Breeding habitat of poorly studied humpback whales (*Megaptera novaeangliae*) in Boa Vista, Cape Verde

Conor Ryan[1,2,3], Darren Craig[1], Pedro López-Suárez[4], Jose Vazquez Perez[5], Ian O'Connor[2] And Simon D. Berrow[1,2]

Contact e-mail address: cryan@mcr-team.org

ABSTRACT

The waters surrounding Cape Verde comprise one of two known breeding grounds for humpback whales in the North Atlantic. The population remains very small and has apparently failed to recover since the cessation of whaling there. During the breeding seasons of 2011 and 2012, sighting surveys were carried out for humpback whales off Boa Vista, the easternmost island of the Cape Verde Island archipelago. The distribution and relative abundance of humpback whales and mother-calf pairs was investigated by plotting effort-corrected sightings using a 2km^2 grid-square. The study area, a 206km^2 region from the coastline up to 8km offshore, covered the western half of Boa Vista where whales have previously been regularly recorded. Following 1,954km of search effort, 117 sightings of humpback whales were made. An encounter rate of 0.11 whales per km was recorded for both years. It is hoped that these data may assist in implementing conservation measures to protect humpback whales and the habitat of Baia Sal Rei, which appears to be the single most important bay for winter breeding, calving and nursing humpback whales in the eastern North Atlantic.

KEYWORDS: CONSERVATION; MONITORING; SURVEY VESSEL; DISTRIBUTION; BREEDING GROUND; NORTH ATLANTIC; HUMPBACK WHALE; PHOTO-ID; INDEX OF ABUNDANCE

INTRODUCTION

Humpback whales (*Megaptera novaeangliae*) are known to undertake the longest known migrations among mammals (Clapham and Mead, 1999; Robbins *et al*., 2011; Stevick *et al*., 2011) spending the summer feeding at temperate or high latitudes and wintering in shallow tropical waters where they breed and calve (Clapham and Mead, 1999). In the North Atlantic, humpback whales feed in five primary feeding grounds: Gulf of Maine, Newfoundland/Labrador, Greenland, Iceland and Norway before travelling south to two known breeding grounds: West Indies and Cape Verde, where they mix spatially and genetically (Smith *et al*. 1999; Stevick *et al*., 2003). The majority of North Atlantic humpback whales winter in the West Indies. The presence of calves and breeding behaviour indicate that the waters surrounding the Cape Verde Islands also constitute a breeding habitat for humpback whales, which has not been studied intensively (Hazevoet *et al*., 2011; Hazevoet and Wenzel, 2000; Jann *et al*., 2003; Ryan *et al*., 2014; Wenzel *et al*., 2009).

The most recent population size estimate for humpback whales in the North Atlantic for the period 1996–2005 is 17,744 (95% CI 12,061–32,597; Smith and Pike, 2009). The putative Cape Verde population has been estimated at *ca* 100 individuals in 2001 from limited mark-recapture data (Punt *et al*., 2006); however a minimum estimate (based on the total number of identified individuals as of February 2013) of 150 individuals is apparent from more extensive photo-identification data (Fred Wenzel, unpublished data). This suggests a large discrepancy between the estimated number of whales on the two known North Atlantic breeding grounds and the total abundance estimate for the entire North Atlantic Ocean of several thousand animals, suggesting that other breeding grounds may exist in the North Atlantic which have yet to be discovered (Punt *et al*., 2006; Smith and Pike, 2009).

Prior to commercial whaling during the 18th century, Punt *et al*. (2006) estimated the Cape Verde population to be *ca* 5,000 whales. Analysis by Reeves *et al*. (2002) concluded that prior to whaling, the density of whales around the Cape Verde Islands was once comparable to that of the major breeding areas in the West Indies, which is certainly no longer the case. Despite the impacts of historical whaling on this population, and its apparent lack of recovery (in contrast to most other humpback whale populations), it is still encompassed under the species listing as 'Least Concern' by the IUCN (Reilly *et al*., 2008). Recent genetic evidence however, suggests that the humpbacks breeding in Cape Verde are discrete from those in the West Indies and as such may constitute one of the most endangered humpback whale populations in the world (Bérubé *et al*., 2013); this would suggest consideration of this as a separate 'sub-population' in IUCN parlance (*www.iucnredlist.org*).

