Evidence that St. Helena island is an important multi-use habitat for whale sharks, *Rhincodon typus*, with the first description of putative mating in this species

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Preliminary observations of whale shark behavioural ecology are presented from St. Helena, a remote volcanic island in the South Atlantic. Whale shark sightings by fishers, government biologists and the general public have been recorded by the St. Helena Government since February 1999 and are presented here through to the end of 2014. A total of 328 sightings was collected on an *ad hoc* basis, a total of 931 animals, although the number of re-sightings within that total is not known. Increases in observations are likely coincident with increases in surveillance and public awareness of the presence of this species in the waters surrounding St Helena. On two occasions, small aggregations of whale sharks were observed at the bay at Jamestown; the animals were engaged in surface feeding behaviour similar to that seen in coastal aggregations in Mexico and Qatar. In contrast to other aggregations, however, animals observed at St Helena were numerically dominated by adult females, although mature males and some juveniles have also been observed. On two occasions, eyewitness accounts of mating behaviour were reported by two different reliable observers. These events took place in 2005 and 2007, both approximately 16 kilometers from shore, at different sites. They both involved belly-to-belly contact behaviour at the surface, in one case involving at least two males. This is the first report of putative mating behaviour in the whale shark. With the presence of both adult and juvenile animals, surface feeding aggregations, apparently pregnant females and the first observations of putative mating, the waters around St Helena are clearly an important multi-use habitat for whale sharks and are worthy of concerted conservation efforts.

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Abstract

Preliminary observations of whale shark behavioural ecology are presented from St. Helena, a remote volcanic island in the South Atlantic. Whale shark sightings by fishers, government biologists and the general public have been recorded by the St. Helena Government since February 1999 and are presented here through to the end of 2014. A total of 328 sightings was collected on an *ad hoc* basis, a total of 931 animals, although the number of re-sightings within that total is not known. Increases in observations are likely coincident with increases in surveillance and public awareness of the presence of this species in the waters surrounding St Helena. On two occasions, small aggregations of whale sharks were observed at the bay at Jamestown; the animals were engaged in surface feeding behaviour similar to that seen in coastal aggregations in Mexico and Qatar. In contrast to other aggregations, however, animals observed at St Helena were numerically dominated by adult females, although mature males and some juveniles have also been observed. On two occasions, eyewitness accounts of mating behaviour were reported by two different reliable observers. These events took place in 2005 and 2007, both approximately 16 kilometers from shore, at different sites. They both involved belly-to-belly contact behaviour at the surface, in one case involving at least two males. This is the first report of putative mating behaviour in the whale shark. With the presence of both adult and juvenile animals, surface feeding aggregations, apparently pregnant females and the first observations of putative mating, the waters around St Helena are clearly an important multi-use habitat for whale sharks and are worthy of concerted conservation efforts.

Introduction

Current knowledge of the biology of whale sharks, *Rhincodon typus* Smith 1828, was recently and comprehensively reviewed by (Rowat and Brooks 2012). It is the longest and heaviest extant species of fish (Colman 1997, McClain et al. 2015) and, along with the basking shark (*Cetorhinus maximus*) and megamouth shark (*Megachasma pelagios*), one of only three known species of filter-feeding sharks.

Recent growth in the scientific literature pertaining to whale shark natural history has been substantial (Stevens 2007, Rowat and Brooks 2012, Sequiera et al. 2013, Sequiera et al. 2014). This has occurred in part because of the recognition of the phenomenon of whale shark aggregations, reviewed in Rowat and Brooks (2012), in which large numbers of whale sharks gather together to feed, often relatively close to the coast. The more reliable of these aggregations have provided tremendous opportunities for research on a species that was generally considered solitary and oceanic and therefore an intractable species to study. For reasons that are not yet clear, whale sharks appear to segregate space resources at regional scales, such that coastal aggregations are numerically dominated by immature males, whereas oceanic individuals tend to be larger and predominantly female . Knowledge from the study of aggregations is therefore weak in several demographic sectors, namely the biology of small juveniles and of adults of both sexes, especially mature males. In light of this, it is perhaps not surprising that mating has never been observed in this species. Fishery-independent data regarding the occurrence of whale sharks in the South Atlantic are particularly lacking (Sequeira et al 2014) compared to other ocean basins, probably because no coastal aggregation sites have yet been characterized in the South Atlantic.

