Cruise report for a survey of cetaceans in the Azores, Portugal, conducted from R/V *Song of the Whale* 5th April – 8th May 2012 by the International Fund for Animal Welfare and Marine Conservation Research International

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July 2012

Funded by the International Fund for Animal Welfare

CONTENTS

SUMMARY

The IFAW research vessel *Song of the Whale* (SOTW) visited the Azores in April and May 2012 whilst en route from the UK to the USA. The aim of the visit was to build upon recent research effort on the vocalisations of both baleen and beaked whales as part of on-going work to develop acoustic detection systems. The *Song of the Whale* team conducted 34 days of survey effort in the Azores between 5th April and 8th May during which 10 cetacean species were encountered; bottlenose dolphin *Tursiops truncatus*, blue whale *Balaenoptera musculus*, short-beaked common dolphin *Delphinus delphis*, fin whale *Balaenoptera physalus*, Risso's dolphin *Grampus griseus*, sei whale *Balaenoptera borealis*, short-finned pilot whale *Globicephala macrorhynchus*, Sowerby's beaked whale *Mesoplodon bidens*, sperm whale *Physeter macrocephalus* and striped dolphin *Stenella coeruleoalba*. Common dolphins were encountered most often and their distribution appeared to be relatively uniform. Other species were encountered less regularly, with numerous cetacean sightings being made to the south of the island of Pico; it should be noted, however, effort levels here were higher. A more detailed analysis of the acoustic data is currently underway.

1. INTRODUCTION

The International Fund for Animal Welfare (IFAW) has had a long-running interest in the cetaceans of the Azores, primarily through the work conducted from its research vessel *Song of the Whale* (SOTW). The distribution and behaviour of sperm whales was investigated by the team in 1987 to 1991, 1993 and 1995 using photo-identification and passive acoustic techniques (Leaper *et al*., 1992; Gordon *et al*., 1995; Gillespie & Leaper, 1996; Boisseau *et al*., 1999) whilst the distribution of beaked whales was studied in 2008 (Boisseau *et al*., 2009). The field work conducted in 2012 builds on this previous body of non-invasive research. The objectives of the work were two fold; a) to conduct visual and acoustic surveys for baleen whales in the waters of the Azores and mid-Atlantic ocean, and b) to investigate the presence of and make further recordings of beaked whales in the study area.

1.1 Baleen whales

Blue whales (*Balaenoptera musculus*), fin whales (*Balaenoptera physalus*), humpback whales (*Megaptera novaeangliae*), Bryde's whales (*Baleanoptera edeni*) and sei whales (*Balaenoptera borealis*) are thought to undertake extensive seasonal migrations within the Atlantic between winter mating and calving grounds and summer feeding grounds – which are mainly in higher latitudes (Clapham *et al*., 1999). During their migration, peaks in abundance occur in the Azores throughout April and May thought to follow a spring bloom of phytoplankton (Visser *et al*., 2011). In addition to more frequent visitors, a North-Atlantic Right whale (*Eubalaena glacialis*) was sighted off the coast of the Azores in 1999, the first since 1888, by biologists from the University of the Azores Department of Oceanography and Fisheries and a biologist from Whale Watch Azores.

Large whales are subject to a wide range of anthropogenic impacts. Each of the species of large whale sighted in the Azores suffered some degree of population depletion by whaling in the late 1800s and early 1900s. Since the IWC moratorium on whaling came into effect in 1986, other anthropogenic activities continue to threaten their recovery. Entanglement in fishing gear is a major source of non-natural mortality (Lien, 1994; Perrin *et al*., 1994; Volgenau *et al*., 1995) and ship strikes pose a threat to all species of baleen whale, especially from large, fast commercial vessels such as container ships (Clapham *et al*., 1999). Although most large scale commercial whaling no longer takes place, subsistence and aboriginal whaling takes place on a variety of species in the North Atlantic. In addition, continued catches of minke and fin whales by Iceland and Norway are a cause for concern.

There are a variety of conservation measures in effect for the North Atlantic right whale and humpback whale species in the Northwest Atlantic. However, due to the wide ranging nature of the other species of baleen whales seen in the Azores, and the limited knowledge of the status of many species, conservation plans for these are limited.

Baleen whales are known to produce numerous types of low frequency signals (see for example, Cummings *et al*., 1986; Edds, 1988; McDonald *et al*., 2001; Thompson *et al*., 1996), mostly below 50 Hz, although Bryde's whale, sei whales and humpback whales are known to produce calls in frequencies up to 80 Hz (Cummings *et al*., 1986, Edds *et al*., 1993), 600 Hz (McDonald *et al*., 2005) and 1900 Hz (Thompson *et al*., 1986) respectively. With limited knowledge of sei and Bryde's whale vocalisations in the Atlantic and increasing evidence suggesting that song patterns from blue whales can be used to distinguish between stocks (McDonald *et al*., 2006), efforts to describe the vocalisations of baleen whale are particularly important. In addition, it is possible to localise vocalisations if detected on at least three hydrophone elements within a wide aperture array. This allows the subsequent calculation of vocalisation rates, a parameter that is often missing from studies using remote acoustic techniques.