This small and little-known population may be particularly at risk from coastal development and vessel traffic associated with the rapidly expanding resort tourism, which may already have had negative effects on humpback whales around Sal Island (north of Boa Vista) and sea turtle nesting habitat (Wenzel *et al*., 2009; Taylor and Cozens, 2010). Results are presented here, from a survey of an area

[1]*Irish Whale and Dolphin Group, Merchant's Quay, Kilrush, Co. Clare, Ireland.*
[2]*Marine and Freshwater Research Centre, Galway-Mayo Institute of Technology, Dublin Road, Galway, Ireland.*
[3]*Current address: R/v Song of the Whale Team, Marine Conservation Research International, 17a High Street, Kelvedon, Essex CO5 9AG, England, UK.*
[4]*Naturalia Cape Verde Lda., Sal Rei, Republic of Cape Verde.*
[5]*NGO Ilheu Limpo e Seguro, Sal Rei, Republic of Cape Verde.*

that has previously been suggested as an important habitat for humpback whales in Cape Verde (Hazevoet and Wenzel, 2000; Wenzel *et al*., 2009). The aim is to describe the distribution and relative abundance of adult whales and females with dependent calves around Boa Vista: an island which has large areas of shallow continental shelf waters.

METHODS

Dedicated humpback whale sighting surveys were carried out in the continental shelf waters to the west of Boa Vista, Cape Verde (Fig. 1) during the spring/winter breeding, calving and nursing period in two consecutive years (10 April–17 May 2011 and 14 April–15 May 2012). The study area, comprising 206 km^2 of inshore waters (up to 8km from shore) off western Boa Vista, was chosen based on high sightings rates from previous expeditions (Wenzel *et al*., 2009). Surveys were conducted from a 5m rigid-hulled inflatable boat, by two observers and a driver. Observers scanned the sea with the naked eye at an eye-height above sea level of *ca* 2m and surveys were conducted at a speed of 7–10 knots. Search effort was recorded continuously using a *Garmin Etrex* GPS. Once a sighting was made, search effort was postponed while individual identification photographs (fluke and right/left side dorsal fin) and biopsy samples (skin and blubber) were collected. Upon approaching a group of whales, data on group size and group composition were recorded: number of calves, number of adults and the presence of competitive groups (after Clapham *et al*., 1992). Calves were defined as animals less than half the length of the adults with which they are most closely associated, which are assumed to be mothers. In order to reduce duplicate sightings during the surveys, attempts were made to photograph the left and right sides of the adult female dorsal fin, as a means to recognise individuals in the field (tail-fluke images are traditionally used, however females with calves rarely raise their flukes in shallow waters), e.g. see Hammond *et al*. (1990).

Each survey route was decided upon *ad hoc* depending on sea-state conditions, which can be quite challenging in Cape Verde given the strong incessant trade winds and frequently large swell. Attempts were made to cover each part of the study area equally during each season. Most surveys started and ended at Sal Rei in Boa Vista. However during 2012, three surveys commenced at Lacacao on the south side of the island (Fig. 1). Sightings and search effort were mapped using Arc GIS (version 10). Sightings were stratified for mothers with calves. A 2km^2 grid square was used to sub-divide the study area, as the effective strip-width was considered to be *ca* 2km (given an eye height of 2m and swell height which was never <1m). Sightings rate was corrected for effort by considering the number of sightings per km of survey effort conducted per grid square. Sightings

