

Small cetaceans off São Tomé (São Tomé and Príncipe, Gulf of Guinea, West Africa): Species, sightings and abundance, local human activities and conservation

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ABSTRACT

Humans and cetaceans are both part of complex marine ecosystems and large ocean mega fauna, such as marine mammals, are often used to direct conservation efforts. São Tomé and Príncipe is an African equatorial archipelago situated in the Gulf of Guinea, which seems to be an important marine area for cetaceans. However, as in many parts of the world, the status of marine species or populations has not been assessed mainly due to lack of information. Four species of small cetaceans were identified, bottlenose dolphins (*Tursiops truncatus*) with the highest sighting rate and pantropical spotted dolphins (*Stenella attenuata*) the highest abundance rate. These two species occurred during almost all sampling months while killer whales (*Orcinus orca*) seem to be present in just a part of the year. Most observed behaviours were traveling (32%) and feeding (57%) and most of the groups were formed by adults, juveniles and calves (81%). In this study we identified five human activities with very different possible impacts on cetaceans - (1) historical whaling; (2) fishing and by-catches; (3) tourism; (4) debris and pollution; (5) oil exploration - and all this needs to be put into context to understand the dynamics of the ecosystems where these natural populations live. Also, since the ending of 20th century whaling, there is no legal background to regulate specific activities related specifically with marine environment and cetaceans. Several measures regarding the conservation of natural populations of cetaceans are suggested but most importantly, in São Tomé and Príncipe, is to allow a change to a more conservation-oriented perspective. Scientific research, interactive and continuous environmental education plans and well established whale watching programs need to be developed. Moreover, scientists, policymakers and local resources users need to be involved as knowledgeable stakeholders.

KEYWORDS

Dolphins, occurrence, SPUE, APUE, fisheries, eco-tourism, legislation, São Tomé and Príncipe, Gulf of Guinea, West Africa.

INTRODUCTION

Humans and cetaceans are both part of complex marine ecosystems and the regulation of the use of their populations must be based on an understanding of the structure and dynamics of the ecosystems of which they are part (Reynolds *et al.*, 2009). For an ecosystem approach to the management of the marine environment it is essential to understand the role of all components and the consequences of human impacts. The state of global oceans is rapidly deteriorating with dire consequences for marine species (Jackson *et al.*, 2001). Several marine mammals' species or significant populations are currently threatened by a variety of anthropogenic factors, ranging from accidental mortality and vessel-strikes to pollution, global warming, and potential food competition. Generally, these marine species are victims of our increasingly intensive use of the oceans (Schipper *et al.*, 2008). Cetaceans, as a guild of abundant, large organisms that are relatively sensitive to such threats, provide reliable means to determine the boundaries for a conservation area in a certain region (Hooker *et al.*, 1999).

Historically, most conservation efforts have focused on terrestrial systems, but it is becoming increasingly apparent that conservation efforts are urgently required for the oceans as well (Casey & Myers, 1998). Recently, significant attention has been given to the establishment of marine reserves, because marine and freshwater habitats are less well known than terrestrial areas (Boersma & Parrish, 1999; Mangel, 2000; Hooker & Gerber, 2004; Mace, 2005; Schipper *et al.*, 2008). In recent years, many studies on distribution have aimed to identify critical habitats for cetaceans (Greg & Trites, 2001; Harwood, 2001) and, in several cases such data have been used to support the establishment of Marine Protected Areas (Dawson & Slooten, 1993; Hooker *et al.*, 1999; Hastie *et al.*, 2003). In spite of the lack of a solid theoretical foundation, large ocean mega fauna, such as marine mammals and birds, are often used to direct conservation efforts. Cetaceans are not only top predators and indicators of the quality of their ecosystems but also relatively vulnerable to extinction. Marine predators attract significant attention in ocean conservation policy and planning and are therefore often used to promote reserve designation (Hooker & Gerber, 2004).

São Tomé and Príncipe is an African equatorial archipelago situated in the Gulf of Guinea. This seems to be an important marine area for cetacean's concentration probably due to prey abundance and the existence of shallow and protected bays (Picanço *et al.*, 2009). But, as in many parts of the world, the status of species or populations of cetaceans has not been assessed due, in part, to lack of information (Reynolds *et al.*, 2009). Information on cetacean distribution plays an important role in the identification of suitable boundaries for marine protected areas, but is also crucial for developing management and monitoring programmes. Even though data on habitat use by pelagic cetaceans is generally difficult to collect, such information is beneficial to most conservation and management purposes. Obtaining this type of information is of particular relevance in relatively undisturbed ecosystems, and where no baseline data exists, as in the case of many tropical oceanic archipelagos such as São Tomé and Príncipe.