Neither mating nor pupping have been observed in whale sharks (Rowat and Brooks 2012), although we do know that the species is ovoviviparous, has large litter sizes (Joung et al. 1996), and may engage in prolonged sperm storage (Schmidt et al. 2010). Neonatal whale sharks have been observed on a handful of occasions (Rowat et al. 2008, Rowat and Brooks 2012, Hsu et al 2014).

St. Helena is a very remote volcanic island in the South Atlantic Ocean, at 15.95°S, 5.70°W, approximately 1860km due west of the Angola/Namibia border and 3,130 km northwest of Cape Town, South Africa (Figure 1 inset). The nearest island is Ascension, which is 1,290 km to the northwest. Although well within the Tropic of Capricorn, the climate of St. Helena is subtropical and moderated by prevailing trade winds. The largest center of habitation, Jamestown, is on the lee side of the island facing northwest and the total population of the island is around 4,000 people. St Helena is a significant masked booby (*Sula dactylatra*) rookery and calving ground for humpback whales, *Megaptera novaeangliae* and has high rates of both terrestrial and marine endemism. We provide preliminary evidence that whale sharks use habitats around St. Helena for feeding and mating. The observations of mating reported here are the first we are aware of for this species.

Materials and Methods

Research was carried out with the permission of the Environmental and Natural Resources Directorate (ENRD) of the St Helena Government. Records of *ad hoc* whale shark sightings were recorded by ENRD from 1999 to the end of 2014 (Figure 1) . A sighting report included date, species, abundance, location, observer and any photographic evidence, if collected. Observers included scientific staff of ENRD, fishermen and the general public. A standard form

was completed when sightings were reported to ENRD and entered in to a sightings database. Regular observers such as professional fishermen, were issued with a standard logbook to assist in the process. An aggregation was defined as three or more whale sharks visible simultaneously from the observer's boat.

Data on size were visually estimated by each observer. There are well-documented problems with this approach (see discussion in Rohner et al 2011), but for a *post hoc* reporting system we are not aware of another feasible way. Similarly, pregnancy is at present impossible to confirm for whale sharks, since sonography and venipuncture are not practical and blood markers of pregnancy have not been validated anyway. We defined females as "apparently pregnant" when they were observed to have a pronounced abdominal swelling in the region around and posterior to the pelvic fins. This abdominal swelling makes the pale skin that normally faces ventrally in that area begin to face more laterally, which in turn makes a "white wedge" evident to observers viewing from the side. Assessment of presumptive pregnancy was not carried out by most observers, only by ENRD staff during the 2014, 2013 and 2012 aggregations.

Data from whale sharks observed from January 2013 and January 2014 were submitted to Wildbook for Whale Sharks (formerly ECOCEAN, www.whaleshark.org) using photo identification images of the left and/or right flank of the animal (Arzoumanian et al. 2005). These were compared against other sightings in the global whale shark database using the Modified Groth and I3S search algorithms.

Results and Discussion

A total of 328 sightings was recorded between 1999 and October 2013 (Figure 2) for a total of 931 animals, with both the total number of sightings and the average number of whale sharks per sighting increasing monotonically since 2010 (Figure 3), although no data were recorded for 2000-2002 inclusive. The higher reported annual sightings in 2006 and 2007 almost certainly represent reporting bias because during those two years there was a specific public promotion scheme aimed at increasing the collection of marine sightings data. The higher sightings in 2014 represent increased public awareness, but also appear to be a genuinely higher figure because the average number of animals per sighting was also substantially higher. Whale shark sightings around St. Helena were seasonal from November to May (summer) with the highest number of observations occurring in January to March (Figure 4). The data almost certainly include a significant degree of seasonal surveillance bias because the marine environment is used more by both residents and tourists during the summer months.