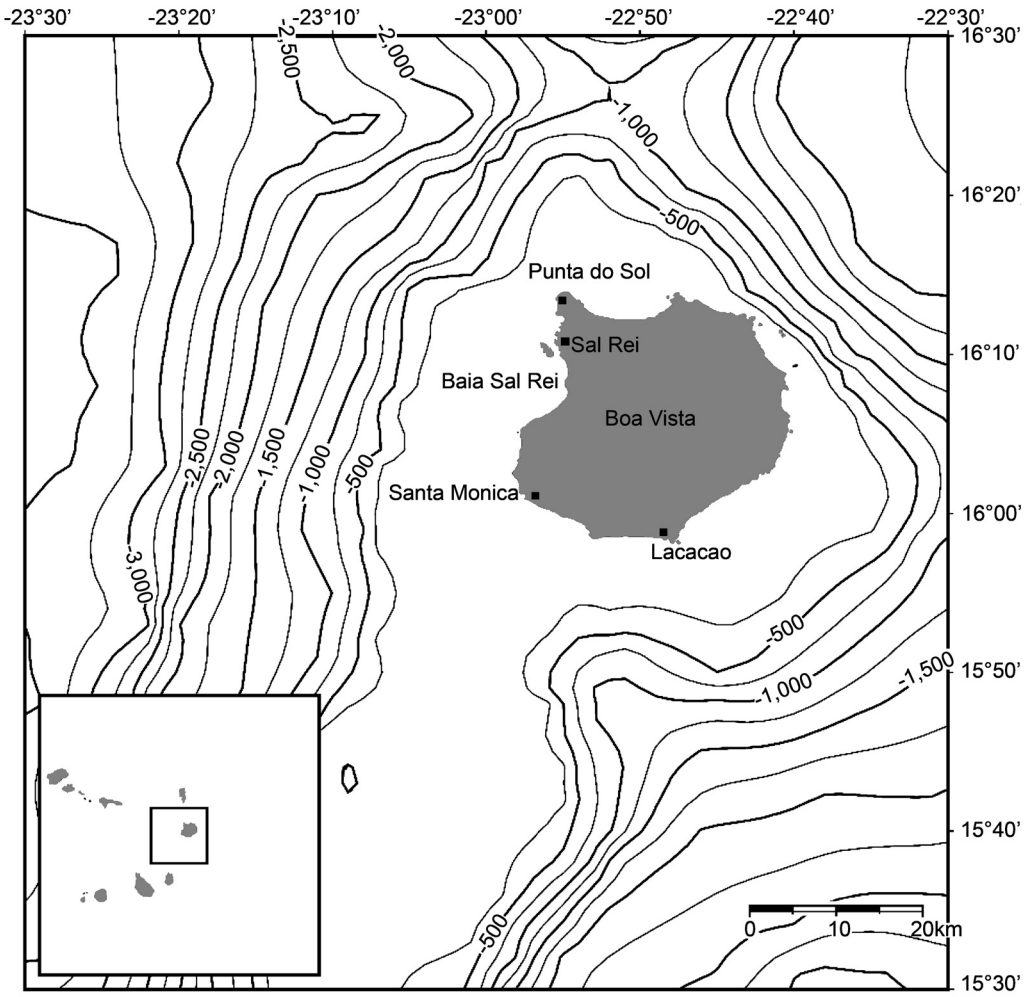

Fig. 1. The island of Boa Vista showing the study area, continental shelf and place-names mentioned in the text.

were categorised according to presence of a mother with a calf, mother calf and escorts or adult(s) only, and plotted accordingly in order to identify areas of particular importance for nursing mothers.

RESULTS

A total of 74 surveys was carried out (40 in 2011 and 34 in 2012) amounting to 1,954km of search effort (Table 1). Sighting rates were similar in 2011 and 2012 (0.10 and 0.16 whales per km respectively), and encounter rates were not consistently higher for any particular month across years (Table 1). For both years combined, the number of whales sighted per km was 0.11 for adults and 0.02 for calves. The encounter rate for calves was higher in 2012 (0.03 whales per km) than in 2011 (0.01 whales per km), however this may have been influenced by the confounding effect of sea state which was higher on average during 2011 (Table 1). It is important to note that some of these records included re-sightings of individual whales, i.e. photo-identification of dorsal fins indicated that sightings were not always of unique individuals (data presented in Table 1).

Tail fluke images obtained during the surveys have been lodged with the North Atlantic Humpback Whale Catalogue, curated by Allied Whale, Bar Harbour, Maine, USA. The mean (±SD) group sizes in the present study were similar for both years: 2.04 (1.29) in 2011 and 1.80 (0.79) in 2012. The maximum group size was six during 2011 and five during 2012. Four competitive groups were encountered where group sizes ranged between five and six during 2011 and four in 2012 (Table 2). It is notable that during both years, sightings of competitive groups were confined to the third week in April.