Assessment of the possible ecological, economic and social effects of using cetaceans as resources should precede both proposed use and proposed restriction of ongoing use (Reynolds *et al.*, 2009). Our objectives were: (1) to determine diversity, occurrence and sighting rate for small cetaceans; (2) to understand which human activities could affect the presence of cetaceans in coastal waters; (3) to review historical and recent legislation related to cetaceans; and (4) to give some preliminary indications to the conservation of coastal small cetaceans.

METHODS

São Tomé and Príncipe is an African equatorial archipelago located in the Gulf of Guinea (between 1°44 N and 0°01 S). With a volcanic origin, this tropical archipelago is the second smallest African country and is composed by two main islands and several small islands and islets (Fig. 1). Between July 2002 and September 2006 a pilot study was conducted allowing a

preliminary assessment on which species of cetaceans regularly occur around São Tomé Island (see Picanço *et al.*, 2009). Recordings included species identification, date, time, geographic coordinates, size of the group, predominant behavior, sea state, bathymetry in the position of the sighting and sea surface temperature. The software ArcGis was used to map the sightings.

We calculated SPUE (sighting per unit of effort) as the number of sighted cetaceans groups per time at sea for all detected species in each area: $n^{\circ} \text{ sightings} / \text{survey effort} \times 60 \text{ min}$. Relative abundance of common dolphins was estimated by calculating APUE (abundance per unit of effort), as the number of individuals (mean estimate of group size classes) per time at sea in each area: $n^{\circ} \text{ dolphins} / \text{survey effort} \times 60 \text{ min}$. For this analysis we only used sightings with complete information, such as time at sea and group size.

For the behavioral analysis we considered the following categories: traveling, feeding, inquisitive; interactions; and other aerial behaviors. Group types were considered as: only adults; adults + juveniles; and adults + juveniles + calves.

During the same period an exploratory historic and socio-cultural research was carried out. This investigation took place in national archives and libraries, especially at the São Tomé and Príncipe National Archive and Library, as well as in local environmental and historical associations and NGO's. Our objective was to obtain historical information on maritime and coastal human activities in the archipelago as well as their possible relation to cetaceans. A careful and detailed review of more recent bibliography regarding cetacean occurrence, fishing and conservation of marine environment in the Gulf of Guinea, was also conducted.

RESULTS

Occurrence of cetaceans

Results from 210 boat-based surveys, with a total effort of 39500 min at sea (Fig. 2) shown 66 encounters with small cetaceans. The occurrence of four species was recorded ($n=66$): pilot whale, *Globicephala spp.* ($n=1$); killer whale, *Orcinus orca* ($n=6$); pantropical spotted dolphin, *Stenella attenuata* ($n=16$) and bottlenose dolphin, *Tursiops truncatus* ($n=43$).

We observed particular areas of small cetaceans' concentration, particularly for the pantropical spotted dolphins occurring mostly in the northeast part and at high depths; bottlenose dolphins seem to occur all along the coast (Fig. 3). No measure of effort per sub-area was conducted and this observation is rather qualitative.

Sighting and abundance rates were calculated, using the total effort at sea and number of observations and mean group sizes, respectively SPUE and APUE (Table I): bottlenose dolphins have the highest sighting rate and spotted dolphins the highest abundance rate. Monthly analysis (Fig. 4 and 5) shows that bottlenose and spotted dolphins have the widest temporal distribution; killer whales seem to occur in just a part of the year.

Considering all species, we found that sighted groups were mostly feeding (57%) and traveling (32%) (Fig. 6) and were mostly composed by adults, juveniles and calves (81%) (Fig. 7). Distribution of two most common behavioural activities are shown together with an overlap of areas with more intense human impacts (Fig. 8).

The only occurrence of pilot whales was in a mixed group with bottlenose dolphins during a feeding event.

Human activities

We establish five human activities related to the marine environment with possible strong, direct or indirect, impacts on natural populations of small cetaceans occurring in the area: (1) historical whaling; (2) fishing and by-catches; (3) tourism; (4) debris and pollution; (5) oil exploration.

The Gulf of Guinea has been reported as a breeding ground for humpback whales since the 19th and 20th century whaling period (Figueiredo, 1958). In the year 1854, two humpback

whales were caught in Fernando Pó island (north of Príncipe island), and in 1869, six humpback whales were caught off Príncipe (Townsend, 1935). In this whaling ground, which includes both Cape Lopez (Gabon) as well as the main islands of São Tomé and Príncipe, an industrial activity occurred between 1912 and 1959 and a total of 15715 large whales were captured (Budker, 1952; Budker, 1953; Figueiredo, 1958; Budker & Roux, 1968): 15447 humpback whales and 268 of other whales, including several baleen whale species and sperm whales. For the period between 13 July and 25 October 1951, an anglo-norwegian whaling company was established in the Island of São Tomé and captured a total of 714 large whales. For this period there is information regarding the species captured: 53 sperm, 2 fin, 336 Bryde's and 323 humpback whales (Budker, 1952; Figueiredo, 1958). Whaling no longer occurs off São Tomé and Príncipe. However, an aboriginal whaling activity still persist in Pagalu (a small island south of São Tomé) to these days, dedicated mainly to the capture of humpback whale calves (Aguilar, 1985), but no recent surveys have been conducted. Even though industrial captures of cetaceans do not occur in the region, occasional and opportunistic catches of small cetacean may still be a reality in the islands of São Tomé and Príncipe.

