

African Journal of Marine Science

ISSN: 1814-232X (Print) 1814-2338 (Online) Journal homepage: <https://www.tandfonline.com/loi/tams20>

The waters of São Tomé: a calving ground for West African humpback whales?

I Carvalho , C Brito , ME dos Santos & HC Rosenbaum

To cite this article: I Carvalho , C Brito , ME dos Santos & HC Rosenbaum (2011) The waters of São Tomé: a calving ground for West African humpback whales?, African Journal of Marine Science, 33:1, 91-97, DOI: [10.2989/1814232X.2011.572353](https://doi.org/10.2989/1814232X.2011.572353)

To link to this article: <https://doi.org/10.2989/1814232X.2011.572353>



Published online: 10 Jun 2011.



Submit your article to this journal [↗](#)



Article views: 81



Citing articles: 4 View citing articles [↗](#)

The waters of São Tomé: a calving ground for West African humpback whales?

I Carvalho^{1,2,3*}, C Brito^{4,5}, ME dos Santos⁶ and HC Rosenbaum^{2,3}

¹ Faculdade de Ciências do Mar e Ambiente – Universidade do Algarve, Campus Gambelas, 8000-139 Faro, Portugal

² Sackler Institute for Comparative Genomics, American Museum of Natural History, Central Park West at 79th street, New York, NY 10024, USA

³ Cetacean Conservation and Research and Ocean Giants Program, Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, NY 10460-1099, USA

⁴ Centro de História de Além-Mar, Faculdade de Ciências Sociais e Humanas, Universidade Nova de Lisboa, Avenida de Berna, 26 C, 1069-061 Lisboa, Portugal

⁵ Escola de Mar – Edifício ICAT Campus da FCUL, Campo Grande, 1749-016 Lisboa, Portugal

⁶ Eco-Ethology Research Unit, ISPA – Instituto Universitário, Rua Jardim do Tabaco, 34, 1149-041 Lisboa, Portugal

* Corresponding author, e-mail: carvalho.inesc@gmail.com

Manuscript received April 2010; accepted October 2010

In the Southern Hemisphere, humpback whales *Megaptera novaeangliae* feed in Antarctic waters during the austral summer and migrate to their breeding grounds in subtropical and tropical waters during the winter. Historical whaling records suggest that the Archipelago of São Tomé and Príncipe, located in the Gulf of Guinea, serves as a possible breeding ground. In order to investigate the temporal occurrence and group composition of humpback whales around São Tomé Island, annual surveys were conducted during the breeding season between 2002 and 2006. A total of 186 boat-based surveys took place during this period. Data collected during each sighting included geographical positions, group size, group composition and behavioural classifications. Of the 66 groups encountered, mother/calf pairs made up a large proportion (65.15%), followed by solitary individuals (15.15%). Mother/calf pairs were seen in the region into November and resightings of identified animals indicate periods of occupancy that extended over three weeks. Few behaviours typically associated with mating activity were observed. Given the high percentage of mother/calf pairs, sometimes with very young calves, and the low frequency of mating activity, the waters of São Tomé may primarily serve as a calving and nursing or resting area for humpback whales.

Keywords: behaviour, breeding grounds, group composition, South Atlantic

Introduction

The humpback whale *Megaptera novaeangliae* is an inhabitant of all the oceans. Typically, it undertakes annual migrations from summer high-latitude feeding grounds to winter breeding grounds in tropical and subtropical waters (Dawbin 1966). Populations of Southern Hemisphere baleen whales are divided into six management units, termed Areas I–VI (Mackintosh 1942, Donovan 1991). Humpback whales from all six areas feed in the circumpolar waters of the Antarctic and Antarctic convergence and migrate to distinct breeding grounds in tropical waters. In the South Atlantic Ocean, breeding grounds have been described in tropical waters off the east coast of South America and the west coast of Africa. These aggregations are termed Breeding Stocks A and B by the International Whaling Commission (IWC 2001) respectively. However, it has been proposed that there may be two breeding substocks in the

eastern South Atlantic: whales that winter along the central West African coast and around the northern islands of the Gulf of Guinea putatively constitute the B1 substock and whales that have been sampled off the west coast of South Africa in an area which appears to serve as a feeding site or possibly a migratory corridor, the B2 substock (the actual breeding site of the latter is unknown). A boundary between these two substocks has been described in the vicinity of 18° S, where the Walvis Ridge meets the African coast and the Angola/Benguela Front (IWC 2006, Pomilla et al. 2006, Rosenbaum et al. 2009, Barendse et al. 2010).

The Gulf of Guinea and adjacent waters were subjected to extensive whaling activity during the 18th, 19th and 20th centuries (Townsend 1935, Budker 1953, Best et al. 1998). Modern whaling started in the region in 1910 at Cap Lopez (Gabon) and ended in 1959 when only 160 whales were

caught. Catch records indicated that the mean length of humpback whales declined substantially during this period (Budker and Roux 1968).