Baia Sal Rei, the largest bay in Boa Vista contained the highest abundance of humpback whales (see Fig. 2). Santa Monica contained fewer humpback whales during our surveys, while at the southern end of the island intermediate abundances of humpback whales were found, albeit this was based on lower effort (Fig. 2). Groups of whales which included calves (31.6 % of all sightings) were exclusively within 4km of the coast, in shallower waters (Figs 1 and 3; Table 1). High sightings per unit effort were detected throughout Baia Sal Rei, and in localised pockets around Punta do Sol and Lacacao (Fig. 2). Only one other cetacean species was encountered during this study: four sightings of rough-toothed dolphins (*Steno bredanensis*; mean group size of 4, range 2–7).

DISCUSSION

The results herein confirm that the western coast of Boa Vista is used by humpback whales for breeding and calving (Wenzel *et al*., 2009) and suggest that Baia Sal Rei is the most important known location for humpback whales breeding in the eastern North Atlantic. Mother/calf pairs were observed regularly in the study area, and competitive groups were observed on three occasions, confirming that that the area is used for both nursing calves and mating. The densities reported herein are intermediate between those estimated by Mattila *et al*. (1994) for Samana Bay in the West Indies (0.63 whales per km presented as 1.7 whales per hour at a speed of 5 knots) and by Swartz *et al*. (2001) for the wider eastern Caribbean (0.011 whales per km) in the western North Atlantic. Around Boa Vista, 31.6% of groups recorded included a calf but only 3.5% of groups were considered competitive groups, i.e. behaviour consistent with mating. This compares with 15.2% and 11.2%, groups with calves and competitive groups respectively in Samana Bay, Dominican Republic (Mattila *et al*., 1994). However, due to differences in platform height, vessel speed, sea state and geographical coverage, caution is warranted in interpreting the comparisons between these studies. Nevertheless, our findings of a high proportion of groups with calves and the presence of some competitive groups indicate that the waters to the west of Boa Vista provide an important habitat for nursing and breeding humpback whales.

When on their breeding grounds, humpback whales are generally distributed evenly throughout continental shelf waters (Zerbini *et al*., 2004; Félix and Botero-Acosta, 2011). However, the distribution of mother-calf pairs is usually much higher in shallow water, closer to shore (Mattila *et al*., 1994; Smultea, 1994; Zerbini *et al*., 2004; Félix and Botero-Acosta, 2011; Palacios *et al*., 2012). Our results are consistent with these findings, as calves were mostly recorded inside a sheltered bay (Baia Sal Rei) within 4km of shore, and never beyond 6km. Both Smultea (1994) and Félix and Botero-Acosta (2011) found that time of day and depth were important co-variates determining calf presence, suggesting that they sheltered in shallow bays during afternoons when trade winds are strongest. It should be noted however that due to their small size, calves are less conspicuous and there is a risk that they are detected at a lower rate further from shore where sea conditions are generally worse. Furthermore, the estimates presented herein may be conservative due to the adverse affects that high sea states have on visual detection rates.

Table 1

Summary of search effort, sightings and sightings rates of humpback whales during visual surveys inshore waters of Boa Vista, Cape Verde during April and May 2011 and 2012.

	Effort (hr)	Effort (km)	Sightings	Whales (*n*)	Calves (*n*)	Whales km^{-1}	Calves km^{-1}	Beaufort sea state (mode)
2011								
April	108	1,160.2	39	91	15	0.08	0.01	5
May	28	301.8	34	52	5	0.17	0.02	4
Total	136	1,462.0	73	143	20	0.10	0.01	4
2012								
April	27	311.4	30	59	14	0.19	0.04	4
May	21	180.6	14	22	3	0.12	0.02	3
Total	48	492.0	44	81	17	0.16	0.03	4
					Total	**0.11**	**0.02**	