Artisanal fishing is an important resource to local people of São Tomé Island and fishery products are a very important source of food protein, reaching, according to estimates, a *per capita* consumption of about 25 kg (ACP, 2007), and representing 60 to 70% of the animal protein into the local population diet (Afonso *et al.*, 1999). Fishing plays an important socio-economic role given the large number of people involved in this work and the fact that many coastal communities rely exclusively on this activity. The fisheries sector is presently composed of three sub-sectors which have different characteristics: industrial fishing, carried out by long-lining and purse seiner vessels with fishing licenses, semi industrial fishing, with vessels catching fish up to the 20 mile limit and the artisanal fleet, operating in the coastal zone (ACP, 2007). Artisanal fishing takes place in small wooden canoes moved by paddles or small outboard motors, mostly using traditional fishing gears, from main urban agglomerates such as the city of São Tomé (on the northeast), Neves (northwest) Angolares and Ilheu das Rolas (south) (see Fig. 8). In these areas very small mesh fishnets as well as hand grenades and scuba diving equipment are being used to increase captures, which may pose a significant impact in local fish communities. The fish are unloaded directly onto the beaches, where they are sold either directly by the fishermen or by dealers. There is no economically dominant fish species that is landed, however there are more than fifty species that are sold (ACP, 2007). A former expedition (Santos *et al.*, 1995) showed an occurrence of 127 species of fishes and considered littoral ichthyo-diversity of São Tomé Island high if compared to other Eastern Atlantic Islands, mainly due to its biogeographic influence. Abundance and biodiversity is also reflected in the marine resources exploitation through traditional and industrial fishing (from other nations), which are important everyday activities in the archipelago.

By-catches of small cetaceans are not documented to São Tomé but oral information given by fishermen refers to their occasional capture. Three occurrences during our study period can be referred to the city of São Tomé, Neves and Angolares as evidence of by-catch (see Fig. 8), but no effort has yet been done to record continuously possible by-catches or direct captures.

A fairly recent activity is now growing as part of a tourist increase in São Tomé and Príncipe: whale watching and related maritime activities. Scuba diving, snorkelling and small boat tours are flourishing in the coastal waters of São Tomé; encounters with humpback whales and other small cetaceans are frequent and could represent a significant economic income. These activities are referred to the city of São Tomé and Ilhéu das Rolas (see Fig. 8), but they most certainly occur in the Island of Príncipe where not study regarding this issues was ever conducted.

There is also a problem of pollutant discharges in the maritime areas. The main sources of coastal and marine environment pollution are: industrial and domestic sewage; solid wastes, detritus, plastics and marine debris; physical modifications of the shoreline, including the degradation of the critical habitats and coastal erosion; oil residual wastes and other

hydrocarbons, most often due to uncontrolled shipping operations off the coast of the archipelago (UNEP, 1999).

Gulf of Guinea is one of the most prolific hydrocarbon provinces of the world. An intensive exploration effort over the last 35 years in and around the Niger Delta in particular has led to a succession of significant discoveries. However, the full potential of the continental slope and rise seaward of the shelf break is only recently becoming apparent, with a number of exploration programs having resulted in world-class discoveries being made in recent years (Gerhard Seibert, personal communication). The *Nigeria – São Tomé and Príncipe Joint Development Zone* (JDZ) is between latitudes 1 and 3 degrees north and longitudes 4 and 8 degrees east in the Gulf of Guinea. It covers an area of 34,548 km² with water depths ranging from about 1500m in the northern part of the JDZ to over 4000m at its south-western sector (Nigeria – São Tomé and Príncipe Joint Development Authority, 2003).

Legislation for the marine environment

We found several 20th and 21st century laws regulating human activities on the marine environment, but especially in relation to whaling management. From a total of eleven different laws, six were whaling related and the others (all post whaling) are related to general aspects of environment protection (Table II).

An important difference between these laws is that whaling legislation until mid-20th century was rather precise in terms of hunting seasons, number of whales to be captured and to be discarded on shore, about the place to establish land-based operations and factories, as well as approved whaling licenses. Since the end of this activity we could not find any other legislation referring specifically to whales or dolphins occurring in the region. In fact, most of legal attention is given to land and forest protected areas and species.

