

Fourth IWDG Humpback Whale Research Expedition: Cape Verde 2012



12 April 2012 – 17 May 2012

Funded by Island Foundation and supported by Natura 2000



Report prepared by Conor Ryan on behalf of the Irish Whale and Dolphin Group

Cover Image: Humpback Whale breaching in Baia Sal Rei, Boavista, Cape Verde (Conor Ryan)

Fieldwork Team:

Conor Ryan^{1,2} (Expedition Leader, Biopsy Sampling & Acoustics), Darren Craig² (Photo ID & Skipper), Pedro Lopez Suarez³ (Photo ID & Acoustics), Simon Berrow^{1,2} (Biopsy Sampling), José Vazquez Perez (Skipper)

Partners:

Frederick Wenzel⁴, Vanda Monteiro⁵, Per Palsbøll⁶, Martine Bérubé⁶, Peter Stevick⁷, Sonia Araujo⁸

1. Irish Whale and Dolphin Group, Merchant's Quay, Kilrush, Co. Clare, Ireland
2. Galway-Mayo Institute of Technology, Dublin Road, Galway, Ireland
3. Natura 2000, Sal Rei, Boa Vista, Cape Verde
4. NOAA Northeast Fisheries Science Center, Woods Hole, MA, USA
5. Instituto Nacional de Desenvolvimento das Pescas, Mindelo, Sao Vicente, Cape Verde
6. Marine Evolution and Conservation, Centre for Ecological and Evolutionary Studies, University of Groningen, The Netherlands
7. Allied Whale, Bar Harbour, Maine, USA
8. Direcção Geral do Ambiente, C.P. 115, Praia, Republic of Cape Verde



Contents

Summary.....	3
Introduction	3
Humpback Whale Biology & Ecology.....	3
Current Knowledge on Cape Verdean Humpback Whales	4
Previous Research Expeditions.....	4
Aims for 2012 Expedition	4
Methods.....	5
Study Area and Research Platform.....	5
Survey Methodology	6
Photo Identification	7
Biopsy Sampling	8
Acoustic Recordings.....	9
Results	10
Sightings.....	10
Biopsies.....	12
Photo ID Matching.....	13
Acoustic Recordings.....	14
Discussion	14
Uses for Biopsies	14
Biopsy Sampling: Reactions and Sample Success Rate	15
Timing and Distribution of Whales.....	15
Photo ID Matching.....	16
Sustainable Development of Whale-watching in Cape Verde	17
Future Work	18
Acknowledgements	18
Literature Cited	19

Summary

To assess their conservation status and to effectively manage and conserve the humpback whales (*Megaptera novaengliae*) breeding in Cape Verde, we must address significant shortfalls in our knowledge on their basic ecology and population structure. As part of an ongoing research programme, initially set up to determine the breeding grounds of Irish humpback whales, the Irish Whale and Dolphin Group carried out its fourth humpback whale expedition to Cape Verde during April and May 2012. The expedition was six weeks in duration with a shore-based team using a rigid-hulled inflatable to carry out fieldwork when weather conditions allowed. Photo ID images of tail flukes were catalogued and submitted to Allied Whale for matching with those taken elsewhere in the North Atlantic. As in 2011, individual whales were again matched to Norway and Iceland and there were inter-annual re-sightings from within Cape Verde (with at least three whales observed there in consecutive years). To facilitate molecular genetic, persistent organic pollutant and stable isotope studies, biopsy samples were collected (n=21) using a crossbow with modified darts bringing to 49 the number of samples taken from this region since 2011. Maps are presented on the distribution of humpback whales around Boavista during April and May 2012.

Introduction

Humpback Whale Biology & Ecology

Humpback whales (*Megaptera novaengliae*) occur in all oceans and famously undergo the longest annual migration of any mammal. They summer in high latitude feeding grounds, feeding when productivity and hence food availability is highest and winter in low latitude breeding grounds. During winter, the majority of humpback whales are found in shallow tropical seas where calving and mating occurs simultaneously as the mothers are in oestrus while lactating and gestation is 11.5 months. No consensus exists as to why they need to undertake such protracted migrations. It has been suggested that killer whale avoidance and the need for warm waters due to thermoregulatory challenges faced by small calves explain their migratory ecology.

Given that humpback whales in the northern hemisphere will be at high latitudes during boreal summer when those from the southern hemisphere will be calving in low latitudes, the populations from the two hemispheres are always separated by several thousand kilometres of ocean. These movement patterns are known as 'anti-tropical' migrations and have given rise to reproductively isolated populations of humpback whales within ocean bodies in the absence of any physical barriers to dispersal. In the North Atlantic, there are believed to be about 11,600 humpback whales (Smith et al. 1999). Their primary breeding ground is in the West Indies, particularly around the Dominican Republic where the majority of humpbacks from the North Atlantic go to breed. These whales have been found to migrate to four main feeding areas; Gulf of Maine/Newfoundland, West Greenland, Iceland and northern Norway.

