

# Occurrence and distribution of humpback whales (*Megaptera novaeangliae*) on the north coast of the State of Bahia, Brazil, 2000–2006

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The Abrolhos Bank off Brazil is considered the main breeding ground for the humpback whale (*Megaptera novaeangliae*) in the Southwest Atlantic. However, owing to an increase in the occurrence of the species along the north coast of the State of Bahia, it has been suggested that the species is reoccupying that region, which was probably utilized by the whales before commercial whaling. Information is presented on the occurrence and distribution of humpback whales along the north coast of the State of Bahia, with a comparative overview, for the period 2000–2006. Daily research cruises were conducted from July to October, departing from Praia do Forte (13°40'S 38°10'W) and lasting ~9 h. Data on sampling and sighting effort, and geographical position and composition of groups of humpback whales, were collected on standardized field sheets. In all, 230 surveys were performed, covering some 9740 nautical miles in 1645 h of sampling effort, during which 1626 humpback whales were sighted, including 118 calves. Humpback whales were sighted throughout the study area. Solitary individuals and pairs were the most frequent group composition, 26% and 37% of the observed groups ( $n = 723$ ), respectively. Depth of water varied from 15 to 1657 m (mean = 62.4; s.d. = 99). The sightings values were grouped into depth classes to ascertain the highest frequencies (~30%) for the two classes, i.e. between 35.1 and 55 m of water. There was an increase in the encounter rates of humpback whales on the north coast of the State of Bahia between 2000 and 2006, identifying a difference in SPUE [sightings per unit (h) of effort] among years (Kruskal–Wallis  $H = 30.155$ , d.f. = 6,  $p < 0.05$ ). The results support the hypothesis that humpback whales are reoccupying former breeding areas along the Brazilian coast.

**Keywords:** Brazil, distribution, humpback whale, *Megaptera novaeangliae*, State of Bahia.

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## Introduction

Humpback whales (*Megaptera novaeangliae*), are among the most endangered cetacean species in the world (Reeves *et al.*, 2003), mainly because of extensive whaling in the last century (Headland, 1984). On the Brazilian coast, particularly in the northeast, the species was heavily exploited commercially from colonial times (Tavares, 1916; Tollenare, 1961).

Despite there being very little detailed information on past whaling activities, we know that whaling was started by Biscay whalers in 1602, in the State of Bahia, the first Brazilian capital (Ellis, 1958; Lodi, 1992). Reports from the 19th century state that the whales were abundant (Tavares, 1916; Tollenare, 1961) and the country was even considered as the biggest producer of whale products in the world, up to four whales per day being taken (Viana, 1951; Ellis, 1958). For the 20th century, there are some data from 1913, when some 352 humpback whales were caught (Williamson, 1975) and the last known report for the area is of around 13 whales captured in 1967 (Paiva and

Grangeiro, 1970). The massive reduction in local stocks of humpback whales was verified through the difference in annual mean catch between the periods 1910–1914 (222.6 whales per year) and 1960–1963 (9.8 whales per year). At least 1539 whales were captured off northeastern Brazil between 1911 and 1967 (Paiva and Grangeiro, 1965, 1970).

Humpback whale sightings started again near the Abrolhos Bank (17°20'–18°10'S 38°35'–39°20'W) in 1988, when a Marine National Park was established, and when a long-term research programme for the species commenced (IBAMA/NEMA, 1990). Since then, the Abrolhos Bank has been considered to be the main breeding ground for the species in the Southwest Atlantic (Engel, 1996; Martins *et al.*, 2001; Andriolo *et al.*, 2006a, b), and the population that visits the area was labelled by the International Whaling Commission (IWC, 1998) Breeding Stock A (BSA). In fact, Caravelas, the main coastal town near the Abrolhos Bank, was once one of the largest whaling centres in Brazil, six landing stations operating there from 1847

to 1924, processing humpbacks on the shore (Paiva, 1965; Lodi, 1992).