Photographic identification images of baleen whales allow for the on-going investigation of the movements and residency of individuals. It is unclear to which populations or stocks the baleen whales encountered in the Azores belong. Photo-identification images taken of individually distinguishing features including the tail flukes (blue and humpback whale) skin mottling (blue whale), flank chevron (fin whale) and callosity patterns (right whale) allow identification of individuals. Comparison of these images with local photo-identification catalogues and those further afield, for example in Canada, the USA and Iceland, can provide information on whale movements, population structure and stock identity. Improved knowledge of cetacean movements and the areas they pass through has implications for conservation and mitigation of threats. This is particularly important for fin whales, as those passing the Azores may be from the same stock that visits Icelandic waters, a region where an intermittent hunt, removing significant numbers of individuals, has been taking place in recent years.

1.2 Beaked whales

The beaked whales, or Ziphiids, are one of the least known families of cetaceans. They are particularly difficult to study, because they are both deep divers and oceanic in distribution. They are also very difficult to detect visually at sea. In recent years, there has been increasing evidence that they are vulnerable to anthropogenic sounds, particularly seismic airguns and military mid frequency sonar (2-10 kHz). In the past 40 or so years, over 40 mass strandings have been reported world-wide (probably representing a small proportion of all beaked whale strandings). Some of these were concurrent with naval exercises and the use of active sonar, and the overall pattern of strandings has led to increasing concerns that certain sounds from sonar may result in the death and injury of beaked whales.

Beaked whales are known to be difficult to spot visually (e.g. Barlow *et al*. 2006), so improved systems for detecting beaked whales for example using passive acoustic techniques have intrinsic value. Where there are data, beaked whales have been found to use relatively high frequency echolocation (up to 120 kHz or more) and non–echolocation sounds in the region of up to at least 16 kHz. Some of these vocalisations appear to be quite distinctive from those of other cetaceans (Johnson *et al*. 2004; Zimmer *et al*. 2005), a very positive finding in terms of the viability of identification of beaked whales by acoustics.

Current information on beaked whale distribution is sparse, but they "seem to be most common in slope waters and around offshore volcanic islands" (Kaschner, 2007). Certainly, many of the recent strandings have been in areas with abrupt undersea topography (e.g. Hellenic Trench, Greece, the Canary Islands and Galápagos Islands). The physical basis for the association probably lies in the effects of topography on the water column and the way it concentrates nutrients and prey. A better understanding of the preferred habitats of these whales will support measures to protect them.

A pilot study was carried out in 2008 by IFAW to investigate beaked whale distribution in the north-eastern Atlantic, focused on the Canary Islands, Azores and Madeira. This research provided useful initial data on beaked whales and their vocalisations (Boisseau *et al*., 2009) with potential hotspots of beaked whale presence being identified in the waters south of the main islands.

1.3 Aims

Through a combination of dedicated survey effort and opportunistic sightings via land-based Vigias and whale-watching vessels, the team aimed to:

- Investigate the presence and offshore distribution of baleen and beaked whales in the spring.
- Acquire high quality recordings of various species for subsequent description and comparison.
- Identify the position and identity of vocalising whales in order to estimate vocalisation rates.
- Contribute to photographic–identification catalogues for the Azores through local collaboration.

2. METHODOLOGY

The research was conducted in the Azorean EEZ from 5th April to 8th May 2012 between 36° and 42°N. Surveys were conducted from the 21m auxiliary-powered cutter-rigged research vessel *Song of the Whale*, under sail, motor or motor/sail between a minimum of 5 knots (to stream hydrophones) and a maximum of 8 knots (to reduce cable strum and keep the arrays at depth). Survey effort was conducted in a quasi-random fashion based largely upon prior sightings, winds favourable to sailing, regions of unusual and varied bathymetry and passage destination.

2.1 Data collection

In daylight hours and in sea states below four, two visual observers with binoculars were positioned on a sighting platform that provided an eye height of 5.5 m above sea level. Observers were prompted by acoustic cues and/or deck observers. In higher sea states, observers kept a lookout from deck. Sightings were logged to a database via the Logger software (IFAW). Environmental and GPS data were logged automatically to the same database, including date, time, vessel position (lat-long), sea surface temperature (°C) and wind speed (knots). Manual records of other environmental variables (such as sea state, wave and swell height) and survey effort (numbers and positions of observers) were made hourly.

Acoustic surveys were primarily conducted using 400 m towed four-element broadband hydrophone arrays (SEICHE Ltd.). Continuous stereo recordings were made at sampling rates of both 8 kHz and 192 kHz via bespoke buffer boxes passing signals to an NI-6251 data acquisition card and an RME Fireface 800 sound card respectively. The 8 kHz recording system also incorporated a Behringer Ultracurve DEQ2496 to introduce a 4 kHz low-pass filter prior to signal digitisation in order to prevent aliasing. The buffer boxes provided variable frequency responses; however, the entire system was capable of detecting signals from 10 Hz to 200 kHz. For the bandwidths of interest for baleen whale vocalisations (10 to 8000 Hz) and beaked whale clicks (25 to 50 kHz), the response of the system was approximately flat. Recordings were made using Pamguard and written to disk as two-channel 16 bit wav files.

The team also explored coastal and offshore habitats around the Azores for other marine mammals. Additional research effort was spent on priority species such as bottlenose and Risso's dolphins and included photo-ID and high-frequency recording. The click detection software RainbowClick (IFAW) was run continuously to log odontocete click trains in the audio range (2 to 24 kHz); Whistle detection software (IFAW) was also run to detect FM calls produced by odontocetes.