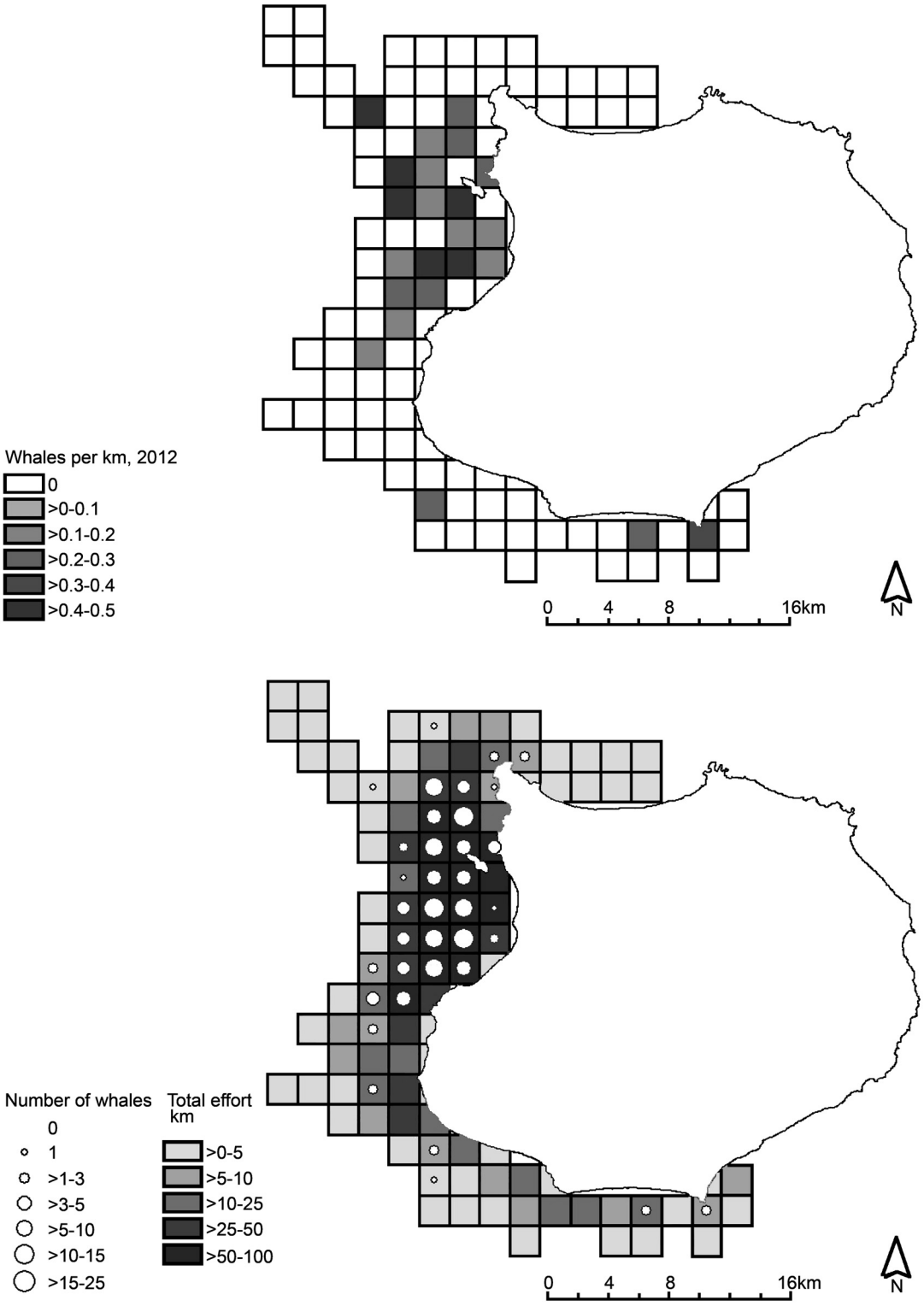

Fig. 2. Relative abundance and distribution of humpback whales (adults and calves) recorded in inshore waters of Boa Vista, Cape Verde during April and May 2011 and 2012 combined.

The apparently small population size and the near-shore distribution of calves around Boa Vista may make these animals particularly vulnerable to shore-based activities and developments including potential impacts associated with blasting, dredging, vessel traffic and the use high-speed craft and whalewatching which is expanding rapidly in Cape Verde. In 2008 *ca* 300 people went on whalewatching tours and this has increased to *ca* 5,000 in 2012 (PLS, unpublished data). The importance of implementing effective conservation measures and monitoring cannot be understated. The Cape Verdean authorities are therefore urged to consider strict protection of these whales and their breeding ground, and to urgently regulate whalewatching and other activities which may adversely affect or displace these whales. A management plan will help to evaluate gaps in existing marine conservation efforts in Cape Verde, and identify potential roles for a sanctuary. More research is necessary in this region to study the use of