Twenty-three aggregations of three or more whale sharks were reported between 1999 and 2014. Aggregations of ten or more individuals took place in January 2011, February 2012 and January 2013 (twice). A persistent aggregation of 17 whale sharks took place from January 28-29, 2013, in the harbour adjacent to Jamestown (5˚43’52.52”W 15˚54’46.14”S); with 21 animals reported on January 27 being the highest number ever reported in St. Helena. We are aware of aggregations of 10 or more in 2010 and summer 2014 that were not formally reported Video recordings and observations of the January 2013 event confirm that whale sharks were feeding by the active ram surface feeding method (Motta et al. 2010); vertical feeding was not observed. Qualitative plankton analysis revealed large numbers of fish eggs very similar to another

aggregation where whale sharks have been shown to tuna eggs in similar abundance (Motta et al. 2010, De la Parra Venegas et al. 2011). Skipjack tuna, *Katsuwonus pelamis*, were observed schooling on the surface in the vicinity of the whale shark aggregation. At least one mature male was also observed during the January 2013 aggregation (EC - personal observation) and mature males were routinely observed in 2014. Average total length of the larger animals in the aggregation was estimated visually to be 10 m or more, but several smaller individuals estimated visually to be around 4m total length were also observed.

None of the encounters uploaded to Wildbook for Whale Sharks matched existing records from the approximately 23,000 encounters in the database as of January 24, 2014. Nineteen of the encounters had a left side image suitable for the establishment of new sharks and were assigned identification numbers SHA-001 to SHA-019, accordingly. These animals, consisting of 8 males, 6 females and 5 of undetermined gender, represent the first named animals from this location. The majority of the females were large and appeared to be pregnant (Figure 5).

On two occasions during the reporting period, putative mating behaviour of whale sharks was reported to ENRD staff. These events took place in 2005 and 2007 at opposite ends of the island, on popular fishing grounds approximately 16 kilometers from shore. The observations were made by two different people. The 2005 event was reported by the island's chief fisheries officer at the time, whereas the 2007 event was reported by a career professional fisherman. On January 28, 2005 on the New Shoal fishing ground (5˚50'21.97"W 15˚59'28.12"S and see Figure 1) the chief fisheries officer reported:

153 "*Two whale sharks mating! Came together - one on* [its] *back swimming below the other one,*
154 *then came belly to belly, very near to the surface for a few minutes. Came alongside the boat,*
155 *lifted its head out of the water. Quite a few remoras on them - were pale white*"
156
157 On February 15, 2007 on the Dawson's fishing ground (15˚52'2.83"S 5˚42'19.25"W and see
158 Figure 1) a professional fisherman reported:
159
160 "*Saw two smaller ones (male) and one larger female. The two males were trying to mate with the*
161 *female. Saw the male going belly to belly with female and other male also trying to get in there!"*
162
163 While photo and video documentation was not made of these events, both observers are
164 competent naturalists and would be expected to recognise mating behaviour among sharks. The
165 descriptions of the events are remarkably similar, despite being made 2 years apart, in different
166 locations, by different people, and they are also consistent with known mating behaviour in other
167 species of sharks (Carrier *et. al* 2004). There seems little reason to doubt that the two separate
168 eyewitness accounts do in fact represent observations of mating behaviour and we feel confident
169 to report them here as such. One interesting aspect of the reports is that mating takes place at the
170 surface, at least in the observed cases.
171
172 Figure 1 shows a map of St. Helena, with the location of the January 2013 aggregation and the
173 reported location of mating behaviours in 2005 and 2007. Other sightings are grouped by zones
174 (lettered A-H), where the dot size represents the number of sightings. A significant spatial bias
175 exists in these data because few fishers or boaters regularly visit the windward side of the island.