Current Knowledge on Cape Verdean Humpback Whales

A second North Atlantic breeding ground is known from whaling records and more recently from observational and photo identification studies (Jann et al. 2003). This breeding ground consists of the waters around Cape Verde but possibly extends to the West African continental shelf of Senegal and Western Sahara. The size estimate of the putative Cape Verde population was estimated by photo identification mark-recapture analysis at just 99 (CV=0.23) individuals, a mere relict of the *circa* 4000 whales there before whaling commenced (Punt et al. 2007). However the Cape Verde photo ID catalogue currently contains *circa* 130 individually recognisable individuals, mostly from Boa Vista (Fred Wenzel, pers. comm.). Given that humpbacks mate and calve in the same area (the breeding ground) reproductive isolation among populations has arisen. The Cape Verdean humpback whales are believed to be one of the most endangered populations in the world given the small population size, yet IUCN does not recognise this, and they are listed as 'Least Concern'. Preliminary results from genetic analyses of Cape Verdean whales from 28 samples collected in 2011 and one in 1995 suggest that these whales belong to a population that is isolated from that of the West Indies (Per Pallsboll, pers. comm.). Furthermore, by using patterns and concentrations of persistent organic pollutants (namely polychlorinated biphenyls and organochlorine pesticides) found in blubber biopsies as eco-tracers, the results suggest that Cape Verdean humpbacks comprise only those whales that summer in the eastern North Atlantic. The results from this analysis are in preparation and will be submitted for publication in due course as part of CR's PhD thesis.

Previous Research Expeditions

The Irish Whale and Dolphin Group first went to Cape Verde in Spring 2003 in search of the breeding grounds of Irish humpback whales. They returned again in 2006 and 2011 to continue the search but there has yet to be a link made between Irish and Cape Verdean humpback whales. There are no cetacean research groups in Cape Verde. Collaborative cetacean research has been carried out by of visiting scientists since the early 1990s including Frederick Wenzel, Beatrice Jann, Pedro Lopez-Suarez, Cornelius Hazevoet, Simon Berrow and Pádraig Whooley. The primary focus has always been on the humpback whales and the expeditions have been timed to coincide with the breeding period from January to May (Wenzel et al. 2009)

Aims for 2012 Expedition

1. Continue to collect skin samples from humpback whales for molecular genetic analysis, towards obtaining a total sample of 50.
2. To simultaneously collect blubber samples for ecological tracer analysis (stable isotopes and persistent organic pollutants)
3. To take photo identification images for matching Cape Verdean whales to those from elsewhere in the North Atlantic
4. To assess areas of particular importance to whales and nursing areas by analysing distribution and relative abundance
5. To record singing males using a hydrophone for comparing songs between other breeding grounds.

Methods

Study Area and Research Platform

As in 2011, this year's fieldwork was shore-based and confined to a single island, Boa Vista (Figure 1). The study area comprised coastal waters (generally to 6km) of the west and south coast of Boa Vista from Ponta de Sol in the North to Ervatão in the southeast (Figure 4). The study area was chosen based on access to suitable vessels, knowledge by local researchers and a high sightings rate from previous expeditions in this area. A 5 metre rigid-hulled inflatable (RIB) with a four-stroke 50 horse-power outboard motor was used for the fieldwork (Figure 2). There were two moorings: one in the northwest at Sal Rei and the other on the south coast at Lacacão which enabled us to cover a more extensive area this season by comparison with 2011.