According to recent population estimates (Kinas and Bethlem, 1998; Freitas *et al.*, 2004; Andriolo *et al.*, 2006a, b), the size of the humpback whale population in Brazilian waters has been increasing since commercial whaling was banned. Consequently, sightings of these animals are becoming more frequent along the northeastern Brazilian coast, including in coastal bays such as Baía de Todos os Santos (13°00'S 38°35'W), State of Bahia, where the whales were abundant before whaling activities (Tavares, 1916; Tollenare, 1961).

Because of an increase in humpback whale sightings along the north coast of the State of Bahia, ~500 km north of the Abrolhos Bank, the Instituto Baleia Jubarte (Humpback Whale Institute) established a research station at Praia do Forte, 55 km north of the state capital, Salvador, in 2000. Some preliminary data (Más-Rosa *et al.*, 2002; Baracho *et al.*, 2006; Rossi-Santos *et al.*, 2006a) suggest that the species is reoccupying the region, a likely former breeding ground that was used by humpback whales before whaling started. This reoccupation hypothesis for BSA humpbacks has been addressed briefly by other authors (Andriolo *et al.*, 2006a; Ward *et al.*, 2006; Zerbini *et al.*, 2006).

Here, we aim to re-address this reoccupation hypothesis, presenting data on occurrence, distribution, and social structure of the humpback whales visiting the north coast of the State of Bahia, with a comparative overview of data from 2000 to 2006.

## Material and methods

### Study area

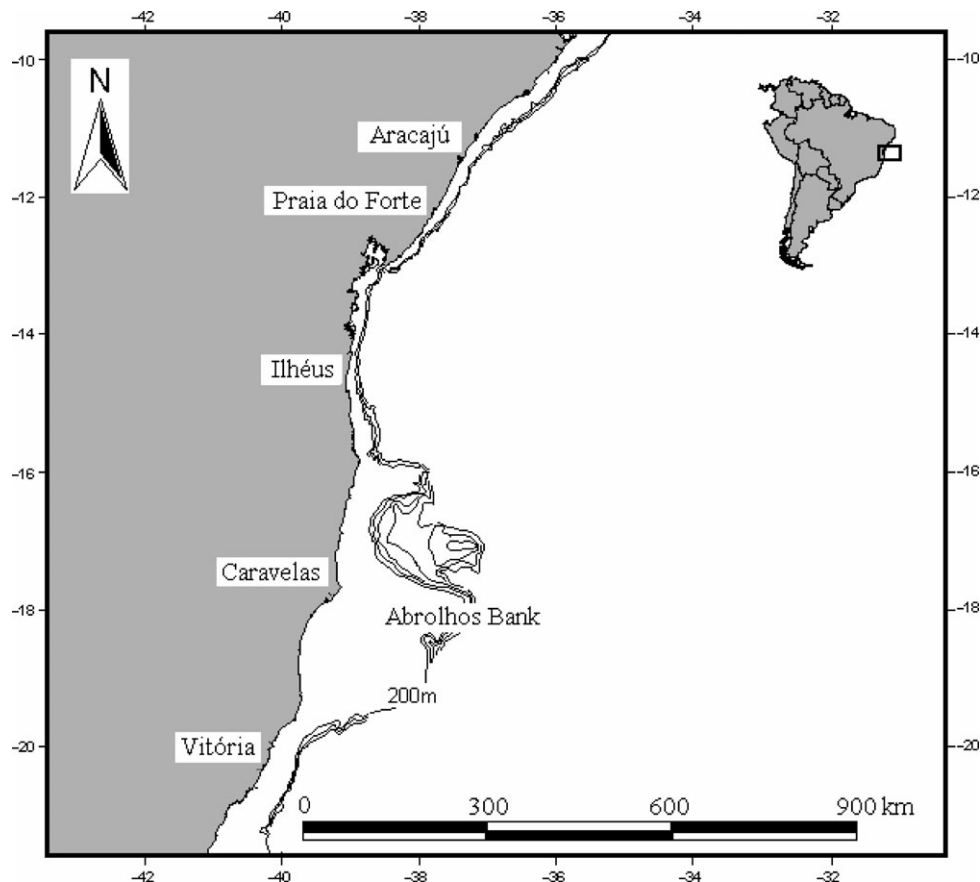
The study area is shown in Figure 1. Its main characteristic is the presence of a narrow continental shelf of just ~15 km. The mean depth of the shelf is 50 m, and the tidal amplitude varies between 0.1 and 2.6 m (DHN, 1995).