176 It is quite possible that the windward side is also used by whale sharks, but the lack of
177 surveillance makes this hard to determine.
178
179 **Conclusions**
180 St. Helena is a remote oceanic island in the South Atlantic that forms critical habitat for whale
181 sharks. We base this conclusion on several key pieces of information:
182 • Consistent sightings annually since Government record-keeping began in 1999,
183 • Observational, video and photographic evidence of feeding aggregation behaviour
184 associated with fish spawning events,
185 • A preponderance of large, apparently-pregnant females, but also the presence of clearly
186 mature males and juvenile animals, all in feeding aggregations,
187 • Two eyewitness accounts of mating behaviour in 2005 and 2007 by separate reliable
188 observers, consistent with each other and with known mating behaviour in other shark
189 species.
190 Taken together, these data suggest that whale sharks use St. Helena for a greater diversity of
191 purposes – feeding and mating - than any other known location. For this reason, more research
192 into the behaviour and habitat usage of whale sharks at St. Helena is warranted, and so is a
193 concerted effort to put in place effective conservation measures that will protect whale sharks
194 into the future. This is especially important because St Helena is scheduled to open its first
195 airport before the end of 2016, after which tourism, especially ecotourism, is expected to expand
196 dramatically.
197

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Figure captions

Figure 1: Whale shark sightings around St. Helena 1999-2014. The size of circles and color intensity indicate the total number of whale sharks seen in that sector. The two sites identified as Dawon's and New Shovel are the sites described in the text, where mating was observed.

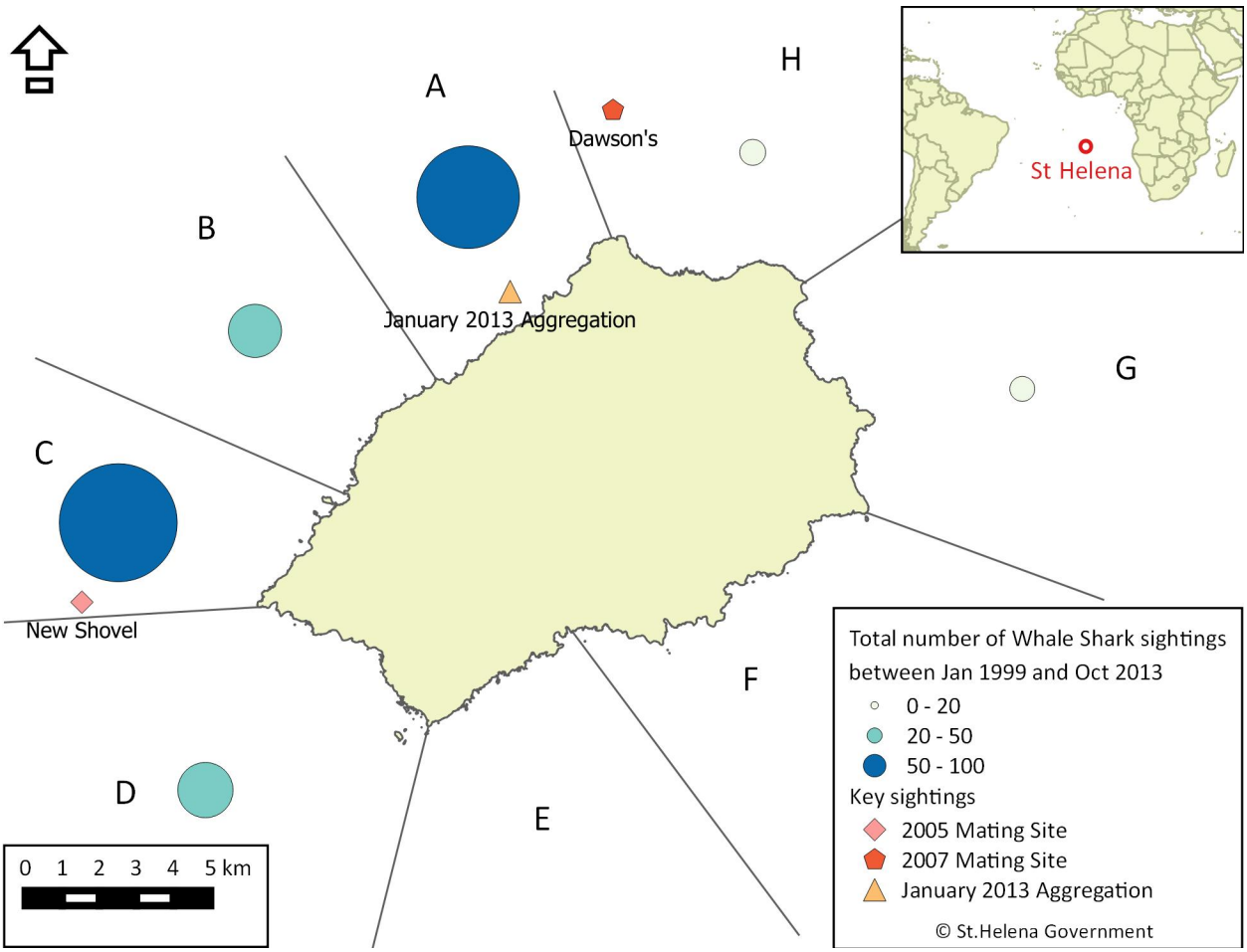
Figure 2: Total annual number of whale shark sightings at St. Helena 1999-2014