2.1 Baleen whales

In addition to making recordings with R/V *Song of the Whale*'s towed array, attempts were made to record and localise baleen whale vocalisations using a wide-aperture hydrophone array. When baleen whales were encountered and their movement patterns were predictable, Non-Anchored Underwater Tracking Instrumentation buoys (NAUTI-buoys) were deployed if environmental conditions and daylight hours were conducive. NAUTI-buoys incorporate a hydrophone and a digital recorder suspended below the water surface with a GPS receiver mounted above the waterline to record the track of the buoy (Figure 1). The NAUTI-buoys were deployed in an attempt to make recordings consecutively with towed hydrophone arrays. Ideally, two NAUTI-buoys approximately a kilometre apart with the towed array providing the third point of an equilateral triangle could provide a suitably wide aperture for the localisation of whale vocalisations.

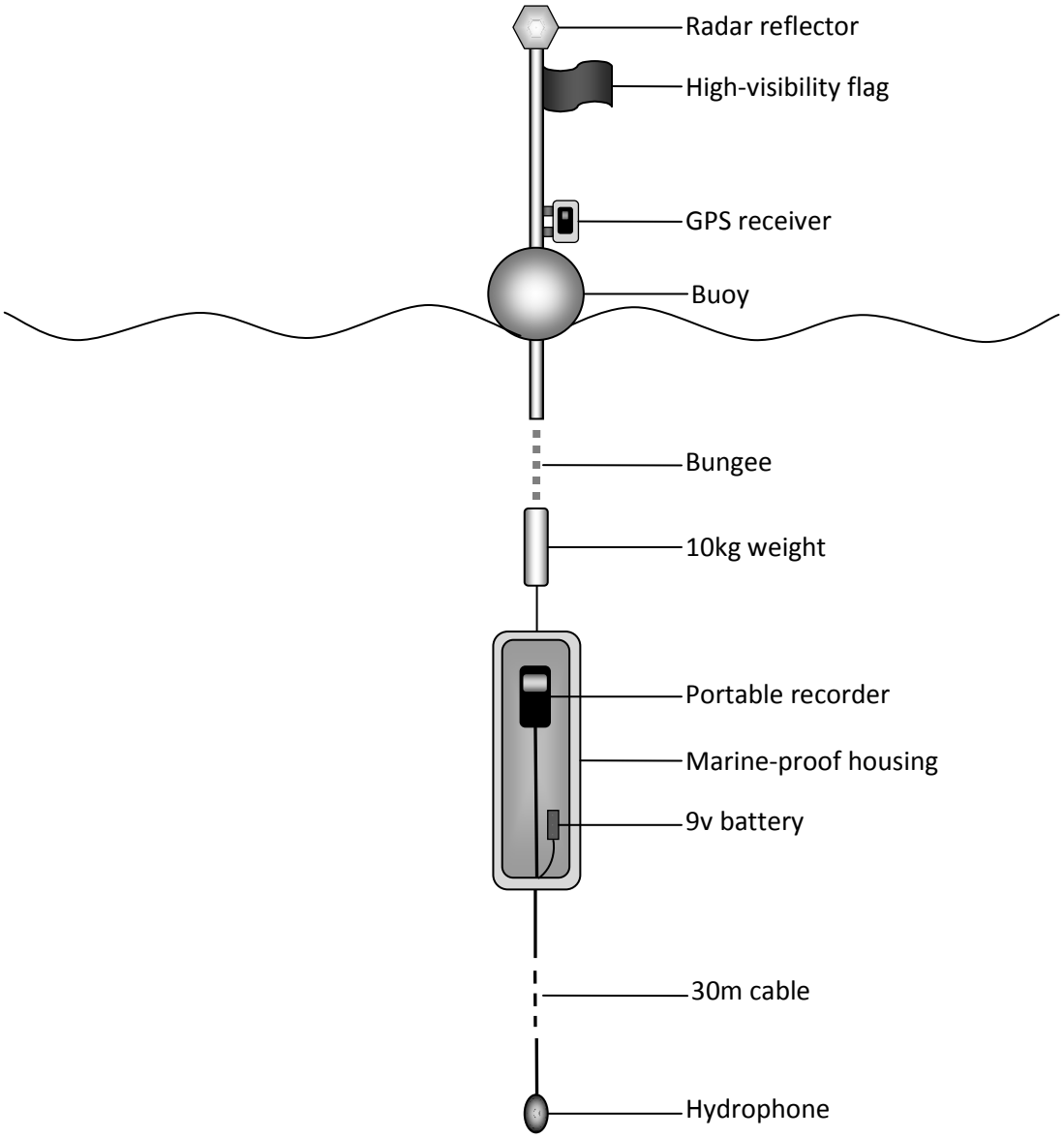


Figure 1. Cross-section schematic of a free-floating NAUTI-buoy. The hydrophone and recorder are suspended below the water surface using a bungee and weight.

2.1 Beaked whales

As typical beaked whale clicks have the distinctive form of a relatively long duration (~200 µs) FM upsweep with dominant energy between 25 and 50 kHz (Johnson *et al*. 2004; Johnson *et al*. 2006; Gillespie *et al*. 2009), it is possible to detect and extract potential beaked whale clicks from background noise using click detection algorithms. Thus, acoustic signals were monitored in real-time during this survey using a click detector module in Pamguard (Passive Acoustic Monitoring Guardianship, www.pamguard.org) whereby sounds with significant energy (>6 dB above background noise) in the 25 to 50 kHz band were classified as potential beaked whale clicks (see Gillespie *et al*. 2009 for details). Extra survey effort was spent in those areas previously identified by the *Song of the Whale* team as important for beaked whales (Boisseau *et al*., 2009).