The stretch of coast is characterized by sandy beaches, with some rocky substrata in the river mouths, and coral reefs close to the shore, up to 12 km from the beach (Marcovaldi and Laurent, 1996). The coast from Salvador to Ilhéus also has large bays, estuaries, and mangrove systems, as well as two large bays (Baía de Todos os Santos and Baía de Camamú; Herz, 1991).

As already stated, Praia do Forte is 55 km north of the state capital, Salvador. The area sampled between 2000 and 2006 covered around 370 km of coast, from the northern state limit at Subaúma (12°23'S 37°77'W) to the southern limit at Ilhéus (14°31'S 38°93'W).

### Field procedures

Daily research trips were conducted from July to October, the breeding season of humpback whales in the southern hemisphere, on an 18 m schooner powered by a 250-hp diesel. All research trips were in favourable weather and sea conditions (up to Beaufort 5), with a mean duration of 9 h. Most of the cruises departed from Praia do Forte (13°41'S 38°10'W). Attempts were made in all seasons to cover areas north and south of Praia do Forte during



**Figure 1.** Study area during the breeding season (July–October) of humpback whales (*Megaptera novaeangliae*), 2000–2006.

**Table 1.** Data collected [nautical miles covered, effort, observation time (h), number of individuals, calves, whale sightings per hour, and calves per total whales sighted], 2000–2006, on the north coast of the State of Bahia, Brazil.

Parameter	2000	2001	2002	2003	2004	2005	2006
Crz (sampled days)	20	27	33	33	36	44	37
Miles covered	904.5	971.6	1 397.8	1 458.4	1 527.1	1 812.3	1 667.3
Effort (h)	145.5	209	245.2	240.1	259.4	278.4	266.6
Observation time (h)	35.4	47.4	63.5	96.4	91.2	87.6	109.4
Humpback whales sighted	104	147	170	325	303	260	317
Number of calves	4	13	12	17	19	20	33
Number of whales per hour	0.71	0.70	0.69	1.35	1.17	0.93	1.19
Number of calves per total number of whales	0.04	0.09	0.07	0.05	0.06	0.08	0.1
Number of whales per nautical mile	0.11	0.15	0.12	0.22	0.20	0.14	0.19

longer research cruises of 4–5 days, to minimize sampling bias. The daily surveys around Praia do Forte also varied the route, sometimes sailing north and sometimes south.

In the initial phase of this research (2000–2003), data were collected utilizing platforms of opportunity, such as fishing and tourist boats, resulting in haphazard sampling (though see Rossi-Santos *et al.*, 2006b), so accounting for the lack of track lines for that period. Thereafter, though, the research was more systematic.

On-board observers, sited at the bow, scanned the horizon, covering a 180° visual field angle, generally without binoculars (which were used only to confirm eventual sightings), searching for any surface evidence of the presence of a whale, such as blows, back exposure, or breaches (Engel, 1996). Data such as sampling and observation effort, geographic positioning, composition and behaviour of humpback whale groups, and environmental parameters (wind direction and speed, visibility, Beaufort Sea state, depth) were collected while observing on standardized field sheets.

Sampling effort was considered as the time between departure from port and halting of sampling effort (usually arrival back at port). Direct observation time was the time spent with a group of whales, from the moment it was first sighted and approached, to the moment of leaving it (~30 min, as determined by our field protocol; see Martins *et al.*, 2001; Engel, 2003; Simões, 2005). To analyse encounter rate, we utilized the sampling effort, taking into consideration the equivalent time spent with each group so that our results were not biased. To verify the significance of differences in encounter rate between years, we utilized a Kruskal–Wallis (5%) non-parametric test.