Since the cessation of whaling in the Gulf of Guinea, published information on humpback whales in the region has been limited, especially compared to other populations worldwide (e.g. Baker et al. 1998, Smith et al. 1999, Calambokidis et al. 2001, Stevick et al. 2003, Constantine et al. 2007, Engel et al. 2008). This was due to a lack of scientific research on whales in the region. However, studies on humpback whales were initiated off the coast of Gabon in 1998, although these efforts were largely opportunistic at first (Walsh et al. 2000). More recently, dedicated surveys conducted in Gabon waters (Rosenbaum and Collins 2006, Collins et al. 2008, Rosenbaum et al. 2009) and Angola (Weir 2007) have confirmed that these areas are used as breeding grounds. Humpback whales have also been reported in other areas off the Gulf of Guinea, including the Bight of Benin, Togo, Nigeria, Ghana (Van Waerebeek et al. 2001, 2009, Rosenbaum and Mate 2006), the coasts of Equatorial Guinea and Congo (Best et al. 1999, Rosenbaum and Collins 2006) and the islands of Bioko, Pagalu and São Tomé (Aguilar 1985, Picanço et al. 2009).

In 2002, dedicated surveys were initiated to study the occurrence and distribution of cetaceans around the island of São Tomé, where humpback whales have been reported since the 19th century (Townsend 1935). Based on these surveys, the objectives of this study were to describe the temporal occurrence and group composition of humpback whales in São Tomé waters, and to determine whether these waters are a breeding ground for Gulf of Guinea humpback whales.

Methods

Study area

The Democratic Republic of São Tomé and Príncipe is located in the Gulf of Guinea between 1°44' N and 0°01' S. It forms the middle section of a volcanic island group that extends across the Gulf of Guinea (Figure 1). As a consequence of their volcanic origin, the islands display high relief and the littoral surrounding fringe is very narrow, especially in São Tomé (436 km² above 200 m depth). São Tomé is the second largest island in the chain (836 km²) and is situated about 275 km west of Gabon (Lee et al. 1994). Sea bottom depths of up to 2 000 m occur between the islands and the African mainland.

Data collection and analysis

Data were collected between 2002 and 2006. The field seasons varied in terms of timing, duration and effort (Table 1), with the shortest occurring in 2006. We made use of various fibreglass boats (6–8 m), powered by engines ranging from 25 hp to 200 hp, to conduct the surveys. Sampling was carried out only when the sea state was assessed to be \leq Beaufort 4 and surveys were cancelled if conditions deteriorated beyond this state. Surveys were conducted on all days of each field season when the weather permitted.

When humpback whales were sighted, search effort (time spent searching for animals) was switched to encounter

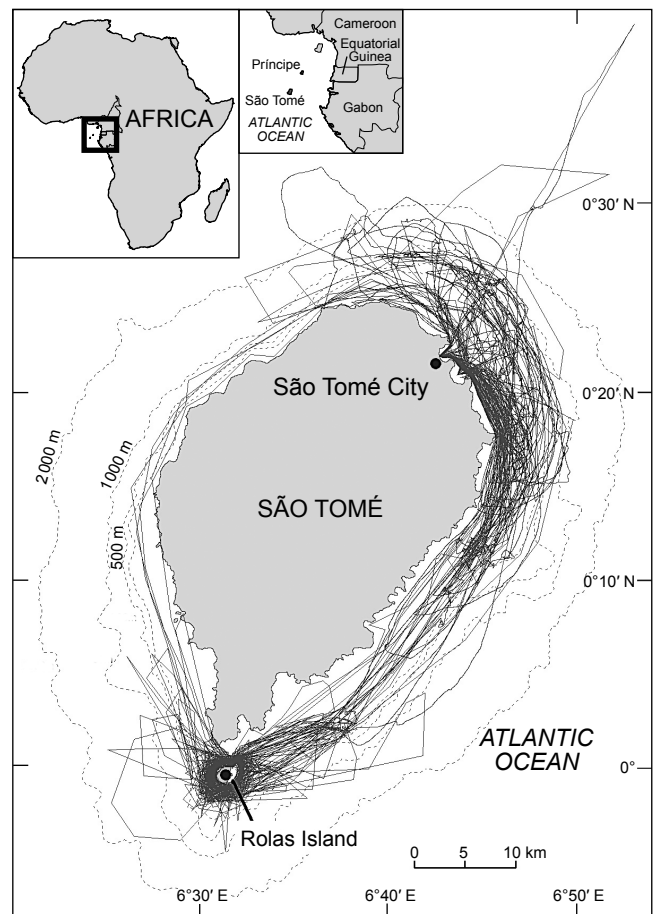


Figure 1: Map showing the survey effort carried out around São Tomé Island, 2002–2006

effort (time with the animals). For each sighting, the following data were recorded: sighting date, time, position, group size, group class, and predominant surface behaviour. Whales were considered to be associated as a group if they were swimming side by side, and their surfacing, diving, speed and direction of movement were generally coordinated (Mobley and Herman 1985). Group class classification followed the definitions of Tyack and Whitehead (1983), Baker and Herman (1984) and Clapham et al. (1992), with the following categories recognised: singleton, singer pair, competitive group, competitive group with mother and calf, non-competitive group, mother/calf pair, and mother/calf/escort. Occurrence was defined as the proportion of observer days within a field season during which an individual whale was sighted. Occupancy was defined as the number of days from the first to the last sighting of an individual, inclusive.