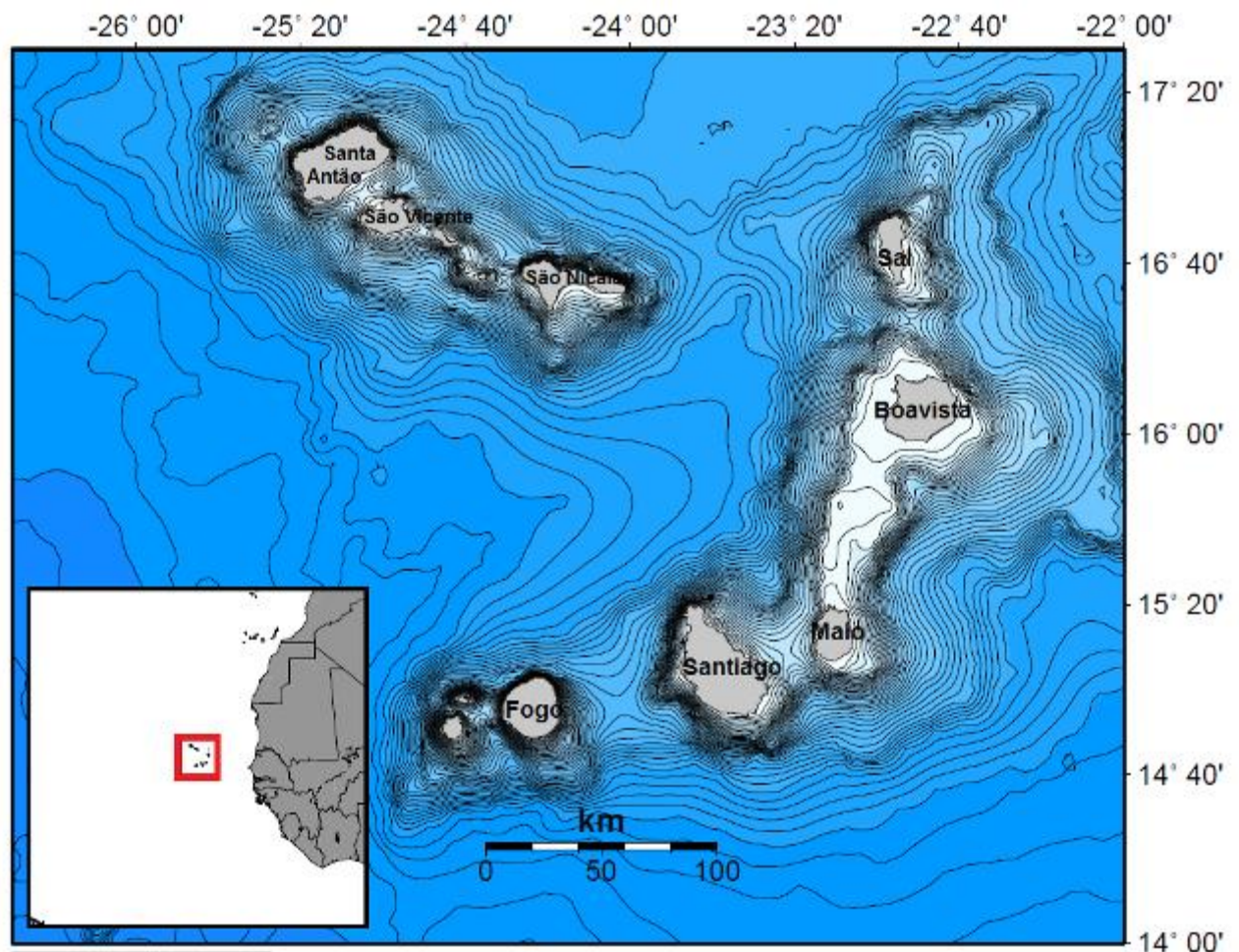


Figure 1. Cape Verde Islands, showing Boavista in the east of the archipelago on a continuous shelf with Maio.



Figure 2. Launching the research vessel (5m rigid-hulled inflatable) at Sal Rei

Survey Methodology

Searches were carried out at an average speed of 10 knots (20 km/hr) by two to three experienced observers (CR, DC, SB and PLS) scanning the sea with the naked eye (figure 3). This search effort: speed, location and time were recorded continuously using a Garmin Etrex GPS. By recording search effort, a more thorough analysis of sightings within the study area can be carried out (i.e. sightings per unit effort, number of sightings per unit area). When whales were sighted, their position was recorded using a GPS, they were approached from behind at 45° to their direction of travel and tracked until a biopsy sample and photo ID were taken. If an individual was re-sighted within a survey it was not tracked. Tracking was stopped if the whales were showing signs of stress (tail swiping, trumpet blows, bubble-blowing). The location, group size and the presence of calves were recorded. Biopsy sampling was carried out by CR, PLS and SB, photo ID was carried out by DC and PLS and both JFP and DC were skippers. Analysis is currently underway to identify critically important habitat for the whales and specifically the calves within the study area. It is our intention to publish these findings to inform management decisions to ensure a sustainable whale-watching industry is maintained in the region.



Figure 3. Survey team: Top left - Darren Craig (Skipper), Pedro Lopez-Suárez (Photo ID); Top right - Simon Berrow (Biopsy); Bottom: Pedro Lopez-Suárez (Photo ID), Conor Ryan (Biopsy), and José Vazquez Perez (Skipper)

Photo Identification

Photo identification is a method of studying individual whales by using images of features that are unique to those individuals. The pigmentation patterns on the ventral surface of humpback whale flukes are believed to be unique to individuals (figure 4). Dorsal fins also exhibit a certain degree of individuality in shape and scarification. Tail fluke ID images were taken for comparison with those in

the North Atlantic Humpback Whale catalogue (Allied Whale, Maine). Fluke ID images enable us to investigate possible movements between the Cape Verdean breeding grounds and the high latitude feeding grounds (and indeed the other breeding and feeding areas). As the whales do not always show their flukes upon diving, particularly in shallow waters, ID images of the dorsal fins were taken in order to recognise individuals that had already been biopsy sampled. The photo ID catalogue was brought out on the boat in order to facilitate the identification of individuals in the field. This helped to keep duplicate biopsy sampling to a minimum.



Figure 4. Example of a photo ID match of 'NAHWC# 4504' between Iceland in 1982 (top) and Sal Rei in 1999 (bottom) from Jann et al. (2003)

Biopsy Sampling

A Barnett Panzer V (150lb draw-strength) re-curve crossbow was used with modified bolts (Palsbøll et al. 1997). Biopsy tips were manufactured by Specials Engineering, modelled on those of CETA-DART, but modified to give sharper cutting heads and stronger barbs. 25mm and 40mm sampling tips were used for calves and adults respectively. Non-tethered CETA-DART bolts were used which float after striking the animal and are brightly coloured to aid retrieval. Between samples, the tips were scrubbed in hot soapy water, sterilized over a flame and rinsed with 99% ethanol. These measures were taken to prevent infection in the whales, to prevent cross-contamination of DNA between sampling events and to ensure that blubber samples were not affected by extraneous

residues which might affect the persistent organic pollutant analysis (which is highly sensitive, detecting compounds in parts-per-billion).

Individual whales were identified in the field using a catalogue of dorsal fin images (left and right). For those that had not yet been biopsied (since 2011), their behavioural state was recorded and an approach was made in the boat. Approaches were carried out at 45° from behind the whales and a parallel course was maintained with them thereafter. Preferred sampling distance was 10-20m. Shots were aimed at the region below the dorsal fin, where a large area is presented above the water as the whales arch their backs to dive.

The reaction to the dart was recorded on a scale of 0 to 4:

0. No discernable reaction
1. Slight acceleration and/or large fluke 'footprint' on the water's surface
2. Flinch and/or tail-flick
3. Trumpet-blow and/or lob-tailing
4. Breaching and/or head-lobbing (where this did not occur immediately before sampling)

Samples were wrapped in aluminium foil and were processed in the lab within 3 hours of sampling. In the laboratory, skin and blubber samples were duplicated using a solvent-washed scalpel and forceps and frozen in aluminium foil for stable isotope and persistent organic pollutant analyses. Half of the skin from each biopsy was preserved in a vial of salt-saturated 20% DMSO (Dimethyl sulphoxide) and frozen for later DNA analysis.

