J. Mar. Biol. Ass. U.K. (2007), **87**, 207–212
Printed in the United Kingdom
doi: 10.1017/S0025315407055683

Residence and site fidelity of *Sotalia guianensis* in the Caravelas River Estuary, eastern Brazil

Marcos R. Rossi-Santos*†ʃ, Leonardo L. Wedekin*† and Emygdio L.A. Monteiro-Filho†‡

*Instituto Baleia Jubarte, Rua Barão do Rio Branco, 26, Caravelas-Bahia, Brazil, 45900-000. †Pós-Graduação em Zoologia, Universidade Federal do Paraná, Centro Politécnico, Curitiba–Paraná, Brazil. ‡Instituto de Pesquisas Cananéia, Rua Tristão Lobo, 199. Centro, Cananéia–São Paulo, Brazil, CEP: 11990-000. ʃCorresponding author, e-mail: marcos.rossi@baleiajubarte.com.br

Between April 2002 and April 2005, 210 estuarine dolphin groups were sighted, with 58 animals individually identified. Fifteen dolphins were photo-identified just once, while only two animals were sighted in 15 different months. Some individuals showed long-term residence (more than 3 y). Residence rates showed heterogeneity in the dolphin's permanence of the estuary, with 60% of the individuals with low numbers (<10) and only 7% showing high values for residence (maximum=45.9). Continued resightings of some dolphins support the regular use of the study area by the animals, despite some individuals that, after a long time without resightings were registered again. Individual range analysis showed that dolphins shared the same common area, the Caravelas River Estuary. A marked fluctuation in the number of photo-identified dolphins was observed in the study area, revealed by the high number of individuals with just a few resightings. The majority of the dolphins (60%) present a yearly residence pattern, as observed in other areas, suggesting that a few individuals show high fidelity for the area, while many other dolphins move constantly between different areas for unknown reasons.

INTRODUCTION

The term 'residence' may be interpreted as the time spent by an animal in a certain geographical area (Wells & Scott, 1990; Wells, 1991); however, the term has been employed by researchers in different ways according to the parameters used to measure the residence of individually identified dolphins (Wells & Scott, 1990; Ballance, 1992; Simões-Lopes & Fabián, 1999; Hardt, 2005). Site fidelity is defined as the tendency of an animal to occupy an area or to return to a previously occupied area over some period of time (White & Garrot, 1990).

The estuarine dolphin (*Sotalia guianensis*) was recently separated from the tucuxi dolphin (*Sotalia fluviatilis*) based on cranial characteristics (Monteiro-Filho et al., 2002) and genetic divergence (Cunha et al., 2005; Caballero et al., in press). The species inhabits coastal and shallow waters of South and Central America, from southern Brazil to Honduras (Silva & Best, 1996). Along its coastal habitats, the species is subject to a variety of human activities that threaten its conservation, such as fishing operations, boat traffic and habitat destruction (Reeves et al., 2003; Lodi, 2003). According to the IUCN, however, the species is classified as Data Deficient (Reeves et al., 2003) which reinforces the importance of conducting long-term studies about their ecology, such as residence patterns.

In the Caravelas River Estuary, *S. guianensis* has been studied since 2002 by the Humpback Whale Institute, that develops research and conservation activities in the region. It has been demonstrated that estuarine dolphins are present all year round, in mean groups of 3–4 individuals, mainly engaged in foraging behaviour in the river mouth of the estuary (Rossi-Santos et al., 2003; Rossi-Santos, 2006).

Some studies used photo-identification to study diverse aspects of the biology of *S. guianensis*, such as abundance (Pizzorno, 1999), residence and site fidelity (Flores, 1999; Link, 2000; Simão et al., 2000; Santos et al., 2001; Hardt, 2005), individual home-range (Flores & Bazzalo, 2004; Hardt, 2005), population structure (De Oliveira, 2006), individual behaviour (De Jesus, 2004), and others.

The majority of these studies were concentrated in the southern and south-eastern Brazilian coast, with few studies developed in the eastern and north-eastern coast of Brazil. The few exceptions include the studies developed at Pipa Beach, Rio Grande do Norte State, where at least 34 estuarine dolphins were identified (Link, 2000; De Jesus, 2004).