Whales were approached gradually, generally from the side and to no closer than 50 m with the engine on, to collect photo-identification and genetic data (IWC, 1990, 1991). Behavioural definition and group composition followed Engel (1996) and Clapham (2000). The behavioural sampling followed the *ad libitum* method (Lehner, 1996). Geographic information was analysed using Arcview 3.2 (ESRI, Headland, CA, USA).

To supplement the information gathered on population dynamics, and to compare the number of calves with the encounter rates, we analysed the raw birth rate (RBR), defined as  $T_c/T_i$ , where  $T_c$  is the total number of calves observed in a year, and  $T_i$  the total number of individuals sighted during a year/season (Clapham and Mayo, 1987).

## Results

During seven seasons (2000–2006), 230 sighting trips were carried out, covering some 9740 nautical miles in 1645 h of effort, and 1626 humpback whales were sighted, including 118 calves (Table 1). Humpback whales were sighted throughout the study area, with some hotspots close to Praia do Forte, Salvador, and Itacaré, a consequence of the departure from and entrance to harbours of the research cruises (Figure 2). Solitary individuals and pairs were the most frequent group composition registered, 26% and 37% of the observed groups, respectively ( $n = 723$ ; Figure 3).

Bathymetry data registered varied from 15 to 1657 m (mean 62.4; s.d. 99 m). Grouping the values into depth classes helped identify higher frequencies (~30%) for two classes between 35.1 and 55 m (Figure 4). Despite humpback whales being sighted shallower than 200 m, there were no high frequencies.

Data on sightings per unit effort (SPUE) showed preferential habitat use during different months of each year by adults without calves in July, competitive groups in August, and adults with calves in September (Figure 5).

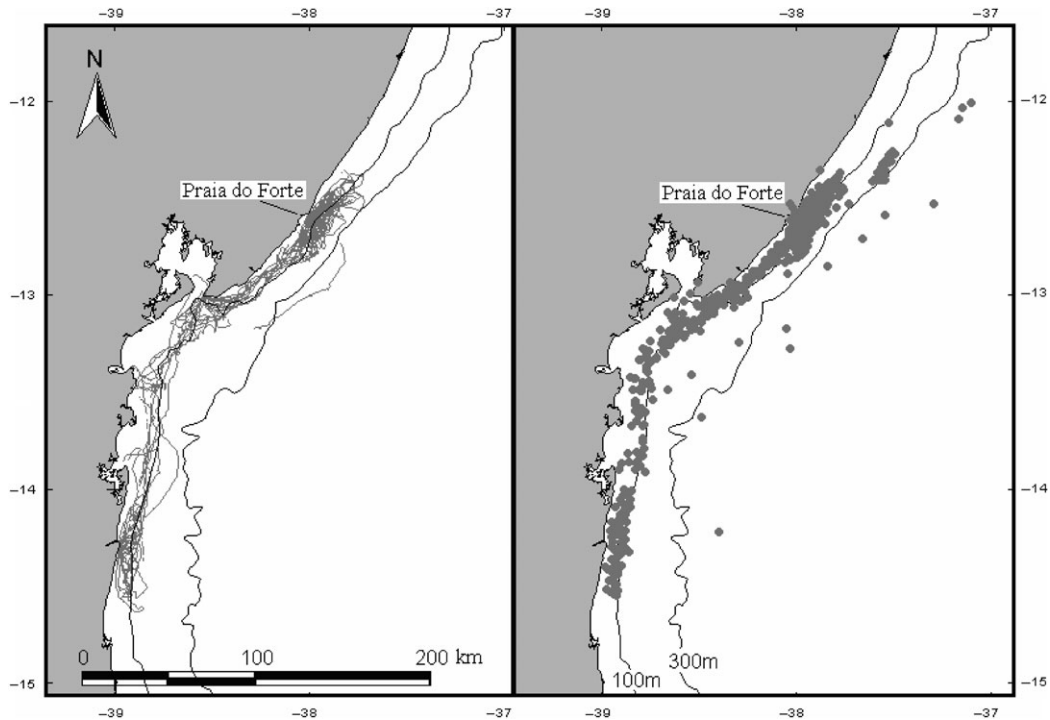
## Encounter rates

Analysing the encounter rates per year revealed a gradual increase in the number of humpback whales along the north coast of the State of Bahia (Figure 6). The Kruskal–Wallis test showed significance between years ( $H = 30.155$ , d.f. = 6,  $p < 0.05$ ). The RBRs registered between 2000 and 2006 showed variation in the numbers of calves, with peaks in 2001 and 2006 (Figure 7).