Acoustic Recordings

When solitary whales were stationary or when their dives exceeded 10 minutes in duration, a hydrophone was deployed in order to record whale song (figure 5). Recordings were made for >20 minutes each in order to record the entire song which generally lasts 10 minutes, but is repeated.



Figure 5. Conor Ryan recording whale song with a hydrophone (Photograph by Darren Craig)

Results

Sightings

39 surveys were carried out in a mean Beaufort sea state 4 (minimum 2, maximum 5) amounting to 999km of search effort during which 49 sightings of humpback whales were recorded (Figures 5 & 6). Two sightings of 10 and 2 rough-toothed dolphins (*Steno bredanensis*) and a single sighting of a bottlenose dolphin (*Tursiops truncatus*) were also made. There were only three surveys in which no sightings of humpback whales were made. Mean group size was 1.80 (SD=0.79) with a maximum of 4 individuals, while 19 singletons were observed. There were 17 calf sightings and all were accompanied by mothers. These figures were comparable to 2011 where the mean group size was 2.04 (SD=1.29) with maximum group size of 7. Calf sightings were distributed throughout the study area and were not confined to shallower waters, with sightings up to 6km offshore (Figure 7). Sightings recorded into mid-May came as a surprise, given that the whales are believed to begin their migration north in mid-spring.

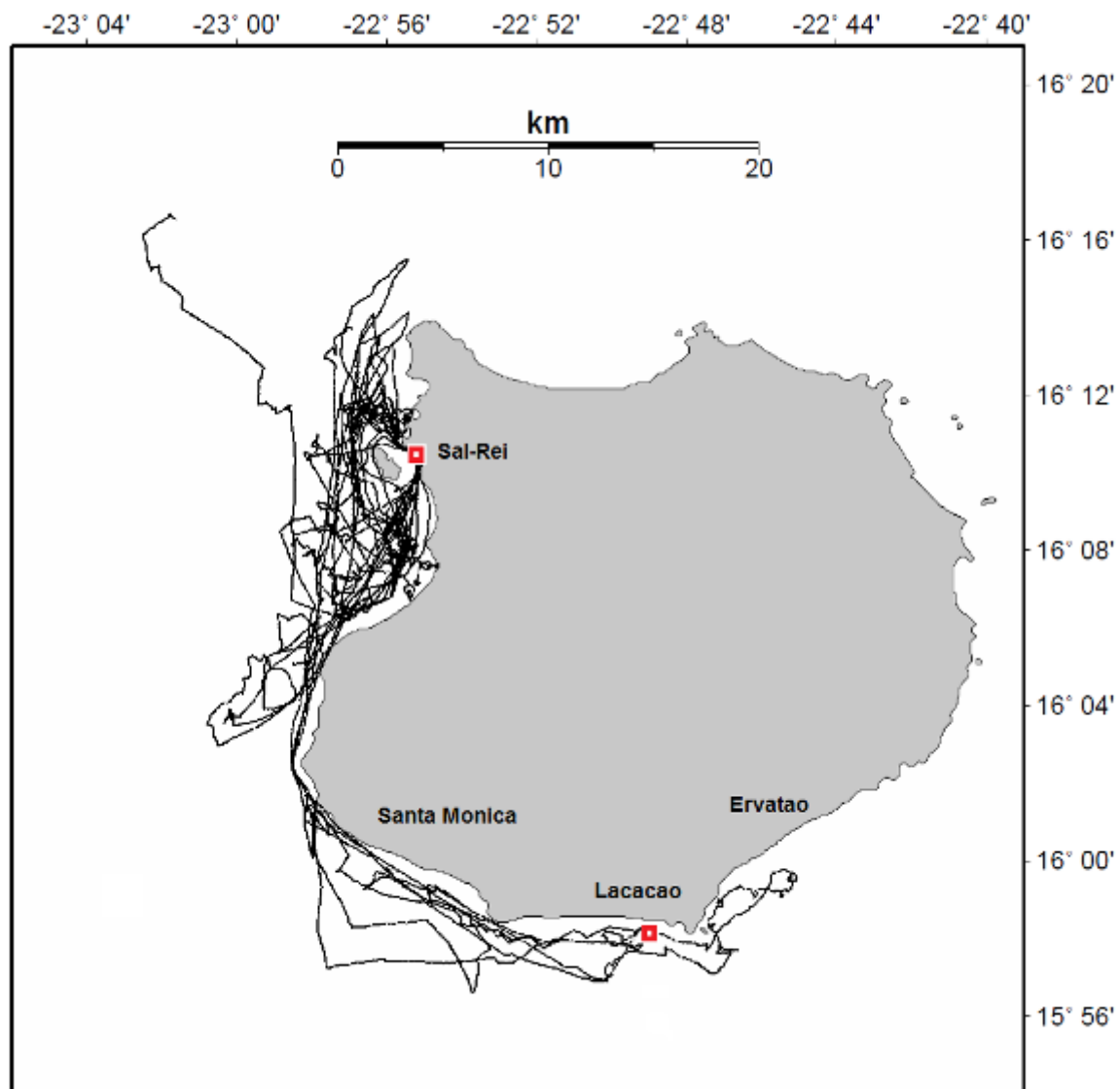


Figure 5. Search effort (black track-line) carried out between 14 April and 15 May 2012, red boxes show the locations of the two moorings.