3. RESULTS

A total of 4342 km (414 hours) of research effort was completed in Azorean waters over 34 days (Table 1). The majority of this effort was concentrated around the central islands of Pico and Faial, partly for logistical reasons and partly as these areas had been identified as being important for baleen and beaked whales from previous studies and sightings made by the local whale-watch operators.

Table 1. Summary of research effort from 5th April to 8th May 2012.

Effort status	Nautical miles	Kilometres	Time (hhh:mm)
Passage	344	636	71:27
Passage + acoustic	548	1015	86:52
Passage + visual	37	68	6:55
Passage + acoustic + visual	201	371	28:57
Track + acoustic	379	701	70:56
Track + visual	304	563	45:08
Track + acoustic + visual	393	728	71:44
Other	139	260	32:04
Total track	2345	4342	414:03

The trackline into and out of the Azorean EEZ coincided with fracture zones of the mid-Atlantic and clusters of seamounts that are thought to be highly productive regions of open oceans (Figure 2).

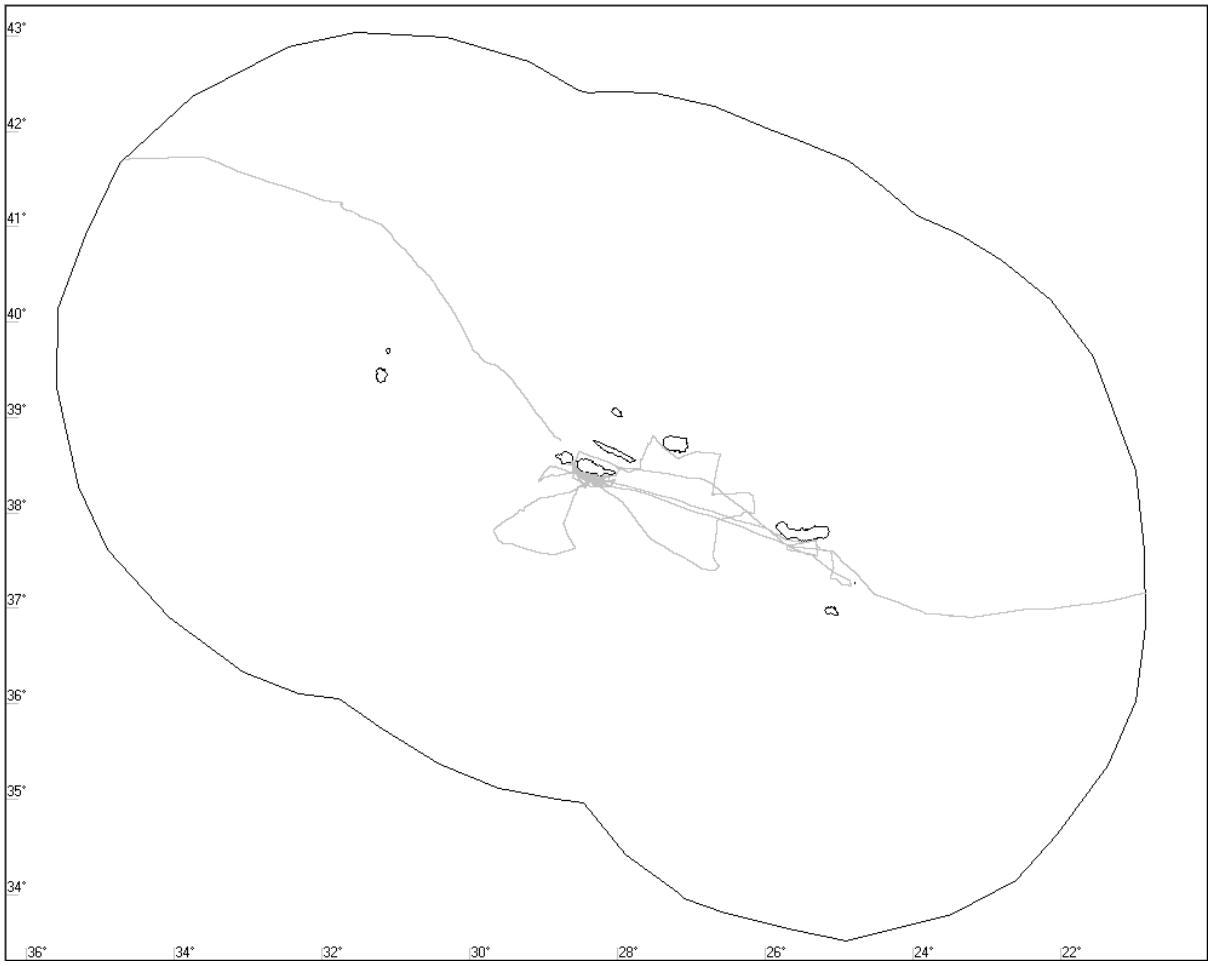


Figure 2. The trackline (in grey) completed by R/V *Song of the Whale* in Azorean waters (the larger ellipse represents the Azores EEZ).