During 2002–2003, a C53 Cetacean Research Technology hydrophone (connected to a Sony DAT TCD-D10 recorder) was used to investigate the presence of singers when one or more whales were sighted.

For individual identification, the ventral surfaces of the humpback whales' flukes were photographed wherever possible (Katona and Whitehead 1981). Photographs were also taken of dorsal fins to assess variation in their size, shape and scarring (Blackmer et al. 2000). Photographs

Table 1: Details of sampling effort and humpback whale sightings during cetaceans surveys in São Tomé, 2002–2006

Year	Date Month	Sampling effort		Sightings		
		Number of surveys	Search effort (h)	Number of groups	Mean group size \pm SD	SPUE (sightings h ⁻¹)
2002	August	15	28.15	5	1.60 \pm 0.89	0.178
	September	18	25.17	8	2 \pm 0.93	0.318
	October	29	56.85	9	1.89 \pm 0.60	0.158
	November	17	41.25	2	2 \pm 0.0	0.049
	December	7	20.13	0	–	–
	Total	86	171.55	24	1.88 \pm 0.74	0.140
2003	August	17	36.08	9	2 \pm 0.5	0.249
	September	13	24.00	9	1.47 \pm 0.33	0.375
	October	8	18.50	5	2 \pm 0.0	0.270
	Total	38	78.58	23	1.96 \pm 0.37	0.290
2004	October	18	86.22	6	2 \pm 0.0	0.070
	November	4	20.08	0	–	–
	Total	22	106.30	6	2 \pm 0.0	0.060
2005	August	5	20.23	0	–	–
	September	22	83.62	8	2.13 \pm 0.35	0.096
	October	6	25.77	2	2 \pm 0.0	0.078
	Total	33	129.62	10	2.10 \pm 0.32	0.080
2006	September	7	28.57	3	2 \pm 0.0	0.105
	Total	7	28.57	3	2 \pm 0.0	0.105
Total		186	514.62	66	1.95 \pm 0.51	0.130

were either taken with 35 mm cameras using ISO 100 or 400 colour slide film (2002–2004), or digital cameras equipped with 75–300 mm zoom lenses (2005 and 2006). During analyses, all non-digital images were scanned at high resolution (2 000 dpi) and converted to an electronic format (TIFF). Each uniquely identified whale received a catalogue number and was represented by one standard photograph in the catalogue.

A value of sightings per unit of effort (SPUE), expressed as the number of sightings per hour of search effort at sea, was calculated by month and by year (field season).

Results

In total, 186 surveys were conducted between 2002 and 2006, totalling 597 hours of survey effort (sampling and encounter effort) (see Table 1). In 2002 and 2003, the survey team was based on Rolas Island and most of the survey effort was concentrated in the waters south of São Tomé (Figure 1). In 2004, the base was shifted to São Tomé City and between then and 2006, most of the survey effort occurred on the north and east coast of São Tomé (Figure 1).

Occurrence and occupancy

A total of 66 groups of humpback whales was observed throughout the study period (Table 1). Sightings took place in each of the months sampled except for December (surveyed only in 2002). The earliest encounter in any of the years was on 8 August 2002 and the latest was on 22 November 2002, but effort was ceased before November in most of the years. The peak occurrence was recorded in August and September, followed by October (Figure 2). Humpback whales were reported from the north-east coast to south of São Tomé (Figure 3).

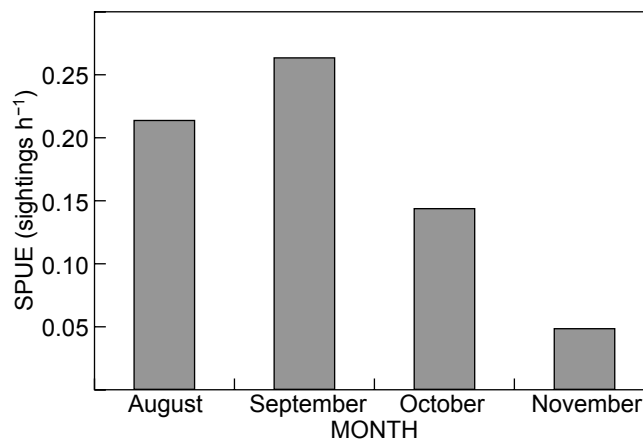


Figure 2: Monthly sightings of humpback whales groups per unit of effort (SPUE) around São Tomé, 2002–2006