DISCUSSION

Cetaceans' occurrence

Conserving cetaceans is an ongoing process that can never be considered complete (Jones, 1994). Conservation measures need to be evaluated and re-evaluated, and new approaches need to be developed to address threats that were unrecognized or non-existent until recently (Reeves *et al.*, 2003). To moderate anthropogenic pressures and protect the abundance and diversity of the species it is necessary to understand which management measures should be applied (Moulins *et al.*, 2007).

Diversity of cetaceans species in São Tomé seems to be smaller than in other areas of the Gulf of Guinea (e.g. Weir, 2007), but data presented here are part of a larger research program mainly focused on humpback whales occurrence during their breeding season (Carvalho *et al.*, 2009) and may be very biased. So, it will be fundamental to extend data collection to different periods of the year, as well as to the island of Príncipe where no cetacean campaign was ever conducted. Besides, complementing information with cetacean data from the other two islands in the Gulf of Guinea (Fernando Pó to the north and Pagalu to the south) would most certainly prove to be very useful.

Bottlenose and spotted dolphins were the most common small cetaceans sighted, the last in much larger groups and occurring in much higher depths (Picanço *et al.*, 2009) which is typical of the species. Most information for pantropical spotted dolphins is from the Pacific or eastern Atlantic and more data would result in greater insights to the ecology and behaviour of this species.

Most observed behaviours are typical of near to shore activities of oceanic dolphins, such as traveling between spots and feeding at certain locations, which may pose important conservation issues especially when overlap with human presence is evident. Great majority of group were composed by individuals in all age classes and, consequently, mating and birth most

certainly occurs in the area. Also, the presence of mixed groups and inter-specific sympatric occurrences and behaviours should be addressed in the future.

Conservation issues

In this study we identified five human activities with very different possible impacts on cetaceans. Referring to historical industrial whaling, a reduced number of captures (only 323 humpback whales in 1951 off São Tomé) lead to the early closing of the whaling company after its first season in the island. The reduced number of available whales was evident, also shown by a striking decrease of the captures off Cape Lopez from 1356 in 1949 to only 264 in 1952 (Budker & Roux, 1968). Since the ending of whaling there is not a legal background to regulate specific activities related with marine environment. Although having some generic laws for local protection of fauna, where cetaceans are generically included, more detailed legislation is required. Whale and dolphin watching is rapidly increasing but unregulated, and conducted without any knowledge by several tourist operators. Protection of the more commonly observed cetacean species is necessary.

Overfishing and use of inadequate fishing gears is a problem and, as in other areas of the Gulf of Guinea (Weir *et al.*, 2008), direct catches or by-catches may also be probable cause of mortality that needs further insight. The seasonality in relative abundance of cetacean species is relevant to the development of effective mitigation measures against anthropogenic threats. In particular, understanding temporal and spatial distribution of cetaceans is essential to determine when animals might come into contact with particular fisheries and to mitigate against potential by-catch (Weir *et al.*, 2007). The management efficacy in this area is also dependent on the degree of adherence to any regulations by local fishermen.

São Tomé and Príncipe has an extensive marine ZEE which is rich not only in biological resources but also in oil resources. Oil exploration is the most recent industry that may negatively impact the marine resources and directly influence their ecosystems. Now it is time to obtain baseline information on cetaceans' occurrence to prevent future destruction of these internationally protected natural populations. Before large-scale exploration and development of oil and gas resources might take place in deep Gulf waters, it is required an assessment on cetacean abundance and distribution in order to detect any changes associated with future developments (Mullin & Hoggard, 2004).

We must manage the human activities that may affect vulnerable species or populations rather than the species themselves. Thus, cetacean conservation is a social problem as well as an ecological one and a conservation strategy must achieve its objectives even in face of scientific uncertainty (Reynolds *et al.*, 2009).

Conservation measures suggested regarding these natural populations of cetaceans are: (1) to develop a more detailed and continuous study on cetaceans occurrence and distribution, including both São Tomé island and Príncipe island, and if possible extending it to the other two islands of the Gulf of Guinea; (2) to establish geographical marine and coastal areas of protection or interdiction to some human activities, like industrial fishing; (3) to create a legal background on fishing activities, tourism (especially whale watching) and implement conservation and management measures; (4) to create and settle down a police brigade in order to guarantee legal accomplishment; (5) to develop environmental studies considering the new tourist and industrial activities in coastal areas and open sea; (6) to provide civic and environmental education, human resources training and awareness-raising campaigns. All these points must be taken into consideration and applied in the field according to local people and country cultures. Where indigenous people and local resources user may be affected, they should be involved as knowledgeable stakeholders in developing appropriate conservation measures (Marsh *et al.*, 2003).