The present study aims to describe residence and site fidelity patterns of individually-identified estuarine dolphins in the Caravelas River Estuary and adjacent waters, eastern coast of Brazil.

MATERIALS AND METHODS

Study area

The study area included the Caravelas River Estuary (17°30'S–39°30'W) (Figure 1) and the coastal adjacent areas which are influenced by an estuarine-mangrove system, the second largest of the north-eastern coast of Brazil (Herz, 1991). This area is an extension of the Brazilian continental shelf, presenting warm and shallow waters, where a great

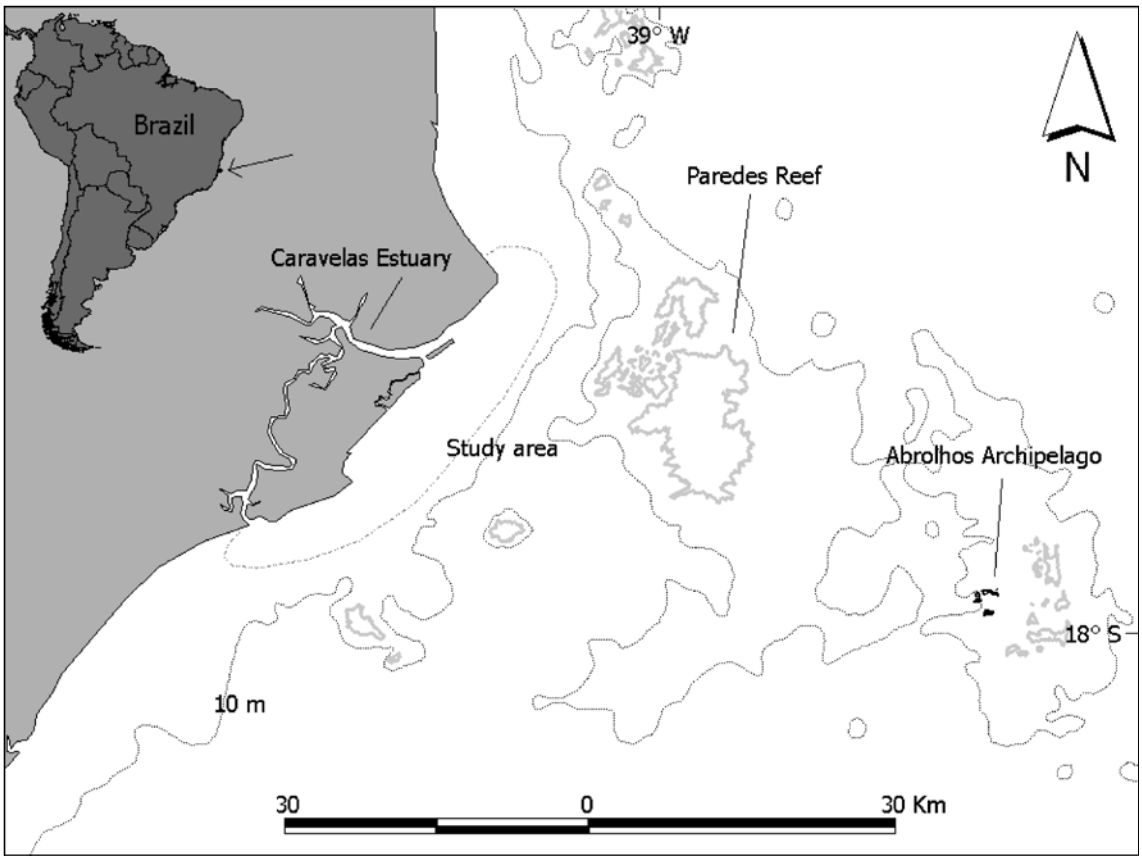

Figure 1. Study area map, located at Abrolhos Bank, eastern Brazilian coast.

number of coral reefs can be found, including the largest coral reef barrier of the southern Atlantic Ocean, the Paredes Reef, less than 15 km off the Caravelas River mouth (Leão, 1994). For further information about our study area, see Rossi-Santos & Wedekin (2006).