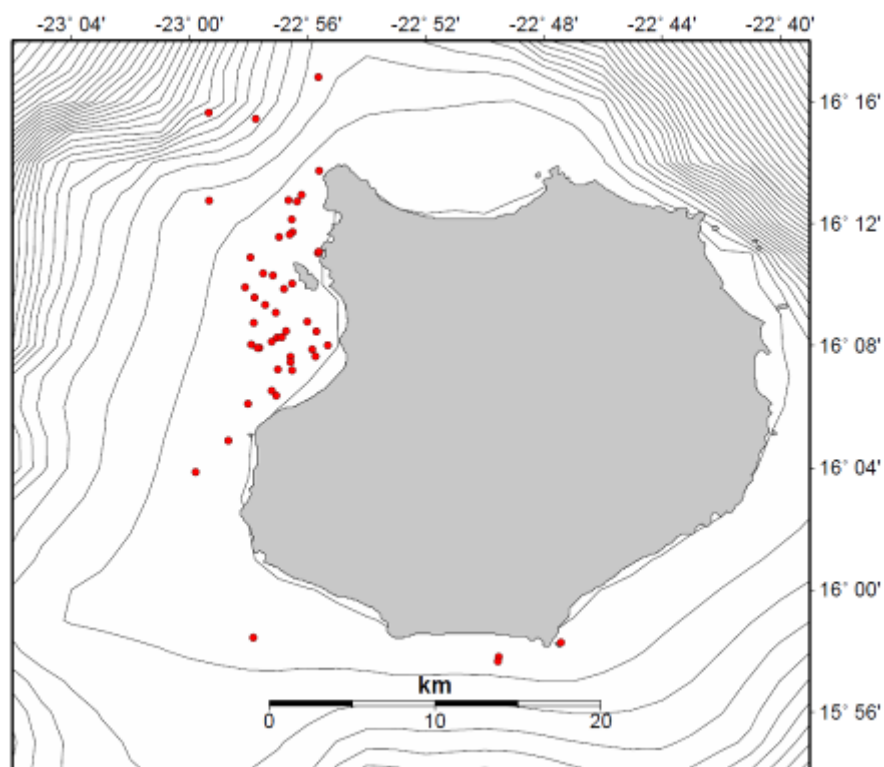


Figure 6. Distribution of humpback whale sightings off Boavista in April and May 2012, showing 50m depth contour lines.

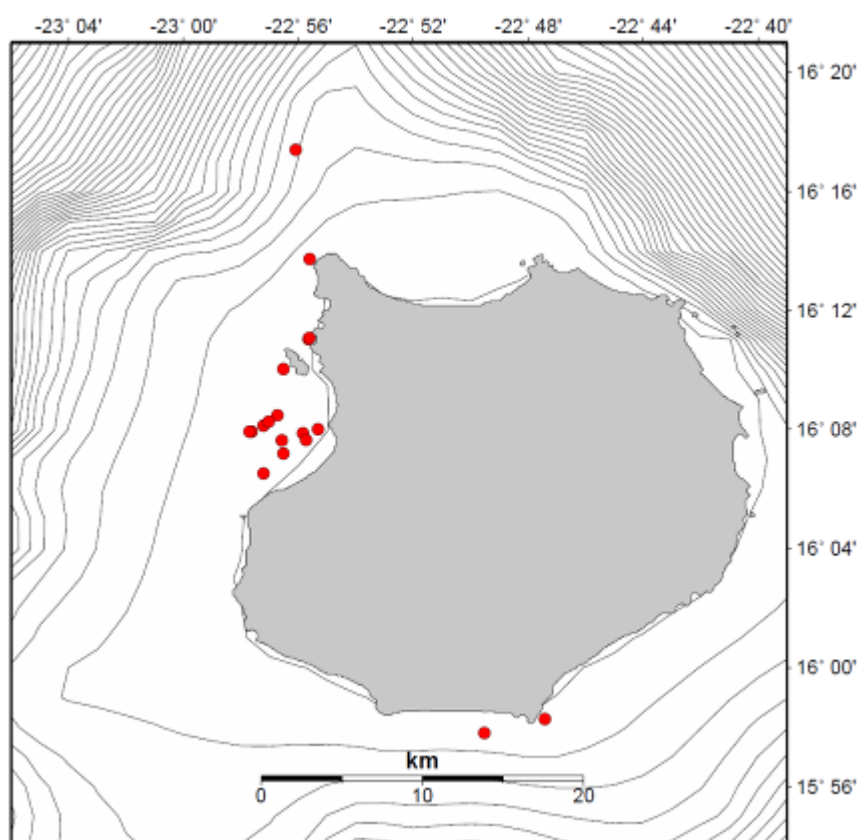


Figure 7. Locations of calf sightings around Boa Vista in April and May 2012, showing 50m depth contour lines. Calves were never observed without their mothers.

Biopsies

21 biopsy samples were collected from 19 new individuals. While every effort was made to avoid duplicate sampling of individuals, there was one duplicate within this season and the second duplicate was from a male sampled in the same region (within 1km) during 2011. Among the 21 samples were three mother-calf pairs, bringing to six the number of mother-calf pair samples from both 2011 and 2012. Dorsal fin photo ID images (left and right) were recorded for each biopsied whale to help prevent future duplicate sampling (figure 10). Fluke photo ID images were recorded for 10 out of the 21 whales sampled this year (although this may increase once the matching process is completed). As in 2011, reactions to biopsy sampling were generally low, on 40% of occasions no discernible reaction was noted, a level 1 reaction was recorded on 36% of strikes, level 2 reaction on 16% and level three on 8% of strikes. No strong reactions (level 4) were recorded. The data presented in figure 8 indicate that sampling distance is not an important factor in determining the reaction strength of the whales. As in 2011, on no occasions did a dart remain lodged in a whale. Across the two years, of 49 successful samples taken, the average distance from vessel to whale has been 15 m (± 6 SD) (*i.e.* approximately one whale-length, or three boat-lengths). The average number of close approaches per successful biopsy sample has been 3 (± 1.9 SD). On 18.8% of direct hits, no sample was retained in the biopsy tip, however a single animal was never struck more than twice in one day or three times in one season.