Figure 3: Average number of whale sharks per sighting at St. Helena 1999-2014

Figure 4: Total number of reported whale shark sightings at St Helena per month, 1999 and 2003-2013

Figure 5: Apparently pregnant female whale sharks seen at St Helena in January 2013. Females were presumed pregnant when they were observed to have a pronounced abdominal swelling in the region around and posterior to the pelvic fins, such that the paler skin that normally faces ventrally in that area begins to face ventrolaterally (arrow) and is therefore significantly more evident to observers viewing from the side

269 **Figure 1**



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271 **Figure 2**

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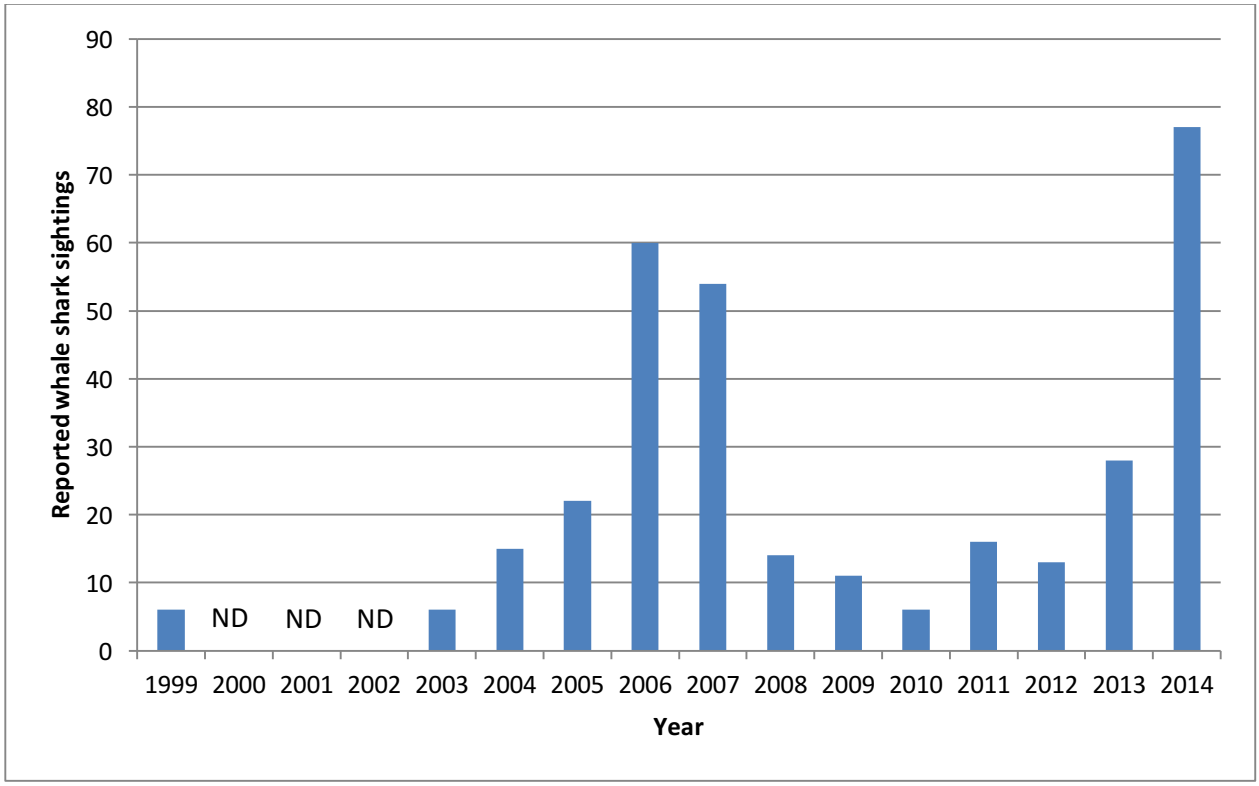