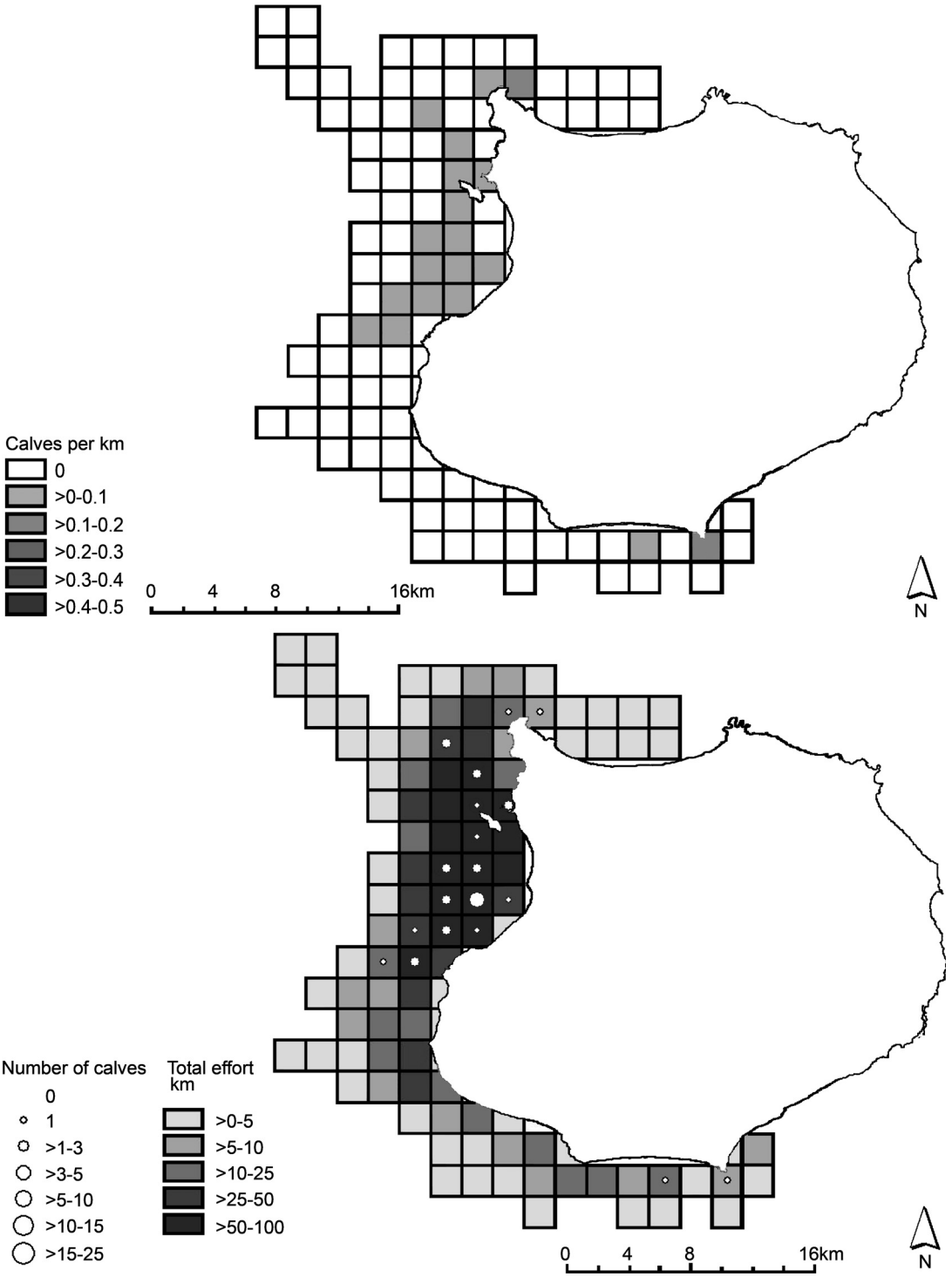

Fig. 3. Relative abundance and distribution of humpback whale calves (always attended by mothers) recorded in inshore waters of Boa Vista, Cape Verde during April and May 2011 and 2012 combined.

habitat, temporal residency, identification of critical habitats, and the interaction between whales and whalewatching boats.