3.1 Sightings

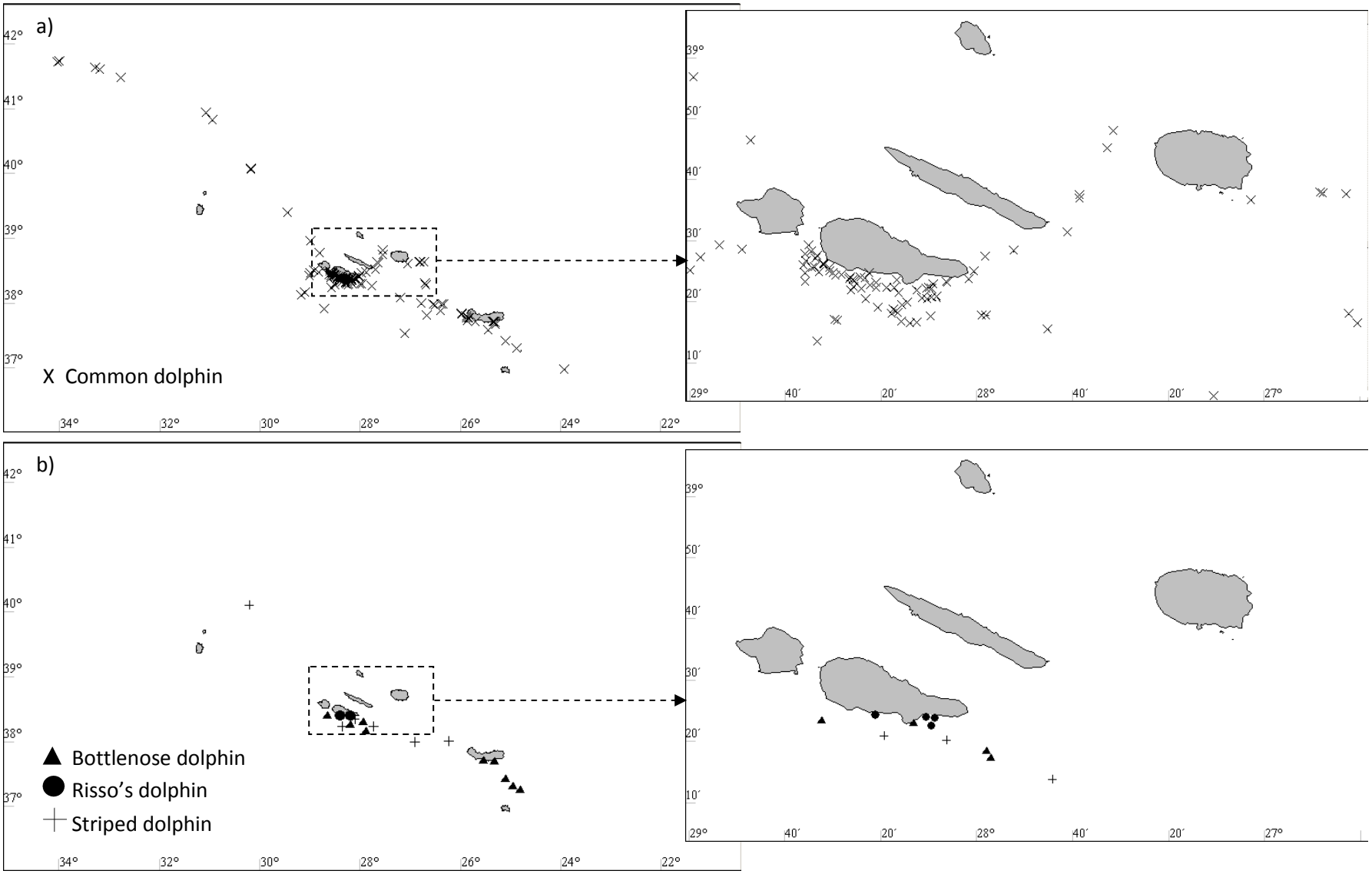
A total of 274 sightings were made of 10 species of cetacean; the species most often encountered was the common dolphin (Table2). In addition, 14 hard-shelled turtles were observed, 3 sunfish and one unidentified shark.