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276 **Figure 3**

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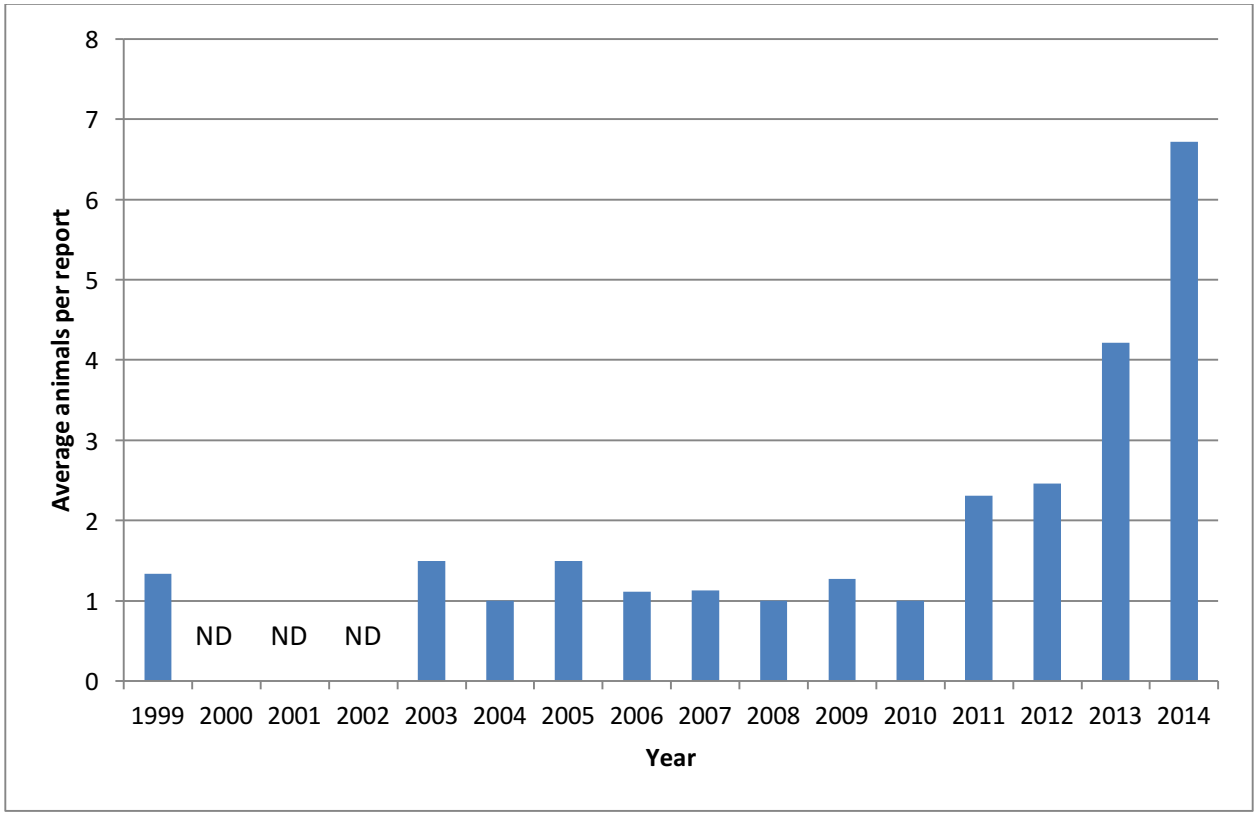