We believe that for an effective conservation the first step is a change in public awareness and actions, in order to allow that local people become spontaneously more disciplined, even though conservation benefits are likely to depend upon greater vision by

scientists and policymakers. All together must decide to favour long-term sustainability benefits over short-term economic profit (Hooker & Gerber, 2004). In general, the single most essential requirement for cetaceans and marine ecosystems conservation is a re-examination of the relationship of humans to the rest of our natural world (Reynolds *et al.*, 2009).

In São Tomé and Príncipe, a change to a more conservation-oriented perspective should now be implemented. Scientific research, interactive and continuous environmental education plans and well established whale watching programs need to be seriously considered. This is the moment towards the creation of a specific legal background and proper measures to support the conservation and management of cetaceans.

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Figure 1 - Geographical localization of São Tomé and Príncipe archipelago in relation to the West Coast of Africa.



Figure 2 – Effort at sea (2002-2006): 39500 minutes; 210 surveys between 2002 and 2006.

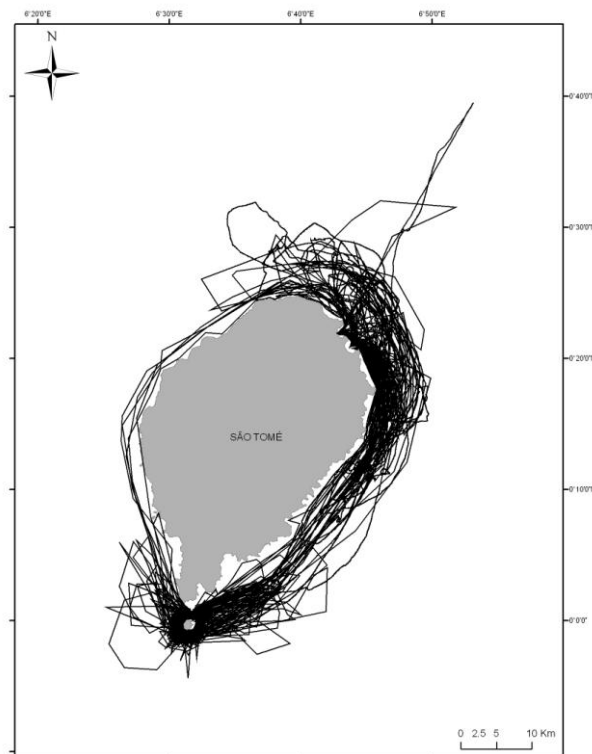


Figure 3 – Occurrence of small cetaceans around São Tomé Island (2002-2006): 66 sightings.