## Discussion

Our dataset demonstrates that humpback whales are widely distributed along the shore of the State of Bahia, not only at the Abrolhos Bank. The distribution probably represents an expanding area required by an increasing population since whaling ended, and it is supported, in our data, by an increasing number of sightings through the years (Figure 6).

Utilizing aerial surveys to produce population estimates of humpback whales in Brazil, Andriolo *et al.* (2006a) sampled from the northern limit of the State of Bahia (12°10'S) to the southern limit of the State of Espírito Santo (20°42'S) from 2002 to 2004, expanding this area in 2005 to 5–25°S. Their results showed that the Abrolhos Bank is still the main breeding ground of the species in the Southwest Atlantic (Engel, 1996;

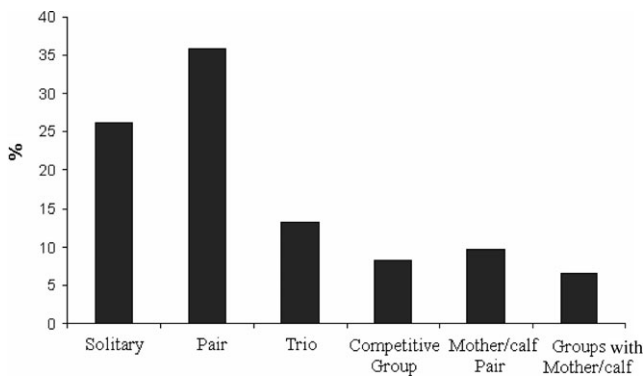


**Figure 2.** Sightings of humpback whales (*Megaptera novaeangliae*) on the north coast of the State of Bahia, Brazil, 2000–2006. Left panel, survey tracks; right panel, sightings.

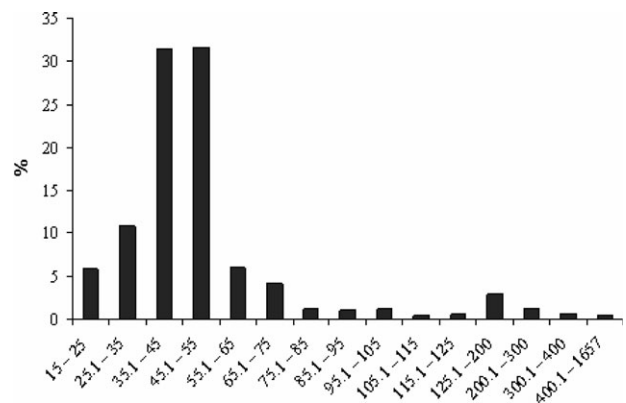
Martins *et al.*, 2001). However, humpback whales were sighted from Rio de Janeiro to Rio Grande do Norte, the entire area surveyed (Andriolo *et al.*, 2006a). In their results, though, there are more sightings along the north coast of the State of Bahia than off all other northern states of Brazil.

Zerbini *et al.* (2006) performed an extensive data revision for BSA humpback whales sighted in feeding and breeding areas, and ran a Bayesian assessment of the stock today, concluding that these whales have now approached their carrying capacity before modern whaling. They estimate that the population was depleted to <5% of its pre-exploitation size by the late 1950s and that the current abundance is 6000–8000 whales in the Southwest Atlantic.