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281 **Figure 4:**

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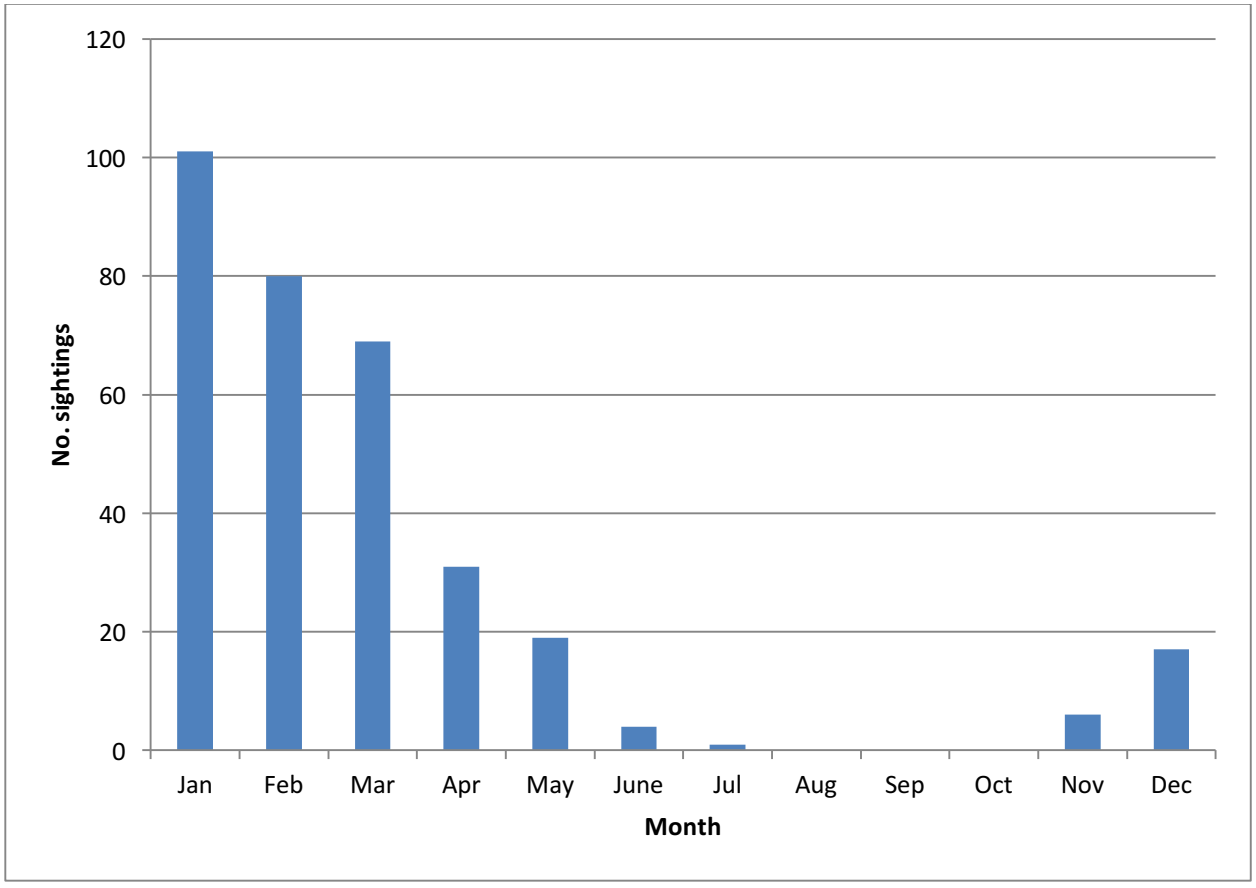