Photographic analysis permitted the photo-identification of 25 individual humpback whales. Six animals were identified in 2002, 10 in 2003, two in 2004, six in 2005 and one in 2006. Of the 25 individuals, six were identified by the ventral surfaces of their tail flukes and by their dorsal fins, the others were identified only by dorsal fin shapes and scarring. Not one of the photo-identified whales was resighted in more than one year. However, multiple sightings of photo-identified individuals occurred within all of the years, with as many as six observations of the same individuals occurring in 2002 and 2003 (Table 2). The longest observed occupancy period was 25 days. All of the individuals that were resighted on multiple occasions were mothers with calves.

Group size and composition

Group sizes varied from one to three animals, with a mean of 1.95 (SD 0.51) (see Table 1).

Humpback whales in São Tomé were observed in five group classes: singletons, pairs, competitive groups, mother and calf, mother and calf with escort (Figure 4). No singers were detected in 2002 or 2003, the only two years when a hydrophone was deployed. The most common group type observed throughout the study period was mother and calf ($n = 43$; 65.15%), followed by solitary animals ($n = 10$; 15.15%) and pairs ($n = 6$; 9.09%). Competitive groups (three adults with an identifiable nuclear animal) were observed on only two occasions (3.03%), in August 2002 and 2003. Social composition of groups varied intra-seasonally (Figure 4);

mother/calf pairs were present in all surveyed months and were the most frequently encountered group type, with a peak in September (no other group types were present in November). Calves were first encountered in August, and of the 66 humpback whale groups observed during the study, 48 contained a calf (72.72%). Some of the calves were very small, with a pale colouration and uncoordinated movements, considered typical of newborns.

Discussion

During the period of study, humpback whales were sighted in the region of São Tomé between August and late November, which in part reflected the peak survey effort, but their presence in these waters is probably longer than our surveys indicate, according to anecdotal information from local fishers and whale-watching operators (opportunistic sightings were made during January, June and July of some years). Historical data also show that late July and early August was the peak whaling season in the Gulf of Guinea (Budker and Roux 1959). In Gabon waters, whales are present between late June and December with peak abundance recorded between July and September and greatest densities recorded in August, (T Collins, Wildlife Conservation Society, pers. comm).

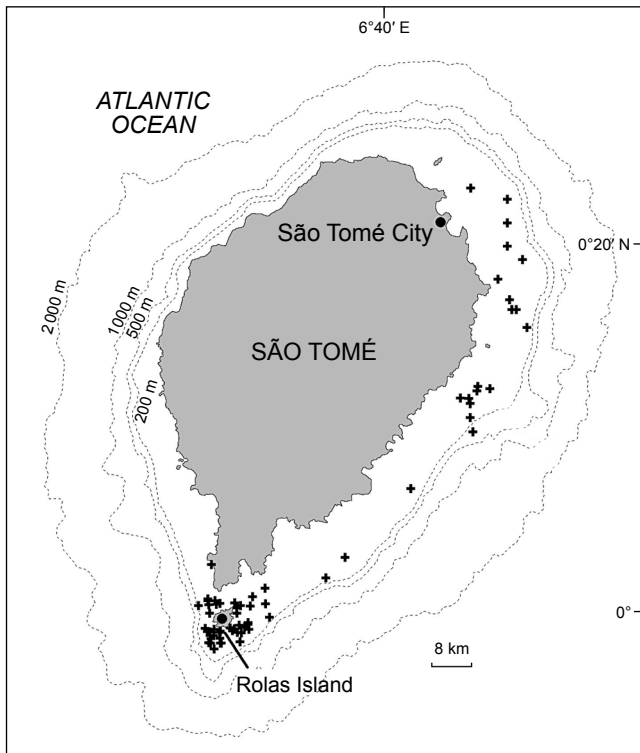


Figure 3: Sightings of humpback whale groups around São Tomé Island, 2002–2006

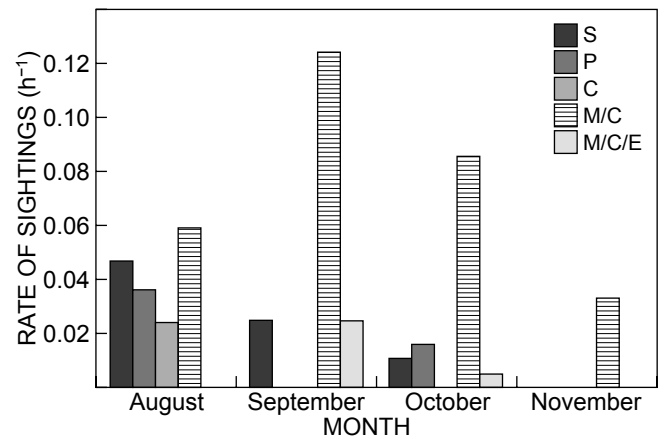


Figure 4: Temporal distribution of the social groupings of humpback whales by month around São Tomé, 2002–2006. S = single, P = pair, C = competitive, M/C = mother/calf, M/C/E = mother/calf/escort