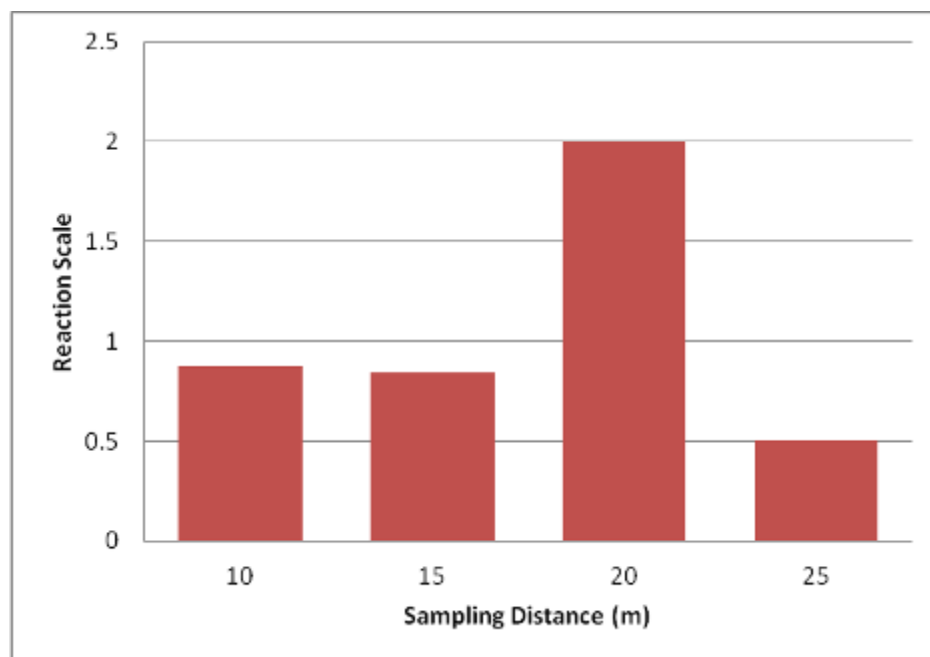


Figure 8. Mean reaction strength by the whales to biopsy sampling at different distance bins. Distance was estimated by eye using boat length for scale. The reaction scale is defined in the methods section.

Photo ID Matching

Dorsal fin photo IDs were taken for all of those whales (n=24) that were biopsied while tail fluke photo IDs were also collected for most of them (Figures 9 & 10). Overall, tail fluke images from 17 whales were taken (however many more were taken by PLS from whale-watching boats does this fir here?). Many of the whales that were biopsied were re-sighted in the study area within several days of the sampling event indicating that the sampling does not cause the whales to avoid the area. Matching of photo ID images with the North Atlantic Humpback Whale Catalogue at College of the Atlantic, Maine is currently underway. Preliminary results from the matching (with thanks to Fred Wenzel and all at Allied Whale) are presented in Table 1.



Figure 9. Tail fluke photo ID image of a humpback whale in Baia Sal Rei. This whale was interacting in a competitive group – notice the fresh bleeding grazes, likely from contact with the other male in the group. (Photograph by Darren Craig).



Figure 10. Dorsal fin photo ID image used for in-the-field recognition of individuals in order to avoid duplicate sampling of individuals. Also showing a dart rebounding with a biopsy sample in the tip. Note the small biopsy scar above the waterline directly below trailing edge of the dorsal fin.

Table 1. Some photo ID matches from the 2012 fieldwork made to date with the North Atlantic Humpback Whale Catalogue (**N.B. matching as yet incomplete for 2012 season**). Some of these images were taken from local whale-watching boats by PLS while working for Naturalia Ecotours.

Date of First Sighting 2012	Location	Previous Records	North Atlantic Catalogue ID
21 March 2012	Boa Vista	Boavista, Cape Verde: 2002	NA4961
23 March 2012	Boa Vista	Iceland, 2005	NA4548
12 April 2012	Boa Vista	Boavista, Cape Verde: 2011	NA4460
13 April 2012	Boa Vista	Boavista, Cape Verde: 2011, 2010	NA4744
19 April 2012	Boa Vista	Boavista, Cape Verde: 2011	NA4950
20 April 2012	Boa Vista	Boavista, Cape Verde: 2006	NA4994
21 April 2012	Boa Vista	Boavista, Cape Verde: 2011, 2004	NA4789
21 April 2012	Boa Vista	Boavista, Cape Verde: 2004	NA4981
22 April 2012	Boa Vista	Norway 1995; Boavista, Cape Verde: 2011, 2008	NA4820
24 April 2012	Boa Vista	Boavista, Cape Verde: 2010	NA4436
05 May 2012	Boa Vista	Norway, 1992; Boavista, Cape Verde: 2011	NA4856

Acoustic Recordings

Nine separate acoustic recordings were made totalling 205 minutes. These have been sent to Beatrice Jann (Swiss Whale Society) for analysis.

Discussion

The 2011 and 2012 expeditions represent the most intensive systematic attempt to biopsy sample humpback whales on their Cape Verdean breeding grounds to date. The optimal target of 50 samples has almost been reached, yielding for the first time a sample large enough to undertake a population genetic and genetic tagging study. Preliminary results from the 2011 samples show a relatively high degree of reproductive isolation between Cape Verde and the West Indies. It is hoped that, with these additional 21 samples, a thorough analysis can be carried out in order to characterize the population structure of Cape Verdean whales within the context of the North Atlantic. Furthermore, it is hoped that additional matches between areas using genetic tagging (at 20 microsatellite loci) will provide more matches between Cape Verde and high latitude feeding grounds.