Data collection

Field surveys were conducted using a five-metre inflatable boat with a 50 hp outboard four-stroke engine. Occasionally we also utilized a five-metre wooden boat, with diesel engine.

Data were collected over 37 months (from April 2002 to April 2005). Field surveys were conducted in an average of 7 days per month. From April 2002 to July 2004 photographs were taken using a reflex camera Nikon N-90, equipped with Nikkor 300 (ft 4.0) and 75–300 (ft 5.6) lenses. The following films were used: Kodak TMAX 400, Fujichrome 100, 200, 400 and Superia 200, 400. From August 2004 we switched to a Nikon D-70 digital camera and the same lenses. The first picture of each film was identified with the film sequential number and date. Focal-group sampling (cf.

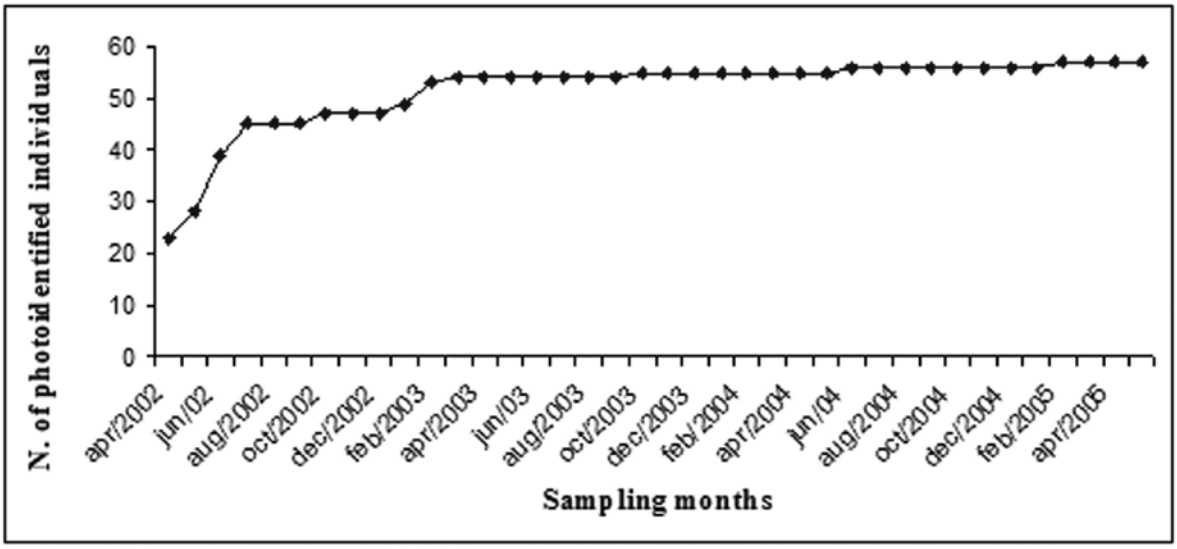

Figure 2. Cumulative curve of *Sotalia guianensis* identified between 2002 and 2005 in the Caravelas River Estuary.

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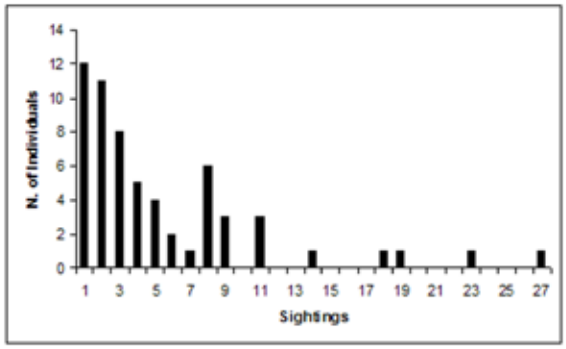

Figure 3. Number of sightings of *Sotalia guianensis* identified between 2002 and 2005 in the Caravelas River Estuary.