Table 2: Sighting history of identifiable humpback whale individuals that were recorded on more than one occasion per field season at São Tomé, 2002–2006: whale ID, date of first and last sightings, number of times sighted and maximum occupancy (number of days from the first to the last sighting inclusive)

Whale ID	First sighting	Last sighting	Number of times observed	Maximum occupancy (days)
HW02-2	18/09/2002	09/10/2002	6	22
HW02-3	18/09/2002	19/09/2002	2	2
HW02-6	29/10/2002	01/11/2002	2	4
HW03-7	22/08/2003	29/08/2003	2	8
HW03-9	02/09/2003	05/09/2003	2	4
HW03-12	20/09/2003	14/10/2003	6	25
HW04-1	13/10/2004	28/10/2004	5	16
HW05-2	11/09/2005	21/09/2005	4	11
HW06-1	16/09/2006	27/09/2006	2	12

The sightings rates by year (0.06–0.29) were much lower when compared with other regions, such as Brazil (0.7–1.9, Martins et al. 2001) or the Comoros archipelago (0.68–2.36, Ersts et al. in press), suggesting that the number of whales in São Tomé is small or is very disperse through the region.

Humpback whale females with calves prefer shallow waters (Martins et al. 2001, Ersts and Rosenbaum 2003). On volcanic São Tomé where deep waters extend close inshore, shallow water areas are limited and are almost only present around Rolas Island and close to São Tomé city (north-east); Picanço et al. (2009) found a tendency for the humpback whales groups to prefer shallow waters around São Tomé Island. Reasons suggested for this include protection against rough sea conditions (Whitehead and Moore 1982), avoidance of conspecifics (Smultea 1994) or large predators such as sharks and killer whales *Orcinus orca* (Smultea 1994, Flórez-González et al. 1994). During our study, killer whales were sighted on six different occasions: five in 2002 and one 2004 (Weir et al. 2010), but these sightings were not coincident with those of humpback whales and were recorded near Rolas Island.

São Tomé Island appears to be used primarily by mother/calf pairs, either as a calving or nursing or resting area. This is suggested by the high frequency of groups with a calf present, sighting of very young calves and the occupancy of some whales in the area. The proportion of groups with calves encountered in this study area (72.72%) was higher than that recorded at other breeding grounds including Hawaii (10%; Smultea 1994), New Caledonia (13%; Garrigue et al. 2001), Madagascar (12%; Ersts and Rosenbaum 2003), Ecuador (~17% in late season; Scheidat et al. 2000) and Brazil (47.7%; Morete et al. 2007) of groups with calves. A similar proportion as that found in our study was recorded in the Comoros Archipelago (Indian Ocean) where groups with calves represented more than 68% of all group sightings (Kiszka et al. 2010, Ersts et al. in press). Off the coast of Gabon (<300 km away from São Tomé), analyses of the group characteristics of whales encountered revealed a lower percentage of mother/calf pairs (~4.6%), and the highest percentage of observed group types were pairs and competitive groups typically with a single-day occurrence (Pomilla and Rosenbaum 2006, Rosenbaum and Collins 2006), a situation similar to Madagascar and the Comoros Archipelago (Ersts and Rosenbaum 2003, Ersts et al. in press). Such findings suggest that some sites within a larger reproductive area, such as the Gulf of Guinea, may be preferred for calving and resting.

The limited occurrence of small competitive groups with no detection of singers raises doubts on the use of São Tomé waters by breeding males. Several studies have shown segregation of group types according to sex, age and/or reproductive status (e.g. Herman and Antinova 1977, Whitehead and Moore 1982, Glockner-Ferrari and Ferrari 1990, Martins et al. 2001, Ersts and Rosenbaum 2003). Humpback whale cows with calves seem to prefer shallow, sheltered or coastal waters whereas other adults are found mostly in deeper, more exposed areas. Because most of our surveys occurred close to shore, it is possible that we failed to encounter group types that occur more frequently farther offshore.

The low number of individuals photo-identified can be explained by the high prevalence of typically non-fluking mothers with calves, and also rough sea conditions limited opportunities for good-quality photography.

In other parts of the Gulf of Guinea, humpback whales sightings are frequent. They are observed regularly off Ghana, Equatorial Guinea and Benin (Van Waerebeek et al. 2001, 2009), and observations are made from whale-watching tours on Príncipe (JL Testorini, ClubMaxel Tours, pers. comm.). At an average swimming speed of 4–6 nautical miles per hour, Pagalu, Bioko and São Tomé are within two days of the Gabon coast (Walsh et al. 2000). In fact, recent telemetry data show that humpback whales tagged off Gabon also use other areas including São Tomé, Príncipe, Cameroon, Nigeria, Bioko and Ghana (Rosenbaum and Mate 2006). All of these areas are clearly important for breeding humpback whales; however, more information is needed to better understand the connection between these sites.