Uses for Biopsies

DNA will be extracted from skin using extraction kits. Sexing, sequencing of the mitochondrial D-Loop (*circa* 500 bp) and genotyping at up to 20 microsatellite loci will be carried out. This will be done in collaboration with Per Palsbøll and Martine Bérubé, who are currently concluding analyses

on over 7000 samples from projects YONAH (Years Of the North Atlantic Humpback whale) and MONAH (More years Of the North Atlantic Humpback whale) from throughout the North Atlantic. Biopsies from Irish and UK waters will be included in the analysis (n=15). CR visited their lab in University of Groningen during winter 2011 to carry out genetic analyses on the samples collected in 2011.

Biopsy Sampling: Reactions and Sample Success Rate

As in 2011, the distance from which the samples were taken from the whales did not appear to determine their reaction. One would assume that a smaller sampling distance might invoke a stronger reaction given the greater force of impact, but this was not observed. It is most likely that behavioural state rather than distance to the animals determines the reaction strength. It is critical that whales are sampled at distances of <40m to provide enough force for the dart to recoil for retrieval. Our results are very similar those on other breeding grounds, where non-detectable reactions to biopsy strikes were as frequent as 44% (Clapham & Mattila 2006).

The success rate of samples was low across both years with just over 81% of strikes retaining a useable tissue sample. A disproportionate amount of these failures occurred when using small (*i.e.* 25mm as opposed to 40mm) sampling tips. We found the Specials Engineering tips to be better at retaining samples and the barbs were more robust to high temperatures, which allow more thorough sterilization over a flame. The sampling experience gathered here will allow us to continue to improve the biopsy technique. The main factor determining successful sampling, however, is sea state. In 2012, the median Beaufort sea state (3.5, range 2 - 4) was better than in 2011 (4, range 1 - 5), however there were fewer 'calm' days presenting less windows of opportunity. This prevented effort in more exposed areas such as the north and north east coasts.

Timing and Distribution of Whales

The humpback whale breeding season is believed to occur between January and May in Cape Verde (Hazevoet et al. 2011). From our observations, group size and abundances peak in April, which is much later than in the West Indies where the peak is in late February or early March (Stevick et al. 1999). As in 2011, during 2012 at least some of the whales remained in inshore waters of Boavista until late May, and were first sighted in mid-March (15 March 2012, P. Lopez Suárez). Females are thought to leave the breeding grounds first, however mother-calf pairs were observed well into May again this year (24 May 2012, G. Cascella Doc). Interestingly, those whales breeding in the West Indies but summering in high latitudes (*i.e.* Norwegian waters) have been found to migrate significantly later than those using other feeding grounds (Stevick et al. 1999, 2003). This is thought to be a function of their feeding strategy and may be due the later arrival of summer (and hence the peak in secondary productivity) in such high latitudes as the Barents Sea. Considering that timing of arrival and departure of whales is dependent on their feeding grounds (Stevick et al. 2003), future research effort in Cape Verde should cover the entire season (from January to May) to ensure that a non-biased sample is obtained.



Figure 11. A mother and calf pair swimming in water just 8m deep, about 30m from the shore between Curral Velho and the main island of Boavista, Cape Verde on 19 April 2012 (Photograph by Darren Craig).

A more detailed study on the distribution of whales off the west coast of Boa Vista, stratified by group-size and calf presence in relation to search effort is underway. We will investigate for differences in relative abundance between years over a 2x2km gridded area to identify fine-scale critical areas of importance for whales, especially mothers nursing calves. It is hoped that this will identify areas of critical habitat for the whales and form a paper for publication which may be useful for management of whale eco-tourism or designation of protected areas.

Corrected for effort, the highest concentration of whales was in Baia de Sal Rei once again in 2012. We carried out more search effort off Santa Monica on the southwest coast this year, however very few sightings were made there despite whale song being recorded there several times. It may be that whales are found further offshore beyond our boat range in this area. The low effort in the south and southeast provided a relatively high sightings rate there. In future years we will attempt to increase our effort along the south coast where conditions are more favourable; however there is no infrastructure here for launching boats and refuelling. We are also keen to explore the offshore banks between Boavista and Maio as this appears to be ideal habitat for breeding whales, however a much larger boat will be required.

Photo ID Matching

Preliminary results (Table 1) already show interesting results, namely that of the *circa* 25 individual whales photo-IDed in 2012, 10 have previously been observed in Cape Verdean waters during the past 20 years. This is a similar re-sighting rate to 2011 (31%). The high incidence of inter-annual re-

sightings for such a small sample is further evidence of a very small population. Two whales observed in 2012 have previously been recorded in early 1990s in the Barents Sea (Wenzel *et al.*, 2009) – some 7000km or 60° of latitude to the north. Another individual recorded by Pedro Lopez Suárez in Sal Rei in March 2012 was photographed in Iceland during 2005 (Christian Schmidt). Despite there being 20 individuals catalogued in Irish waters, to date there has yet to be a match (photo-ID or genetics) between Cape Verde and Ireland. There have also been no matches between Cape Verde and the entire western North Atlantic, despite ongoing research in the Gulf of Maine, Nova Scotia, Newfoundland and Greenland.