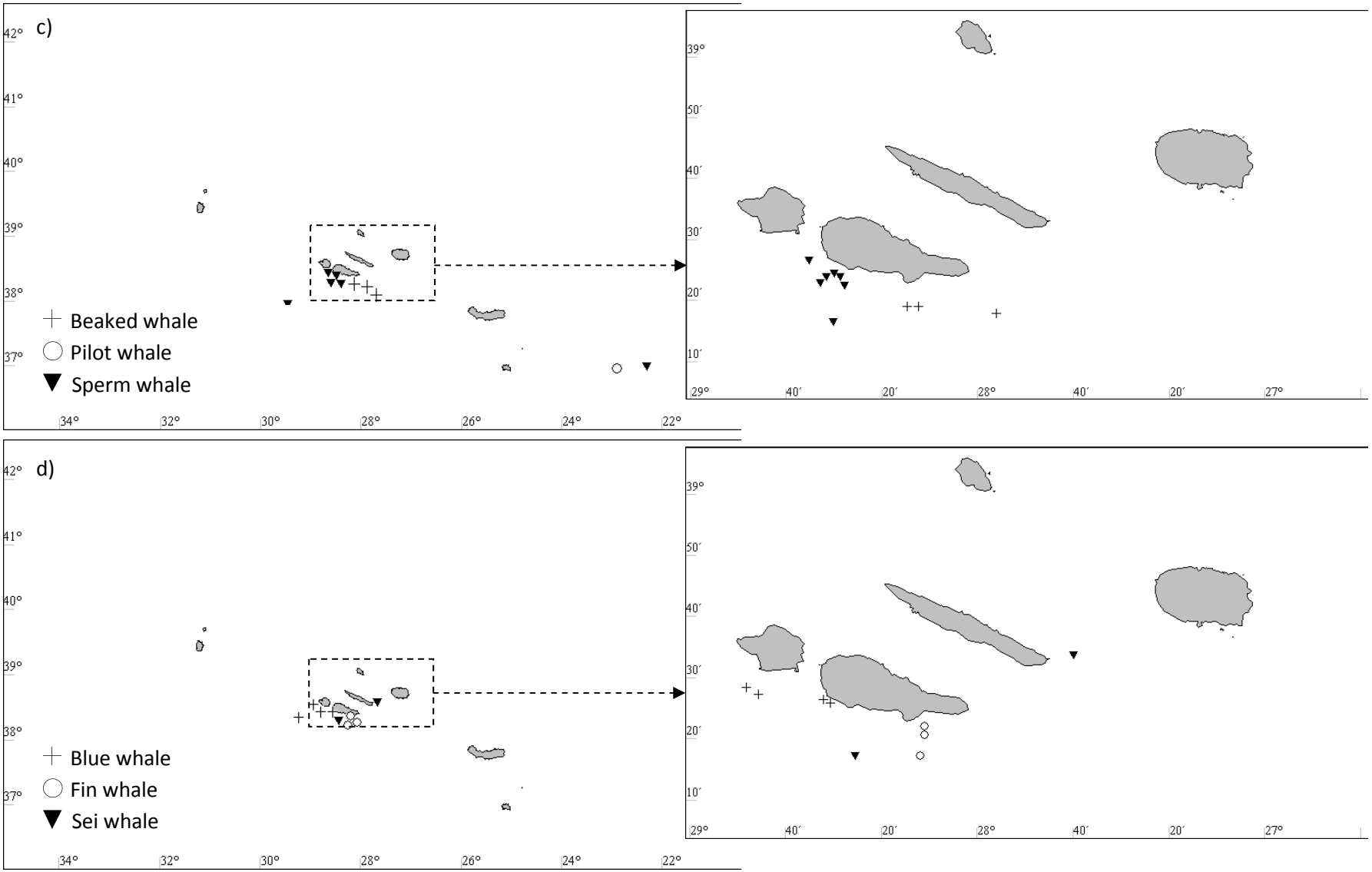
Table 2. Summary of cetacean encounters in Azorean waters.

Species	Number of encounters	Mean group size	Min. & max. group size
Bottlenose dolphin *Tursiops truncatus*	11	11.9	1 - 50
Blue whale *Balaenoptera musculus*	4	1.0	1 - 1
Short-beaked common dolphin *Delphinus delphis*	130	7.9	1 - 70
Fin whale *Balaenoptera physalus*	3	1.3	1 - 2
Risso's dolphin *Grampus griseus*	4	6.3	2 - 12
Sei whale *Balaenoptera borealis*	2	1.5	1 - 2
Short-finned pilot whale *Globicephala macrorhynchus*	1	6.0	-
Sowerby's beaked whale *Mesoplodon bidens*	1	4.0	-

Sperm whale *Physeter macrocephalus*	9	1.9	1 - 2
Striped dolphin *Stenella coeruleoalba*	6	9.2	2 - 30
Unidentified dolphin	74	2.9	1 - 15
Unidentified beaked whale	2	2.0	2 - 2
Unidentified whale	27	1.2	1 - 4

Most of the sightings were clustered to the south of Pico (Figure 3); however, this is in part a reflection of the greater degree of effort in this area. As noted by the local whale-watch operators, this area was typified by frequent encounters with both toothed and baleen whales.