The possible existence of a calving humpback whale site in São Tomé raises important conservation issues, particularly due to the expansion of human activity in these waters. Offshore industrial activity (oil exploration) and tourism (especially whale watching) are increasing in São Tomé. There are few local laws regulating activities that may affect the conservation of humpback whales and other cetacean populations. Baseline studies are necessary in São Tomé and Príncipe, as well as integrated research and conservation effort for the Gulf of Guinea humpback whales.

Acknowledgements — We thank Francisco Reiner for initiating of this study. We also thank the following people and institutions: the President Fradique de Menezes and the Government of São Tomé and Príncipe, especially the environmental director, Dr Arlindo Carvalho, for permission to conduct this study, the Portuguese Embassy in São Tomé and Príncipe for logistical support, Tim Collins from Wildlife Conservation Society, and Jan Hartman and Henrique Costa from Eco São Tomé for all the help and contacts, Peter Ersts for helping with the maps, Herbert Maia, Cristina Picanço, Maria Pimentel, Carlos Carvalho, João Mendes and Edmilson for their valuable help in the field, Norberto Vidal and Jean Louis Testorini for information regarding the humpback sightings, to Projecto Delfim and Rolas Island Resort for logistical and financial support in 2002 and 2003. The 2004 and 2005 field seasons were funded by the ECOFAC (Conservation et utilisation rationnelle des Ecosystèmes Forestiers en Afrique Centrale), project *Espèces Phares* and Paulo Pimentel, the 2006 field season was funded by Wildlife Conservation Society. IC's doctoral grant was funded by the Portuguese Foundation for Science and Technology (Fundação para a Ciência e Tecnologia; SFRH/BD/18049/2004).

References

- Aguilar A. 1985. Aboriginal whaling off Pagalu (Equatorial Guinea) *Reports to the International Whaling Commission* 35: 385–386.
- Baker CS, Herman LM. 1984. Aggressive behavior between humpback whales (*Megaptera novaeangliae*) wintering in Hawaiian waters. *Canadian Journal of Zoology* 64: 1922–1937.
- Baker CS, Medrano-Gonzalez L, Calambokidis J, Perry A, Pichler F, Rosenbaum HC, Straley JM, Urban-Ramirez J, Yamaguchi, M, Von Ziegeler O. 1998. Population structure of nuclear and mitochondrial DNA variation among humpback whales in the North Pacific. *Molecular Ecology* 7: 695–707.
- Barendse J, Best P, Thornton M, Pomilla C, Carvalho I, Rosenbaum