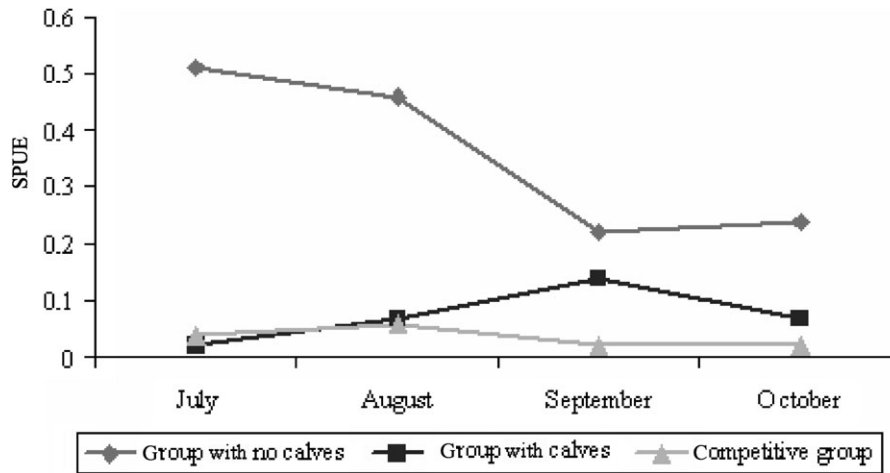
Nevertheless, it is of value to speculate on alternative explanations for the reoccupation hypothesis. A possible explanation would be the abandonment of other areas through human disturbance; certainly the core breeding ground, the Abrolhos Bank, is less densely populated and less disturbed by humans than the north shore, where the State capital is sited along with the largest ports. Moreover, the influence of climate change (see Simmonds and Isaac, 2007) and/or overall population increase associated with large-scale shifts of animals in the feeding areas could trigger this expansion of the BSA, one of the less researched stocks of humpback whales. Future studies in the feeding areas could corroborate or contradict our hypothesis of reoccupation as a consequence of population increase.



**Figure 3.** Frequency of group composition categories (adults without calves, adults with calves, and competitive group) of humpback whales (*Megaptera novaeangliae*), observed on the north coast of the State of Bahia, 2000–2006.



**Figure 4.** Frequency of depth classes for sightings of humpback whales (*Megaptera novaeangliae*), registered on the north coast of the State of Bahia, 2000–2006.

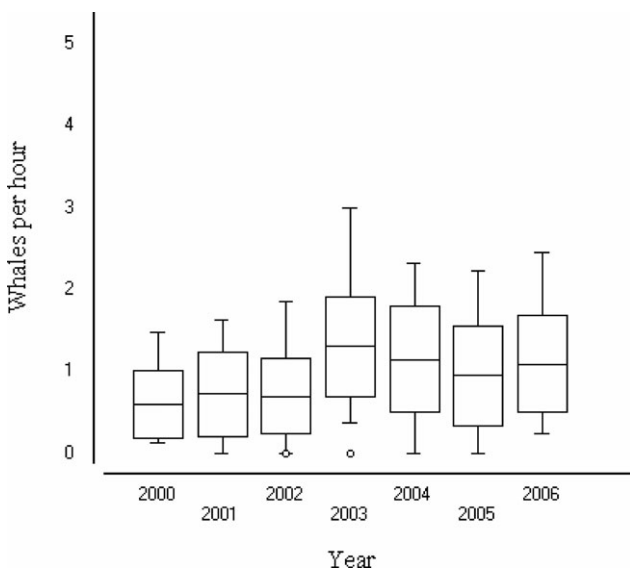


**Figure 5.** SPUE for group composition (adults without calves, adults with calves, and competitive groups) of humpback whales (*Megaptera novaeangliae*), observed from July to October, 2000–2006.

**Social structure**

Solitary individuals and pairs were the most frequent sightings, similar to results observed for the Abrolhos Bank by Martins *et al.* (2001), Simões (2005), and Morete *et al.* (2007), and for Brazil’s northeast coast by Zerbini *et al.* (2004). Clearly such structure is a typical social characterization of humpback whale breeding grounds.

The dynamics of habitat use by different group compositions during the breeding season are well known and documented (Chittleborough, 1965; Dawbin, 1966; Clapham *et al.*, 1992; Craig and Herman, 1997; Clapham, 2000; Martins *et al.*, 2001; Morete *et al.*, 2007), following migration patterns in which the solitary animals are the first to be sighted, followed by pairs, then competitive groups in mid-season, and mothers with calves last of all. Our sightings followed the same pattern.