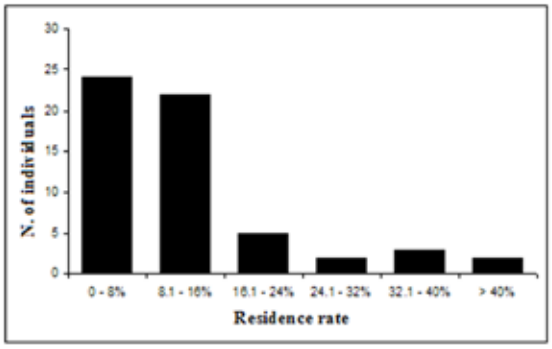

Figure 5. Residence rates of *Sotalia guianensis* identified between 2002 and 2005 in the Caravelas River Estuary.

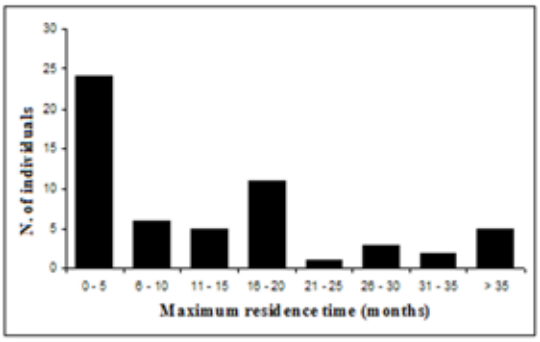

Figure 4. Maximum residence time of *Sotalia guianensis* identified between 2002 and 2005 in the Caravelas River Estuary.

Lehner, 1996) was applied as the method of observation, while the geographical positions were collected at 5-min intervals and photographic information was registered simultaneously on data sheets. Blank pictures were taken to separate each focal-group (whenever more than one group was photographed in the same film).

Data analysis

For individual identification of estuarine dolphins we used nicks and notches on the back edge of the dorsal fin, which varied in shape, size and position among individuals and are largely used for many cetacean species worldwide. Other types of scars such as body scratches were used to help to confirm an identification match of an individual.

Photographs were only considered for photo-identification purposes when good quality criteria were met, which were: sharp focus, angle to the photographer (ideally 90°), close distance to the dolphin and absence of brightness or reflections on the dolphin's body.

Slides were projected onto a smooth white surface to enlarge the image and to get profile drawings of each marked dorsal fin (adapted from Defran et al., 1990). Each profile and the best and most recent picture of each individual were included in a catalogue. Every new good quality picture was compared with the whole catalogue for matches.

To investigate the presence of marked animals in the study area throughout the study period, we calculated: (i) the number of months in which the individual was captured (photo-identified); (ii) the residence rate, or the number of months in which the animal was photo-identified/total number of sampled months×100; (iii) total residence time, or the maximum month interval between captures.

Individual range use (spatial area where an animal was observed during the study period—Hooker et al., 2002) was calculated for dolphins with more than 10 resightings, utilizing the first geographical position of the sighting. Whenever the focal-group was monitored for longer than one hour, we also utilized the last registered geographical position of the group. Data were inserted into ESRI Arcview 3.1 and the individual range use was estimated using the minimum convex polygon (MCP) method with the extension AMAE—animal movement analyst extension (Hooge & Eichenlaub, 1997). The technique was adapted so as to exclude the land masses whenever the MCP included it.

RESULTS

Between April 2002 and April 2005, 210 estuarine dolphin groups were sighted in the Caravelas River Estuary, including 58 photo-identified animals. The cumulative number of identified individuals curve stabilized after one year of data collection (Figure 2), suggesting that the population was well sampled throughout the study period.

We observed a small number of constantly sighted animals, contrasting with the large number of individuals with few resightings (Figure 3). Furthermore, some dolphins were registered for a period longer than 3 y in the estuary (Figure 4), characterizing, consequently, the long term residence for the species in this region.

The residence rate showed different levels in the dolphin's permanence in the region (minimum of 2.7% and maximum of 45.95%), with 79% of the dolphins presenting rates lower than 16%, whereas 12% had the residence rate of 16.1 to 32%. Approximately 9% of the identified dolphins showed high residence values (>32%) (Figure 5). Through the individual range use analysis (Figure 6) we observed that dolphins share common areas inside the estuary, with some animals entering more than 12 km inside the river whereas others are frequently found in coastal waters between Caravelas and Nova-Viçosa, 35 km southwards.