- HC. 2010. Migration redefined? Seasonality, movements, and group composition of humpback whales *Megaptera novaeangliae* off the west coast of South Africa. *African Journal of Marine Science* 32: 1–22.
- Best PB, Findlay KP, Sekiguchi K, Peddemors VM, Rakotonirina B, Roussouw A, Gove D. 1998. Winter distribution and possible migration routes of humpback whales *Megaptera novaeangliae* on the west coast of South Africa. *Marine Ecology Progress Series* 118: 1–12.
- Best PB, Reeb D, Morais M, Baird A. 1999. A preliminary investigation of humpback whales off northern Angola. Document SC/51/CAWS33 presented to the Scientific Committee of the International Whaling Commission, Grenada, 24–28 May 1999.
- Blackmer AL, Anderson SK, Weinrich, MT. 2000. Temporal variability in features used to photo-identify humpback whales (*Megaptera novaeangliae*). *Marine Mammal Science* 16: 338–354.
- Budker P. 1953. Les campagnes baleinières 1949–1952 au Gabon (Note préliminaire). *Mammalia* 17: 129–148 (translated from French).
- Budker P, Roux C. 1968. The 1959 summer whaling season at Cape Lopez (Gabon). *Norsk Hvalfangst-tidende* 6: 141–145.
- Calambokidis J, Steiger GH, Straley JM, Herman LM, Cerchio S, Salden DR, Urban J, Jacobsen JK, von Ziegesar O, Balcomb KC, Gabriele CM, Dahlheim ME, Uchida S, Ellis G, Miyamura Y, de Guevara PL, Yamaguchi M, Sato F, Mizroch SA, Schlender L, Rasmussen K, Barlow J, Quinn TJ. 2001. Movements and population structure of humpback whales in the North Pacific. *Marine Mammal Science* 17: 769–794.
- Clapham PJ, Palsbøll PJ, Mattila DK, Vasquez O. 1992. Composition and dynamics of humpback whales competitive groups in the West Indies. *Behaviour* 122: 182–194.
- Collins T, Cerchio S, Pomilla C, Loo J, Carvalho I, Nguesso S, Rosenbaum HC. 2008. Revised estimates of abundance for humpback whale breeding stock B1: Gabon. Document SC/60/SH28 presented to the Scientific Committee of the International Whaling Commission, held at Santiago, Chile.
- Constantine R, Russell K, Gibbs N, Childerhouse S, Baker CS. 2007. Photo-identification of humpback whales (*Megaptera novaeangliae*) in New Zealand waters and their migratory connections to breeding grounds of Oceania. *Marine Mammal Science* 23: 715–720.
- Dawbin WH. 1966. The seasonal migratory cycle of humpback whales. In: KS Norris (eds), *Whales, dolphins, and porpoises*. California: University of California Press. pp 145–170.
- Donovan GP. 1991. A review of IWC stock boundaries. *Reports to the International Whaling Commission* (Special Issue) 13: 39–68.
- Engel MH, Fagundes NJR, Rosenbaum HC, Leslie MS, Ott PH, Schmitt R, Secchi E, Dalla Rosa L, Bonatto SL. 2008. Mitochondrial DNA diversity of the Southwestern Atlantic humpback whale (*Megaptera novaeangliae*) breeding area off Brazil, and the potential connections to Antarctic feeding areas. *Conservation Genetics* 9: 1253–1262.
- Ersts PJ, Kiszka J, Vély M, Rosenbaum HC. In press. Density, group composition, and encounter rates of humpback whales (*Megaptera novaeangliae*) on three banks in the north-eastern Mozambique Channel. *Journal of Cetacean Research and Management* (Special Issue).
- Ersts PJ, Rosenbaum HC. 2003. Habitat preference reflects social organization of humpback whales (*Megaptera novaeangliae*) on a wintering ground. *Journal of Zoology* 260: 337–345.
- Flórez-González L, Capella J, Rosenbaum HC. 1994. Attack of killer whales (*Orcinus orca*) on humpback whales (*Megaptera novaeangliae*) on a South American Pacific breeding ground. *Marine Mammal Science* 10: 218–222.
- Garrigue C, Greaves J, Chambellant M. 2001. Characteristics of the New Caledonian humpback whales population. *Memoirs of the Queensland Museum* 47: 539–546.
- Glockner-Ferrari DA, Ferrari MJ. 1990. Reproduction in the humpback whales (*Megaptera novaeangliae*) in Hawaiian waters, 1975–1988: the life history, reproductive rates and behaviour of known individuals identified through surface and underwater photography. *Reports to the International Whaling Commission* (Special Issue) 12: 161–169.
- Herman LM, Antinaja RC. 1977. Humpback whales in the Hawaiian breeding waters: population and pod characteristics. *Scientific Reports of the Whales Research Institute* 29: 59–85.
- IWC (International Whaling Commission). 2001. Report of the Scientific Committee. *Journal of Cetacean Research and Management* 3: 26–27.
- IWC (International Whaling Commission). 2006. Report of the workshop on the comprehensive assessment of Southern Hemisphere humpback whales. Document SC/58/Rep5 presented to the International Whaling Commission, June 2006, St Kitts and Nevis, West Indies.
- Katona SK, Whitehead, HP. 1981. Identifying humpback whale using their natural markings. *Polar Research* 20: 439–444.
- Kiszka J, Vély M, Breyse O. 2010. Preliminary account of cetacean diversity and humpback whale (*Megaptera novaeangliae*) group characteristics around the Union of the Comoros (Mozambique Channel). *Mammalia* 74: 51–56.
- Lee DC, Halliday A, Fitton J, Poli G. 1994. Isotopic variations with distance and time in the volcanic islands of the Cameroon line: evidence for a mantle plume origin. *Earth Planetary Science Letters* 123: 119–138.
- Mackintosh NA. 1942. The southern stocks of whalebone whales. *Discovery Reports* 22: 197–300.
- Martins CCA, Morete ME, Engel MH, Freitas AC, Secchi ER, Kinas PG. 2001. Aspects of habitat use patterns of humpback whales in the Abrolhos Bank, Brazil, breeding ground. *Memoirs of the Queensland Museum* 47: 563–570.
- Mobley JR, Herman LM. 1985. Transience of social affiliations among humpback whales (*Megaptera novaeangliae*) on Hawaiian wintering waters. *Canadian Journal of Zoology* 63: 762–772.
- Morete ME, Bisi TL, Rosso S. 2007. Temporal pattern of humpback whale (*Megaptera novaeangliae*) group structure around Abrolhos Archipelago breeding region, Bahia, Brazil. *Journal of the Marine Biological Association of the United Kingdom* 87: 87–92.
- Picanço C, Carvalho I, Brito C. 2009. Occurrence and distribution of cetaceans in São Tomé and Príncipe tropical archipelago and their relation to environmental variables. *Journal of the Marine Biological Association of the United Kingdom* 89: 1071–1076.
- Pomilla C, Best P, Findlay K, Collins T, Engel MH, Minton G, Ersts P, Barendse J, Kotze PGH, Razafindrakoto Y, Nguesso S, Meyer M, Thornton M, Rosenbaum HC. 2006. Population structure and sex-biased gene flow in humpback whales from wintering regions A, B, C and X based on nuclear microsatellite variation. Document SC/A06/HW38 presented to the Scientific Committee of the International Whaling Commission, June 2006, St Kitts and Nevis, West Indies.
- Pomilla C, Rosenbaum HC. 2006. Estimates of relatedness in groups of humpback whales (*Megaptera novaeangliae*) on two wintering grounds of the Southern Hemisphere. *Molecular Ecology* 15: 2541–2555.
- Rosenbaum HC, Collins T. 2006. The ecology, population characteristics and conservation efforts for humpback whales (*Megaptera novaeangliae*) on their wintering grounds in the coastal waters of Gabon. In: Alonso A, Campbell P (eds), *Natural history of the Gamba Complex*. Washington, DC: Smithsonian Press. pp 425–433.
- Rosenbaum HC, Mate B. 2006. From north of the Equator to the Antarctic: unique and unexpected movements for humpbacks whales off the coast of West Africa and throughout the eastern South Atlantic Ocean. Document SC/A06/HW42 presented to the