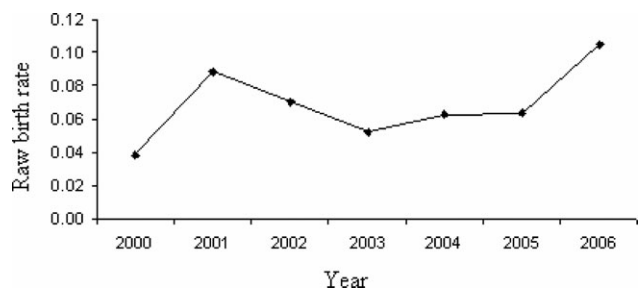
**Figure 6.** SPUE of humpback whales (*Megaptera novaeangliae*) between 2000 and 2006 on the north coast of the State of Bahia, northeastern Brazil.

**Comparative analysis**

Comparing data from 2000 to 2006, we registered annual variation in the total number of whales and calves each year. Our knowledge of habitat use and behaviour in these new poorly studied areas is still limited, but our results bring to bear important insights on the process of reoccupation by the whales of their former breeding grounds along the Brazilian coast. Encounter rates, represented by SPUE data, show that the number of whale sightings is increasing year on year, indicating reoccupation by the whales of a greater area as the population recovers from commercial whaling (Andriolo *et al.*, 2006a; Morete, 2007).

Humpback whales concentrate in shallow water (<50 m), so the narrow continental shelf of Brazil’s north coast may act to attract the whales to the coast in this area. The presence of humpback whales on the north coast of the State of Bahia, Brazil, and their presence elsewhere in major wintering areas with similar topography and bathymetry is a characteristic of calving and mating areas of the species (Whitehead and Moore, 1982; Mattila and Clapham, 1989; Mattila *et al.*, 1994; Silva *et al.*, 2006).

Peaks in calf sightings in our study area were irregular, perhaps representing different habitat use than at the main reproductive site, the Abrolhos Bank, where calf numbers peak biennially (Morete, 2007). This suggests that the north coast of the State of Bahia may be being utilized by passing whales, possibly representing an expansion of area parallel to the increasing “resident”



**Figure 7.** RBR (the total number of calves observed in a year per total individuals sighted during 1 year or season) of humpback whales (*Megaptera novaeangliae*) observed on the north coast of the State of Bahia, 2000–2006.

population numbers (Townsend *et al.*, 2003). Moreover, the more erratic peaks in calf numbers on the north coast of the State of Bahia might indicate yet another core area for females with calves, with other animals moving faster past our study area. Recent reports from fishers and on-board researchers on the large number of humpback whales to the north of the State of Bahia (Zerbini *et al.*, 2004) corroborate this hypothesis.

Previous studies of humpback whales in the northern Caribbean wintering ground have documented the importance of calm water for calving whales (Whitehead and Moore, 1982; Mattila and Clapham, 1989; Mattila *et al.*, 1994; Mignucci-Giannoni, 1998). For the Abrolhos Bank, Martins *et al.* (2001) analysed the distribution of females with calves, suggesting warm, shallow water as an attractive environment for parental care, including suckling of calves. In contrast, our study area is not so well protected and is less calm than some of the other breeding grounds, suggesting depth rather than protection from storms as the key factor influencing the distribution of humpback whales.

Concluding, we have presented information showing that humpback whales are becoming more common along the north coast of the State of Bahia, Brazil, with a distribution pattern similar to that in the core area, Abrolhos Bank, as well as at other breeding grounds worldwide. This recent extension, or reoccupation of the reproductive area, corroborated by the burgeoning abundance of humpback whales along the Brazilian coast (Zerbini *et al.*, 2004, 2006; Andriolo *et al.*, 2006a, b; Ward *et al.*, 2006), especially along the coast of the State of Bahia, our study area, may be indicative of the success of conservation measures. This statement is particularly pertinent given the fact that the area is the main urban centre of the State and one of the largest in north-eastern Brazil.

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