a)
X Common dolphin
b)
Bottlenose dolphin
Risso's dolphin
Striped dolphin


c)
Beaked whale
Pilot whale
Sperm whale
d)
Blue whale
Fin whale
Sei whale

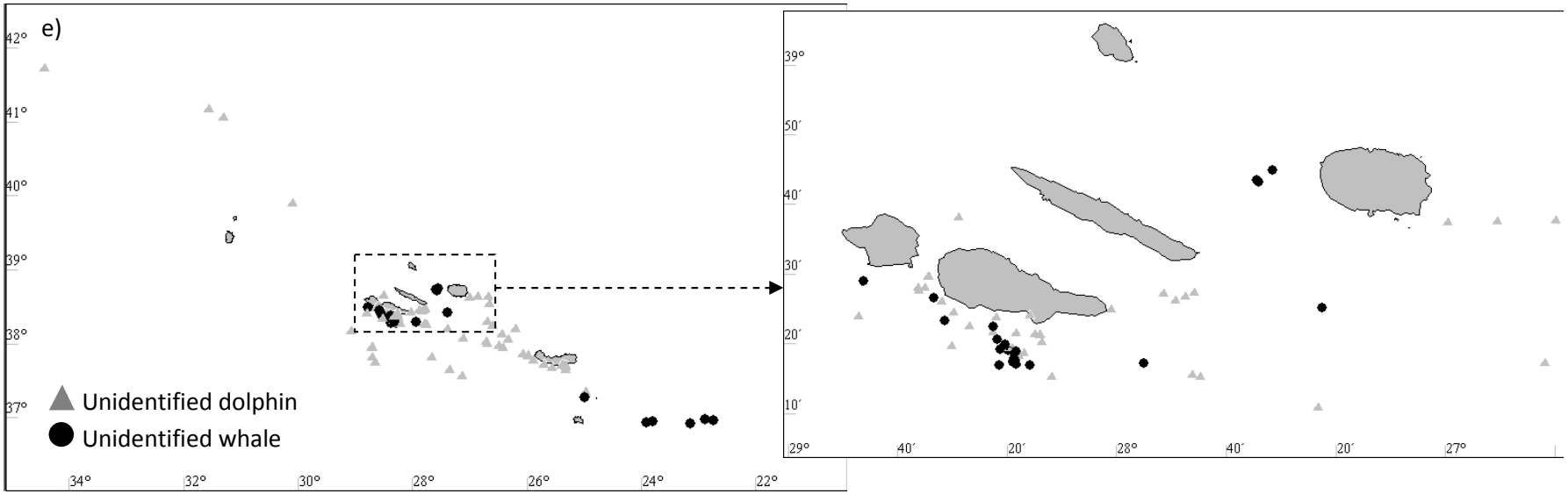


Figure 3. A summary of sightings made from R/V *Song of the Whale* in Azorean waters; a) common dolphins, b) bottlenose, Risso's and striped dolphin, c) beaked, pilot and sperm whale, d) blue, fin and sei whale and e) encounters with unidentified whales and dolphins.

3.2 Acoustic detections

Whenever the water depth and survey speed were appropriate, at least one towed array was deployed from *Song of the Whale*. A member of the team monitored the hydrophone every 15 minutes with headphones and noted the presence of cetacean vocalisations. Dolphin clicks and whistles were heard throughout the study area; sperm whale clicks however were only heard around the islands of Pico and Sao Miguel and towards the fracture zone located to the north-west of the Azores (Figure 4).

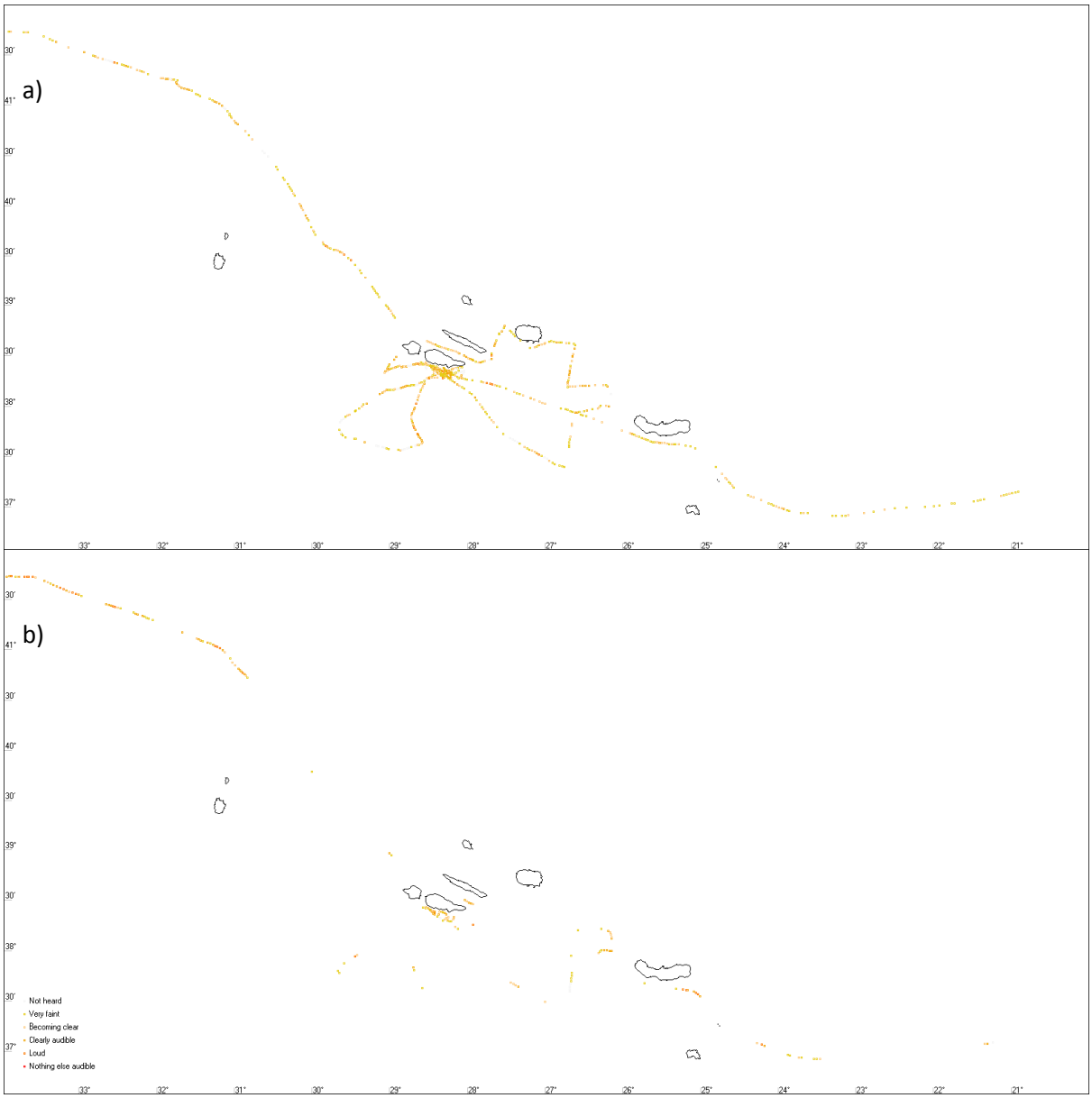


Figure 4. A summary of acoustic detections made from R/V *Song of the Whale* in Azorean waters; a) dolphin clicks and whistles, and b) sperm whale clicks.