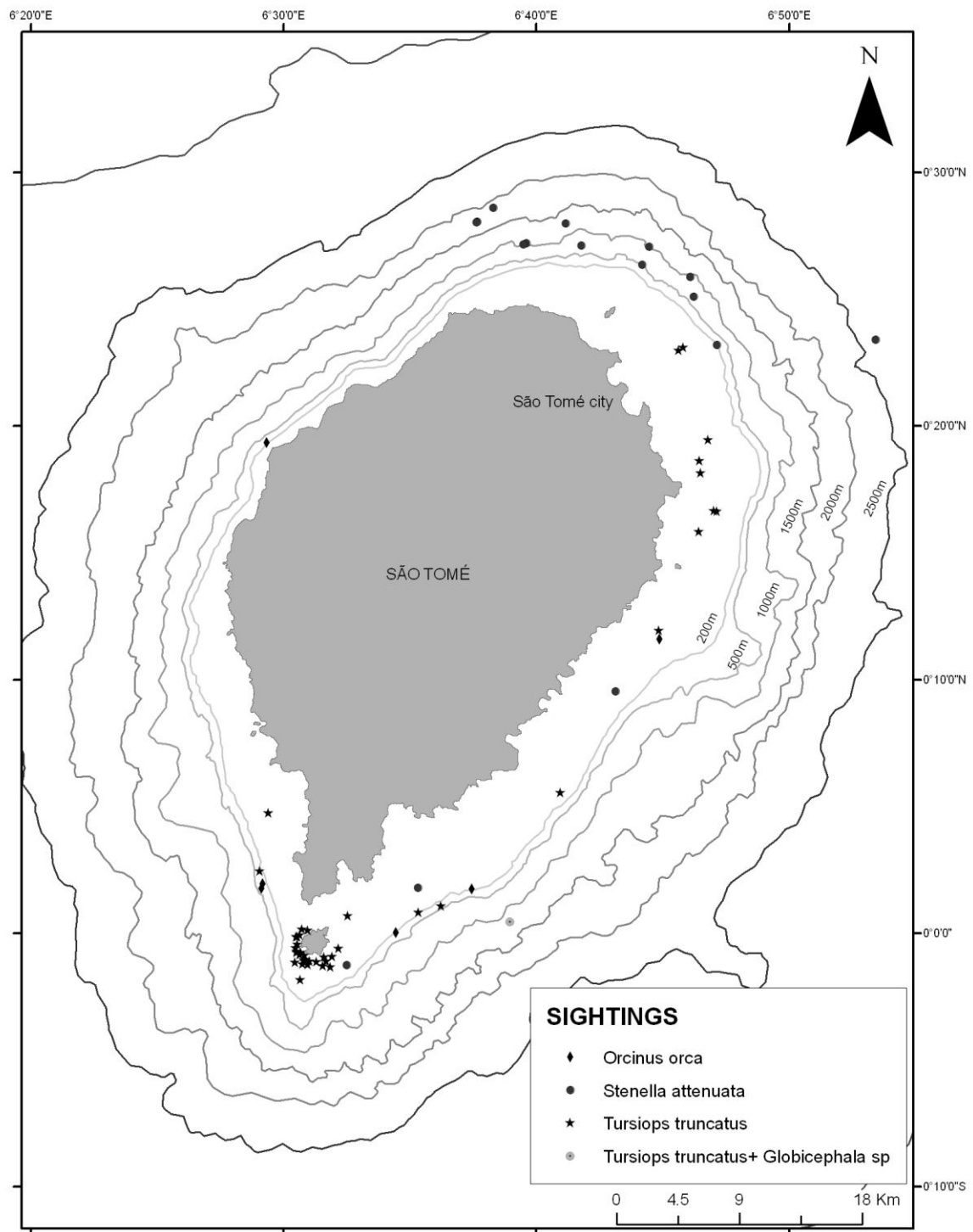


Table I – Sighting per unit of effort, SPUE (h), and abundance for unit of effort, APUE (h), for each species that occurred at the area during the study period: total effort 39410 min.

	Bottlenose dolphin	Spotted dolphin	Killer whale	Pilot whale
SPUE	0,065	0,024	0,009	0,002
APUE	0,074	0,389	0,014	0,03

Figure 4 – Monthly distributions of SPUE (h) for each species.

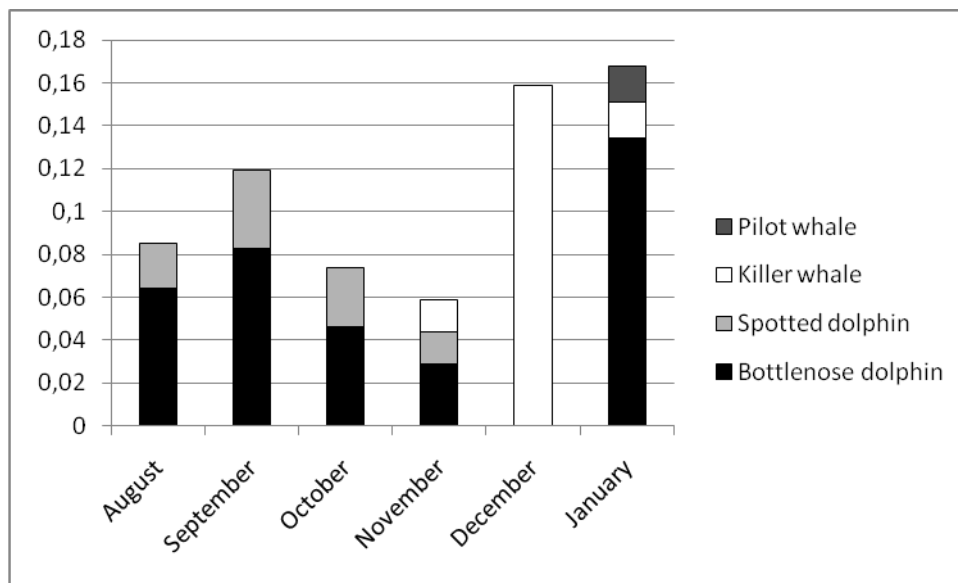


Figure 5 – Monthly distributions of APUE (h) for each species.