ACKNOWLEDGEMENTS

This work was generously funded by the Island Foundation and some anonymous members of the Irish Whale and Dolphin Group. Logistical support, accommodation and a warm welcome were provided by Natura 2000 in Sal Rei. We are grateful to our partners at INDP, especially Vanda Monteiro. Thanks to Juan and Félix Bustos and Scubacaribe for assistance with the boat and thanks to Gennaro Cascilla Doc for good humoured assistance in the field. We are also grateful to Stravagante and Gabriella at naturaliaecotours.com for help and advice. This work would not have been possible without the encouragement, support and advice of our fellow humpback whale researchers: Fred Wenzel, Beatrice Jann and Pádraig Whooley. We thank TUI and the crew of the Sea Turtle sailing catamarans (S/V *Tartaruga do mar I* and *II*) for allowing us on board their whale-watch vessels. This research was carried out under permit by the Environment Ministry of the Republic of Cape

Table 2

Composition of groups observed during April and May 2011 and 2012 around Boa Vista (following Mattila *et al.*, 1994).

Group class	Number of groups	%
Singleton	47	40.2
Groups without calves	33	28.2
– of which competitive groups	1	0.9
Groups with calves	37	31.6
– of which mother-calf pair only	17	14.5
– of which mother, calf and escort trio	14	12
– of which competitive groups	3	2.6
Total	**117**	

Verde, Ministério de Ambiente, Habitacao e Ordenamento do Território (permits 03/2011 and 02/2012). We are grateful to two anonymous reviewers whose comments helped improve the manuscript.

REFERENCES

Bérubé, M., Ryan, C., Berrow, S., Lopez-Suárez, P., Monteiro, V., Wenzel, F., Robbins, J., Mattila, D., Vikingsson, G., Øien, N. and Palsbøll, P. 2013. The Cape Verde Islands are home to a small and genetically distinct humpback whale breeding population. Short talk presented to the 27th ECS Conference, April 2013, Setubal, Portugal. [Abstract available on p.62 of Conference Abstract Book]

Clapham, P.J. and Mead, J.G. 1999. *Megaptera novaeangliae*. *Mamm. Species* 604: 1–9.

Clapham, P.J., Palsbøll, P.J., Mattila, D.K. and Vasquez, O. 1992. Composition and dynamics of humpback whale competitive groups in the West-Indies. *Behaviour* 122(Part 3–4): 182–94.

Félix, F. and Botero-Acosta, N. 2011. Distribution and behaviour of humpback whale mother-calf pairs during the breeding season off Ecuador. *Mar. Ecol. Prog. Ser.* 426: 277–87

Hazevoet, C.J., Gravanita, B., Lopez Suarez, P. and Wenzel, F.W. 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(1): 25–29.

Hazevoet, C.J. and Wenzel, F.W. 2000. Whales and dolphins (Mammalia, Cetacea) of the Cape Verde Islands, with special reference to the humpback whale (*Megaptera novaeangliae*) (Borowski, 1781). *Contrib. Zool.* 69(3): 197–211.

Jann, B., Allen, J., Carrillo, M., Hanquet, S., Katona, S.K., Martin, A.R., Reeves, R.R., Seton, R., Stevick, P.T. and Wenzel, F.W. 2003. Migration of a humpback whale (*Megaptera novaeangliae*) between the Cape Verde Islands and Iceland. *J. Cetacean. Res. Manage.* 5(2): 125–29.

Mattila, D.K., Clapham, P.J., Vásquez, O. and Bowman, R.S. 1994. Occurrence, population composition, and habitat use of humpback whales in Samana Bay, Dominican Republic. *Can. J. Zool.* 72(11): 1,898–907.

Hammond, P.S., Mizroch, S.A. and Donovan, G.P. (Eds) 1990. *Report of the International Whaling Commission (Special Issue 12). Individual Recognition of Cetaceans: Use of Photo-Identification and Other Techniques to Estimate Population Parameters.* International Whaling Commission, Cambridge, UK. [vi]+440pp.

Palacios, D.M., Herreira, J.C., Gerrodette, T., García, C., Soler, G.A., Avila, I.C., Bessudo, S., Hernandez, E., Trujillo, F., Florez-Gonzalez, L. and Kerr, I. 2012. Cetacean distribution and relative abundance in Colombia's Pacific EEZ from survey cruises and platforms of opportunity. *J. Cetacean Res. Manage.* 12(1): 45–60.

Punt, A.E., Friday, N. and Smith, T.D. 2006. Reconciling data on the trends and abundance of North Atlantic humpback whales within a population modelling framework. *J. Cetacean Res. Manage.* 8(2): 145–59.