- International Whaling Commission Scientific Committee, June 2006, St Kitts and Nevis, West Indies.
- Rosenbaum HC, Pomilla CC, Mendez MC, Leslie M, Best P, Findlay K, Minton G, Ersts P, Collins T, Engel M, Bonatto S, Kotze D, Meyer M, Barendse J, Thornton M, Razafindrakoto Y, Nguesso S, Vely M, Kiszka J. 2009. Population structure of humpback whales from their breeding grounds in the South Atlantic and Indian oceans. *PLoS ONE* 4: e7318. doi:10.1371/journal.pone.0007318 [accessed 26 October 2009].
- Scheidat M, Castro C, Denking J, González J, Adelung D. 2000. A breeding area for humpback whales (*Megaptera novaeangliae*) off Ecuador. *Journal Cetacean Research and Management* 2: 165–171.
- Smith TD, Allen J, Clapham PJ, Hammond PS, Katona S, Larsen F, Lien J, Mattila D, Palsboll PJ, Sigurjonsson J, Stevick PT, Oien N. 1999. An ocean-basin-wide mark-recapture study of the North Atlantic humpback whale (*Megaptera novaeangliae*). *Marine Mammal Science* 15: 1–32.
- Smultea M. 1994. Segregation by humpback whale (*Megaptera novaeangliae*) cows with a calf in coastal habitat near the island of Hawaii. *Canadian Journal of Zoology* 72: 805–811.
- Stevick PT, Allen J, Bérubé M, Clapham PJ, Katona SK, Larsen F, Lien J, Mattila DK, Palsbøll PJ, Robbins J, Sigurjonsson J, Smith TD, Øien N, Hammond PS. 2003. Segregation of migration by feeding ground origin in North Atlantic humpback whales (*Megaptera novaeangliae*). *Journal of Zoology, London* 259: 231–237.
- Townsend CH. 1935. The distribution of certain whales as shown by logbook records of American whale ships. *Zoologica* 19: 1–50.
- Tyack PL, Whitehead H. 1983. Male competition in large groups of wintering humpback whales. *Behaviour* 83: 132–154.
- Van Waerebeek K, Ofori-Danson PK, Debrah J. 2009. The cetaceans of Ghana, a validated faunal checklist. *West African Journal of Applied Ecology* 15. Available at http://www.wajae.org/papers/papers_vol15/the_cetaceans_of_ghana_full.pdf [accessed 10 March 2010].
- Van Waerebeek K, Tchibozo S, Montcho J, Nobime G, Sohouhou P, Dossou C. 2001. The Bight of Benin, a North Atlantic breeding ground of a Southern Hemisphere humpback whale population, likely related to Gabon and Angola substocks. Document SC/53/IA21 presented to the International Whaling Commission Scientific Committee, July 2001, London.
- Walsh PD, Fay JM, Gulick S, Sounguet GP. 2000. Humpback whale activity near Cap Lopez, Gabon. *Journal Cetacean Research and Management* 2: 63–68.
- Weir CR. 2007. Occurrence and distribution of cetaceans off northern Angola, 2004–2005. *Journal of Cetacean Research and Management* 9: 225–239.
- Weir CR, Collins T, Carvalho I, Rosenbaum HC. 2010. Killer whales (*Orcinus orca*) in Angolan and Gulf of Guinea waters, tropical West Africa. *Journal of the Marine Biological Association of the United Kingdom* 90: 1601–1611.
- Whitehead H, Moore MJ. 1982. Distribution and movements of West Indian humpback whales in winter. *Canadian Journal of Zoology* 60: 2203–2211.