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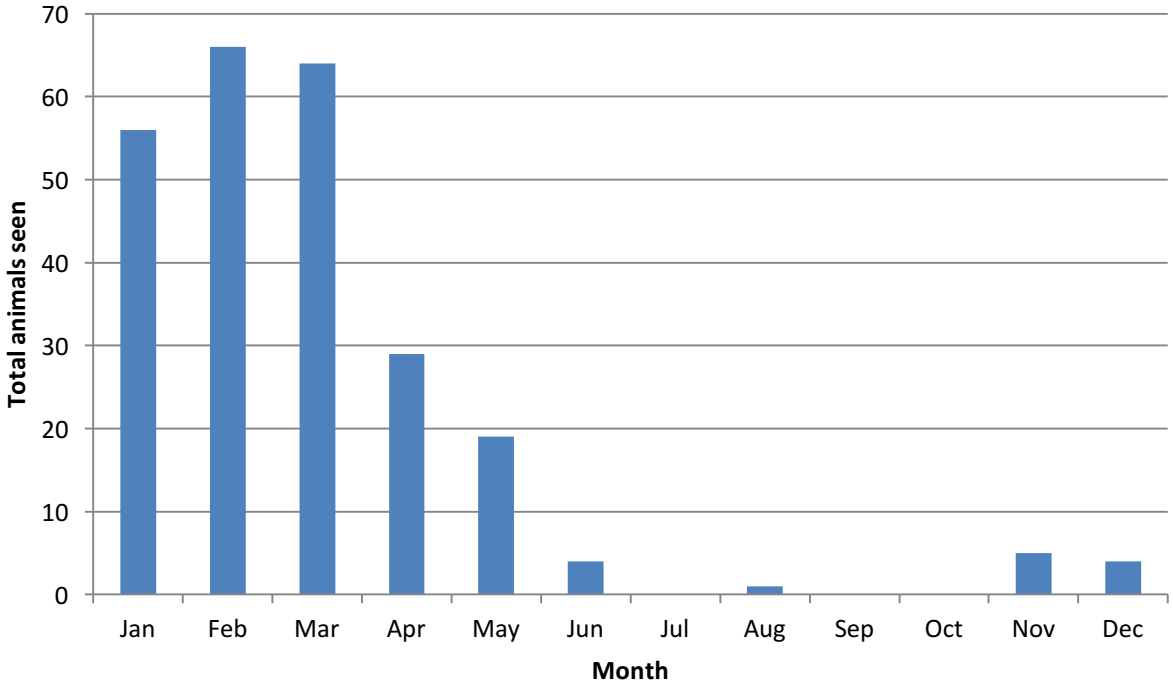
70
60
50
40
30
20
10
0
Total animals seen
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

284

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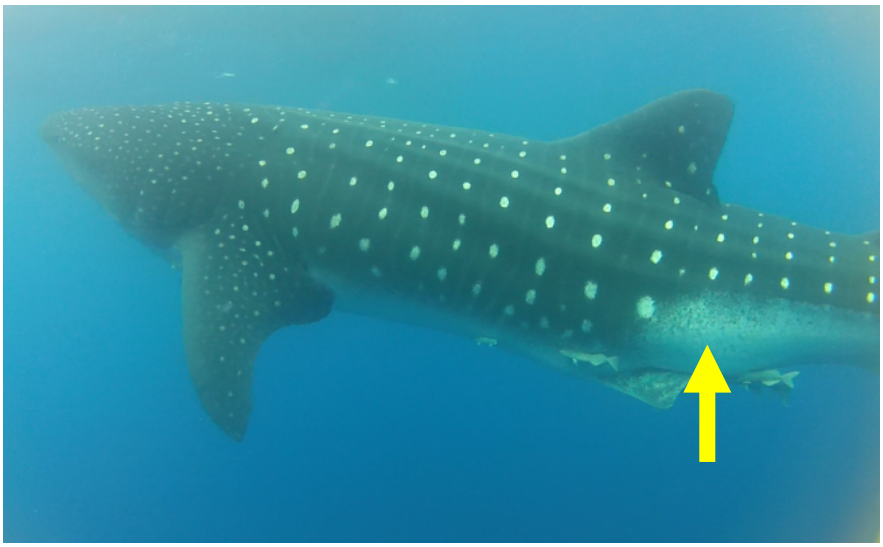
Figure 5:



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