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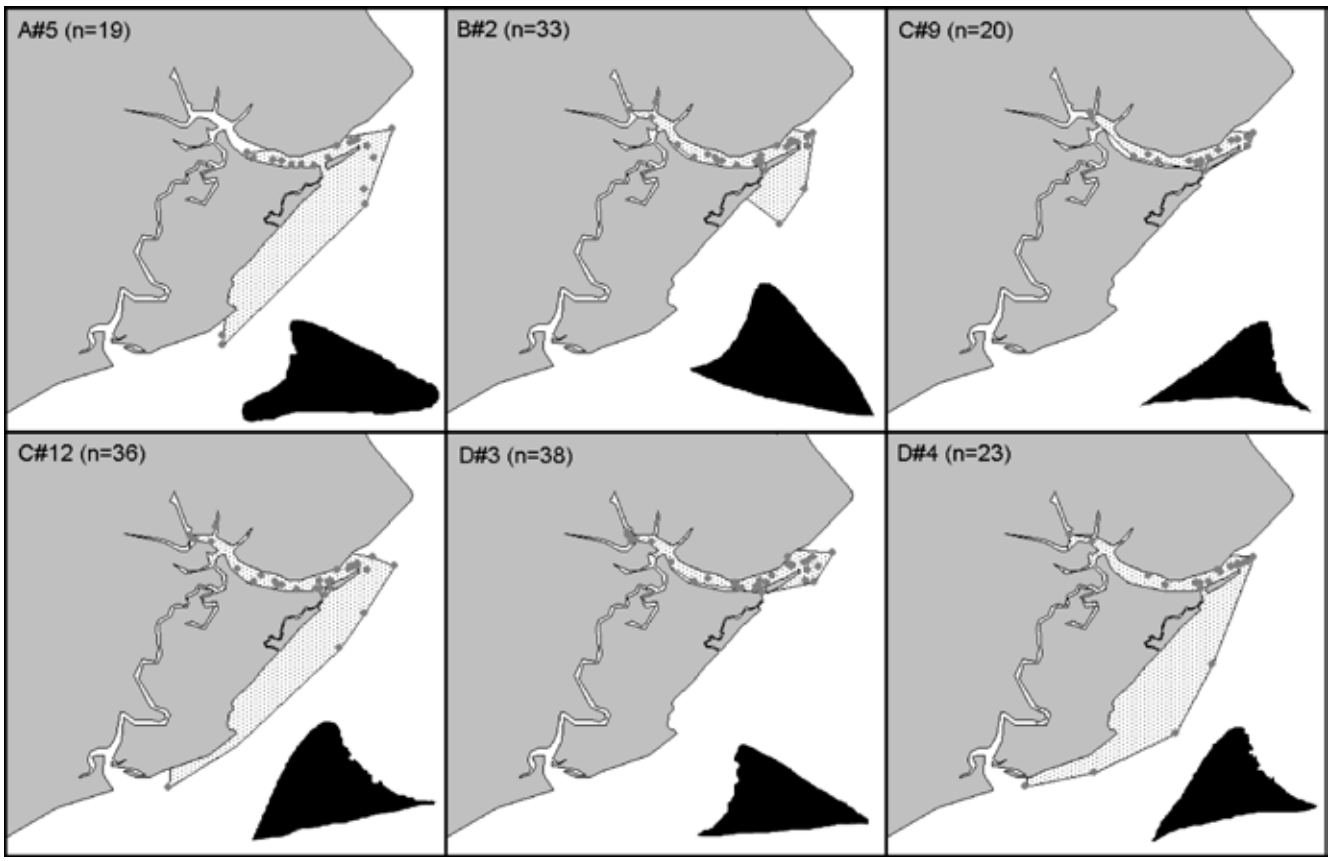

Figure 6. Individual ranges for the identified *Sotalia guianensis* A#5, B#2, C#9, C#12, D#3 and D#4 (N=number of sightings) in the Caravelas River Estuary.

DISCUSSION

Residence patterns may present differences in the individual responses to the heterogeneous environment to essential activities such as foraging and reproduction (Ballance, 1992; Karczmarski et al., 2000; Connor et al., 2000).