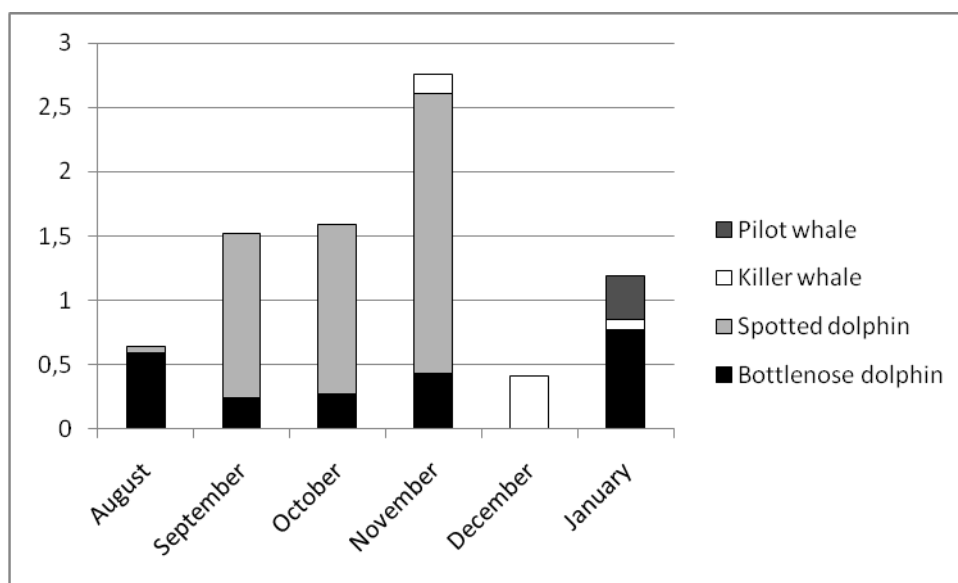


Figure 6 – Distribution of behavioural activities (n=65).

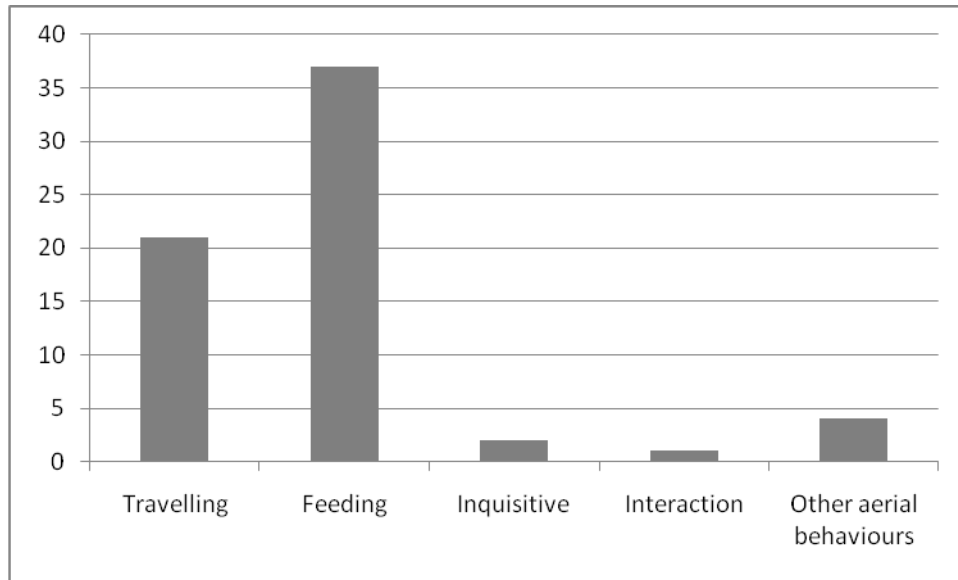


Figure 7 – Distribution of group types (n=63).

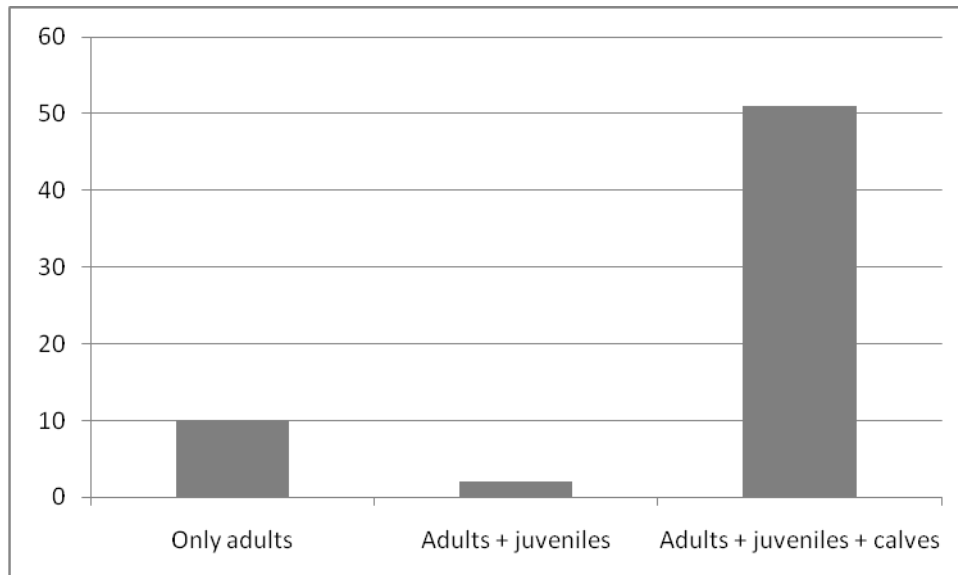


Figure 8 – Distribution of two most common behavioural patterns of all small cetaceans sighted (feeding and travel) showing an overlap with coastal areas of more intense human activities: artisanal fishing (area); by-catch evidence (cross) and whale-watching (W).