3.3 Baleen whales

There were nine encounters with baleen whales during which a stereo hydrophone was used to make continuous recordings. Analysis of these recordings is on-going; unusual calls and vocalisation rates will be described. In addition, NAUTI-buoy deployments were made for two of these

encounters to the south of Pico in an attempt to localise any vocalisations recorded. The first deployment was for a pair of fin whales whilst the second was for a pair of sei whales. Analysis is currently on-going.

3.4 Beaked whales

During the survey, continuous recordings were made at 192 kHz and a Pamguard module was used to scan this audio stream for potential beaked whale clicks in real-time using a click detection module. Beaked whale events were periodically noticed in the field; however, a concerted analysis of these recordings is on-going.

4. DISCUSSION

The survey presented in this document adds to a growing knowledge of the cetacean fauna of the Azores. A total of 24 species of cetacean have been reported alive in the waters of the Azores, ten of which were encountered in this short study. The waters to the south of Pico seemed particularly productive; however research effort was largely focused in this area, in part because of the gracious assistance of the local vigias (land-based lookouts).

Common dolphins were seen regularly throughout the study area. The other dolphin species encountered, however, were mostly seen between the islands of Pico and Sao Miguel. The Risso's dolphins encountered seem to be part of a larger group resident to the south of Pico. The photo-ID images from all encounters, including with Risso's dolphins, will be sent to the curators of the relevant catalogues. Although sperm whales were only encountered off Pico, they were often heard around Sao Miguel and near the fracture zone to the northwest of the Azores. It is likely the upwelling associated with the main islands provides the ideal conditions for the cephalopods that are the preferred diet of sperm whales. As such, sperm whales are perhaps unlikely to forage in the abyssal regions that are prevalent further from the islands.

4.1 Baleen whales

Despite periodic reports of baleen whales off Sao Miguel, and some corresponding survey effort in this area, baleen whales were only seen around the central islands of Pico and Sao Jorge. This area seems of particular importance for migrating whales in spring months. It is possible these sightings represent migrating animals following the mid-Atlantic ridge north to polar waters. However, as the majority of sightings of baleen whales made by local whale-watchers and research groups are to the south of Pico and Sao Miguel, it would appear there is some degree of site selection on behalf of the individuals seen in the Azores. It has been postulated, for example, that migrating whales track secondary production generated by the North Atlantic spring bloom (Visser *et al*., 2011).

With limited knowledge of sei and Bryde's whale vocalisations in the Atlantic, and McDonald *et al*., (2006) suggesting that song patterns from blue whales can be used to distinguish between stocks, it is hoped that the detection, description and localisation of vocalisations made from *Song of the Whale* will provide useful insights in to baleen whale vocal behaviour.

4.2 Beaked whales

Although beaked whales were seen on three separate occasions, the species could only be ascertained as Sowerby's beaked whale for one of these encounters. This is in keeping with local knowledge that most of the beaked whales seen around the Azores are thought to be Sowerby's beaked whales (Espaço Talassa, *pers. commn*). Although a full analysis of the recordings is on-going,

several detections were noted during fieldwork. The results of this analysis will add to the previous survey conducted for beaked whales by the IFAW team from *Song of the Whale* in 2008.

5. ACKNOWLEDGEMENTS

This survey was conducted with funding from the International Fund for Animal Welfare (IFAW). The MCR International team would like to thank the Azores Regional Government and the Government of Portugal for providing the diplomatic clearance and permissions for research to be conducted in their waters. Thanks to Steve Hunt from the British Foreign and Commonwealth Office for assisting with the permitting process.

The MCR International team are very grateful to Mónica Cordeiro de Almeida e Silva and Ana Maria de Pinho Ferreira Silva Fernandes Martins at DOP in Horta for assistance in coordinating research plans and identifying potential participants. The survey team consisted of Richard McLanaghan (MCR), Mat Jerram (MCR), Steve Brown (MCR), Brian Morrison (MCR), Magnus Day (MCR), Edd Hewett (MCR), Anna Cucknell (MCR International), Oliver Boisseau (MCR International), Alexa Kershaw (MCR International), Kerry Froud (MCR International), Susannah Calderan (MCR International), Marina Coles (MCR), Miriam Romagosa, Sigursteinn Masson, Sonia Shomalzadeh, Michelle Braña Bradin (DOP), Ana Besugo (DOP), Ricardo Fernandes (DOP), Mafaldo Machado (DOP), Ana Catarina Morgado (DOP), Catharina Pieper (DOP) and Ana Filipa Sobral (DOP). Many thanks also to the vigias of the Azores and to the local whale watching companies (Whale Watch Azores, Noberto Diver and Espaço Talassa).

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