Sustainable Development of Whale-watching in Cape Verde

After diving, whale-watching is undoubtedly the most rapidly developing marine enterprise on Boa Vista. During 2012 four tour operators were offering boat-based whale-watching tours. *Naturalia* is a locally owned eco-tourism company which provides trained guides and a marine biologist on some whale excursions. Their mission statement is to promote eco-tourism, sustainable and responsible use of natural resources on Boa Vista, support conservation and contribute to a better knowledge of threatened habitats and species through scientific research. Most (but not all) of the tour operators contract *Naturalia* guides to provide interpretation to whale-watchers and to oversee a voluntary code of conduct for responsible boat handling in the presence of whales. A more formal code of conduct would ensure that whale eco tourism continues to be carried out with minimal disturbance to the whales. A responsible whale-watching certification system may provide incentive for tour operators to continue to contract professional guides to educate the whale-watchers – a critical component of effective conservation. Land-based whale-watching is an unexploited activity on Boa Vista. With high vantage points around the coast, this may be a viable option for whale-watch tourism and obviously does not disturb the whales in any way.



Figure 11. Whale watchers on a Naturalia-guided whale excursion on board S.V. Tartaruga do Mar.

Future Work

- Continued photo ID and biopsy sampling to establish new matches between sampling regions.
- More extensive search effort including offshore waters of Boa Vista, Maio, Sao Nicolau and Sal. Extend search effort to the shelf waters between Cape Verde and West Africa (Senegal, Guinea-Bissau, and Western Sahara) given that this area is poorly studied but likely represents a continuous breeding area for humpback whales. The Bijagos Archipelago off Guinea-Bissau in particular is thought to be visited by both northern and southern hemisphere humpback whales, which merits further research (Hazevoet *et al.* 2011)
- Satellite tagging of whales – the equipment and expertise are in place and the INDP have expressed interest to be partners.
- Aerial Survey: humpback whales are good candidates for aerial abundance estimation given their highly visible large white pectoral fins. Furthermore, the shallow and clear inshore waters of Cape Verde make the whales visible from the air. An aerial survey of the entire archipelago is feasible given that most islands have airports and the skies are often clear, however a shortage of suitable aircraft has prevented aerial surveys to date.

Acknowledgements

Thanks to the many people who made this expedition possible, in particular the friendly and hard-working people at Natura 2000 (Laura, Carolina, Juliao, and Maxi) and Naturalia (Stravagante Delgado Rodrigues, Gennaro Cascilla Doc and Gabriella Gatt) who are so dedicated to promoting, recording and conserving Cape Verdean biodiversity. We are very grateful to the Cape Verde humpback whale research community (Fred Wenzel and Beatrice Jann in particular) for their advice and encouragement. We would like to thank Peter Stevick, Rosi Seton, Judi Allen, Leah and Tom Fernald from Allied Whale for matching flukes and for quick feedback while we were still in the field. Gratitude is owed to Ken O'Sullivan (SeaFever Productions) and George Karbus (Emerald-Vision Photography) for great company and assistance in the field. Thanks to Matthew Acre for lending us his Cabo Verdean mobile phone. Thanks to Juan Bustos for putting up with our last-minute changes to fieldwork. We are very grateful to the dive team at Hotel RIU in Lacacão for providing us with thrilling beach-launches and dropping us to our mooring and back to shore. Thanks also to the crew of *Sea Turtle II* for allowing us on board and for lifts to our mooring. Biopsy sampling was carried out under permit from Direcção Geral do Ambiente, Cape Verde (Licence Numbers 03/2011 and 02/2012). Humpback whale tissues were imported to Ireland under CITES permit.

Literature Cited

- Clapham PJ, Mattila DK (2006) Reactions of humpback whales to skin biopsy sampling on a West Indies breeding ground. *Marine Mammal Science* 9:382–391
- Hazevoet CJ, Gravanita B, Lopez Suarez P, Wenzel FW (2011) Seasonality of humpback whale *Megaptera novaeangliae* (Borowski, 1781) records in Cape Verde seas: evidence for the occurrence of stocks from both hemispheres? *Zoologia Caboverdiana* 2:25–29
- Jann B, Allen J, Carrillo M, Hanquet S, Katona SK, Martin A, Reeves RR, Seton R, Stevick PT, Wenzel FW (2003) Migration of a humpback whale between the Cape Verde Islands and Iceland. *Journal of Cetacean Research and Management* 5:125–129
- Palsbøll JP, Judith Allen MB, Phillip JC, Tonnie PF, Philip SH, Richard RH, Hanne Jørgensen SK, Anja Holm Larsen FL, Jon Lien DKM, Jóhann Sigurjónsson RS (1997) Genetic tagging of humpback whales. *Nature* 388:767–769
- Smith TD, Allen J, Clapham PJ, Hammond PS, Katona S, Larsen F, Lien J, Mattila D, Palsbøll PJ, Sigurjónsson J (1999) An ocean basin wide mark recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). *Marine Mammal Science* 15:1–32
- Stevick PT, Allen J, Bérubé M, Clapham PJ, Katona SK, Larsen F, Lien J, Mattila DK, Palsbøll PJ, Robbins J, others (2003) Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). *Journal of Zoology* 259:231–237
- Stevick PT, Øien N, Mattila DK (1999) Migratory destinations of humpback whales from Norwegian and adjacent waters: evidence for stock identity. *Journal of Cetacean Research and Management* 1:147–52
- Wenzel FW, Allen J, Berrow S, Hazevoet CJ, Jann B, Seton RE, Steiner L, Stevick P, Suarez PL, Whooley P (2009) Current Knowledge on the Distribution and Relative Abundance of Humpback Whales (*Megaptera novaeangliae*) off the Cape Verde Islands, Eastern North Atlantic. *Aquatic Mammals* 35:502–510