Reeves, R.R., Clapham, P.J. and Wetmore, S.E. 2002. Humpback whale (*Megaptera novaeangliae*) occurrence near the Cape Verde Islands, based on American 19th century whaling records. *J. Cetacean Res. Manage.* 4(3): 235–53.

Reilly, S.B., Bannister, J.L., Best, P.B., Brown, M., Brownell, R.L., Jr., Butterworth, D.S., Clapham, P.J., Cooke, J., Donovan, G.P., Urbán, J. and Zerbini, A.N. 2008. *Balaenoptera musculus*. *IUCN Red List of Threatened Species*. [Available at: *www.iucn.redlist.org*].

Robbins, J., Dalla Rosa, L., Allen, J.M., Mattila, D.K., Secchi, E.R., Friedlaender, A.S., Stevick, P.T., Nowacek, D.P. and Steele, D. 2011. Return movement of a humpback whale between the Antarctic Peninsula and American Samoa: a seasonal migration record. *Endanger. Species. Res.* 13: 117–21.

Ryan, C., McHugh, B., Boyle, B., McGovern, E., Bérubé, M., Lopez-Suárez, P., Elfes, C.T., Boyd, D.T., Ylitalo, G.M., Van Blaricom, G.R., Clapham, P.J., Robbins, J., Palsbll, P.J., O'Connor, I. and Berrow, S.D. 2014. Levels of persistent organic pollutants in eastern North Atlantic humpback whales. *Endanger. Species Res.* 22: 213–23.

Smith, T.D., Allen, J., Clapham, P.J., Hammond, P.S., Katona, S., Larsen, F., Lien, J., Mattila, D., Palsbøll, P.J., Sigurjónsson, J., Stevick, P.T. and Øien, N. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). *Mar. Mammal Sci.* 15(1): 1–32.

Smith, T.D. and Pike, D.G. 2009. The enigmatic whale: the North Atlantic humpback. *NAAMCO Sci. Publ.* 7: 161–78.

Smultea, M. 1994. Segregation by humpback whale (*Megaptera novaeangliae*) cows with a calf in coastal habitat near the island of Hawaii. *Can. J. Zool.* 72: 805–11.

Stevick, P.T., Allen, J., Bérubé, M., Clapham, P.J., Katona, S.K., Larsen, F., Lien, J., Matilla, D.K., Palsbíll, P.J., Robbins, J., Sigurjónsson, J., Smith, T.D., Øien, N. and Hammond, P.S. 2003. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). *J. Zool*. 259: 231–37.

Stevick, P.T., Neves, M.C., Johansen, F., Engel, M.H., Allen, J., Marcondes, M.C.C. and Carlson, C. 2011. A quarter of a world away: female humpback whale moves 10,000km between breeding areas. *Biol. Letters* 7: 299–302.

Swartz, S.L., Martinez, A., Cole, T., Clapham, P.J., McDonald, M.A., Hildebrand, J.A., Oleson, E.M., Burks, C. and Barlow, J. 2001. Visual and acoustic survey of humpback whales (*Megaptera novaeangliae*) in the eastern and southern Caribbean Sea. *Caribb. J. Sci.* 39(2): 195–208. [NOAA Technical memorandum NMFS-SEFSC-456].

Taylor, H. and Cozens, J. 2010. The effects of tourism, beachfront development and increased light pollution on nesting Loggerhead turtles *Caretta caretta* (Linnaeus, 1758) on Sal, Cape Verde Islands. *Zoologia Caboverdiana* 1: 100–11.

Wenzel, F.W., Allen, J., Berrow, S., Hazevoet, C.J., Jann, B., Seton, R.E., Steiner, L., Stevick, P., Lopez Suarez, P. and Whooley, P. 2009. Current knowledge on the distribution and relative abundance of humpback whales (*Megaptera novaeangliae*) off the Cape Verde Islands, eastern North Atlantic. *Aquat. Mamm.* 35(4): 502–10.

Zerbini, A.N., Andriolo, A., Da Rocha, J.M., Simoes-Lopes, P.C., Siciliano, S., Pizzorno, J.L., Waite, J.M., DeMaster, D.P. and VanBlaricom, G.R. 2004. Winter distribution and abundance of humpback whales (*Megaptera novaengliae*) off northeastern Brazil. *J. Cetacean Res. Manage.* 6(1): 101–07.