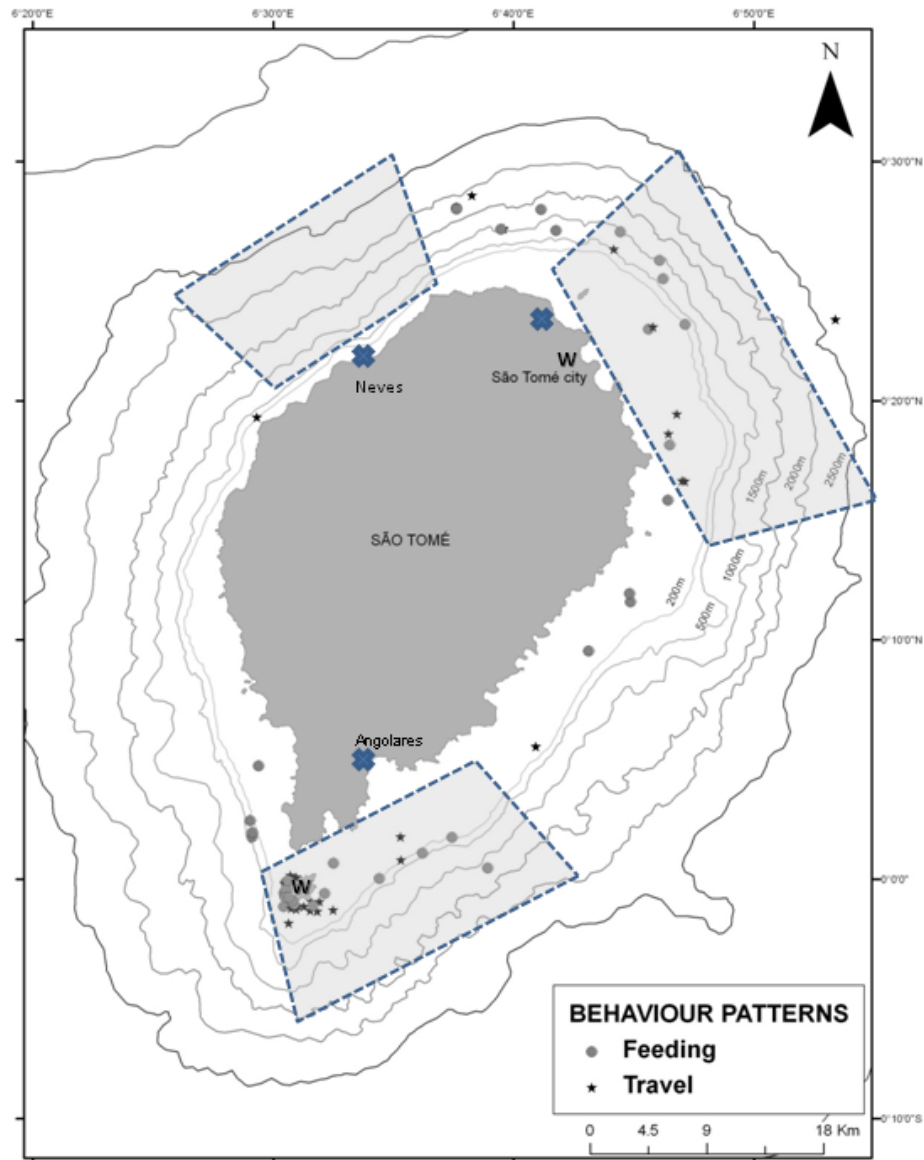


Table II – Review of legislation related with marine environment and cetaceans since 1913 until the present.

Year	Legislation	Subject	Reference
1913	Regulates whaling in S. Tome and Príncipe (STP) waters	Whaling	Lei n.º 58 (1913)
1914	Approves whaling in STP waters	Whaling	Portaria n.º 102 (1914)
1932	Changes to the previous rules on whaling in STP waters	Whaling	Portaria n.º 7 (1932)
1936	General information about whaling activities in STP islands	Whaling	Portaria n.º 102 (1936)
1938	Establish a payment for captured whales in STP waters	Whaling	Portaria n.º 181 (1938)
1951	Gives the exclusive of whale hunting and industrialization for the STP territorial waters to a specific company	Whaling	Portaria n.º 1:537 (1951)
1955	Establishes rules to protect the soil, animals and vegetation of the overseas Portuguese territories	Environment	Decreto n.º 40:040 (1955)
1999	Environmental laws	Environment	Lei n.º10/99 (1999)
1999	Law for the conservation of fauna, flora and protected areas	Conservation	Lei n.º11/99 (1999)
2001	Fishing and marine resources law	Fishing	Lei n.º09/2001 (2001)
2003	Petroleum regulations	Oil exploration	Nigeria-São Tomé and Príncipe joint development authority (2003)