08-2011	1							1					
		2											1	
4	22-08-2011	1											1	
5	25-08-2011	1										1		
6	01-09-2011	1											1	
7	05-09-2011	1								1				
		2									1			
8	10-09-2011	1									1			
		2		1										
9	12-09-2011	1			1									
10	17-09-2011	1								1				
11	20-09-2011	1		1										
12	21-09-2011	1								1				
13	24-09-2011	1		1										
		2								1				
14	24-09-2011	1											1	
15	01-10-2011	0												
16	05-10-2011	1								1				
17	09-10-2011	0												
18	13-10-2011	1									1			
		2		1										
19	13-10-2011	1		1										
20	17-10-2011	1								1				
21	29-10-2011	1							1					
TOTAL		**26**	**0**	**5**	**1**	**0**	**1**	**0**	**4**	**7**	**3**	**1**	**4**	**0**

GAVIÃO														
			SINGLE SPECIES									MIXED SPECIES		
Nº TRIP	DATE	SIGHTING	Bb-NBA	Gma	Oo	Pm	Sb	Sc	Sf	Tt	ZD-NZI	Bb-Tt	Gma-Tt	Gma-Pm
1	05-08-2011	1								1				
		2								1				
2	17-09-2011	1											1	
3	20-09-2011	0												
4	23-09-2011	0												
5	30-09-2011	1		1										
6	07-10-2011	1								1				
7	08-10-2011	0												
8	25-10-2011	0												
TOTAL		**5**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**3**	**0**	**0**	**1**	**0**

SEA BORN I / SEA BORN II														
			SINGLE SPECIES									MIXED SPECIES		
Nº TRIP	DATE	SIGHTING	Bb-NBA	Gma	Oo	Pm	Sb	Sc	Sf	Tt	ZD-NZI	Bb-Tt	Gma-Tt	Gma-Pm
1	03-08-2011	1	1											
		2											1	
		3		1										
2	13-08-2011	1								1				
3	21-08-2011	1							1					
4	25-08-2011	1								1				
5	29-08-2011	0												
6	01-09-2011	1	1											
7	05-09-2011	1								1				
8	11-09-2011	0												
9	18-09-2011	1	1											
		2							1					
10	23-09-2011	1							1					
11	30-09-2011	1		1										
12	06-10-2011	1								1				
13	09-10-2011	1		1										
14	12-10-2011	0												
15	19-10-2011	1							1					
TOTAL		**15**	**3**	**3**	**0**	**0**	**0**	**0**	**4**	**4**	**0**	**0**	**1**	**0**

VENTURA DO MAR														
			SINGLE SPECIES									MIXED SPECIES		
Nº TRIP	DATE	SIGHTING	Bb-NBA	Gma	Oo	Pm	Sb	Sc	Sf	Tt	ZD-NZI	Bb-Tt	Gma-Tt	Gma-Pm
1	08-08-2011	1							1					
		2									1			
		3								1				
2	31-08-2011	1								1				
3	07-09-2011	0												
4	12-09-2011	1								1				
5	03-10-2011	1		1										
6	06-10-2011	1							1					
7	17-10-2011	1		1										
8	27-10-2011	0												
TOTAL		**8**	**0**	**2**	**0**	**0**	**0**	**0**	**2**	**3**	**1**	**0**	**0**	**0**