The maximum residence time showed that some dolphins were registered for longer than 3 y in the estuary area, therefore characterizing long term residency for *S. guianensis* in the Caravelas River Estuary. Long term residency for estuarine dolphins has also been observed in southern Brazil, as described by Flores (1999), who found 29 marked dolphins, with at least two individuals resident for a minimum period of 4.8 y. Simão et al. (2000) also observed resident individuals for more than three years in Sepetiba Bay, south-eastern Brazilian coast. Hardt (2005) observed almost one third of 50 identified estuarine dolphins for more than three years in Babitonga Bay. One individual was resident in Babitonga Bay for at least 8 y, the maximum residence time recorded for the species (Hardt, 2005).

Estuarine dolphins showed varying degrees of residence in the Caravelas River Estuary. Apparently, there is a fluctuation in the number of individually identified dolphins in the study area and also in the time spent by those in the Caravelas River Estuary. Although some individuals appear to temporarily leave the area, the regular use of the Caravelas River Estuary by estuarine dolphins is also indicated by the high numbers of consecutive resightings. Nevertheless, we must consider that a long resighting interval may simply represent that an animal was not found during sampling, but may have been present in some other part of the study area. Hardt (2005), applying the same method of residence rates, observed 19 resident animals (residence rate >11,7%), while 10 dolphins were considered not residents. Estuarine dolphins from Norte Bay also exhibited varying degrees of residence, but the data suggested that the residence rate of the southernmost population of the species is higher than in other study areas (Flores, 1999).

Each dolphin presented a specific ranging pattern, some of them restricted to the estuary, while others visited open sea waters and sometimes reached the southern part of the study area. Nevertheless, these patterns shared common characteristics, such as the overlapping in their individual range use in the river mouth of the Caravelas Estuary. Flores & Bazzalo (2004), using the photoidentification technique, found small home ranges for estuarine dolphins in Norte Bay, where the home ranges of 13 dolphins overlapped intensively. Hardt (2005) also observed home range overlap among five dolphins in Babitonga Bay.

The high site-fidelity and long term residence of bottlenose dolphins *Tursiops truncatus* is well-established (e.g. Shane et al., 1986; Shane, 1990; Wells, 1991, Bearzi et al., 1997). Studying residence patterns for two dolphin species (*Orcaella heinsohni* and *Souza chinensis*) in estuarine waters of Cleveland Bay, Australia, Parra et al. (2006) stated that most of the marked animals are not permanent residents but they are resighted yearly after movement outside the area, thus the study area comprises a key habitat for those species. Parra et al. (2006) also suggest that the habitat characteristics may influence individual behaviour through

https://doi.org/10.1017/S0025315407055683 Published online by Cambridge University Press

the search for foraging and reproductive resources. This may be considered for *S. guianensis* since it is another estuarine inhabitant in a large mangrove ecosystem (Herz, 1991) of the Caravelas River, with a very high frequency of foraging behaviour recorded in this area (Rossi-Santos, 2006).

The individual range use analysis showed that some dolphins utilized the estuary waters and also open waters (outside bays, estuaries or beaches), from Caravelas to Nova-Viçosa, showing movements of about 35 km of extension. These observations, allied to the observations of the species using waters around coral reef formations of the Abrolhos Bank and waters more than 70 km away from the coast (Rossi-Santos et al., in press), are evidence that the species use a wide variety of habitats in the Abrolhos Bank. Studies about the spatial structure of estuarine dolphin populations on a broader scale are suggested to enlarge our understanding of how the species use a patchy and complex environment such as the Abrolhos Bank.

Concluding, in the present study we found a great fluctuation of the identified estuarine dolphins in the Caravelas river estuary, with a large number of animals with few resightings, and a smaller number of frequently resighted dolphins. Furthermore, the residence rates showed different levels of permanence, with only 7% of the total identified individuals presenting high residence rates. Finally, considering that some individuals were sighted for periods longer than 3 years, the population of *S. guianensis* in the Caravelas river estuary may be considered as long term resident.

We thank Instituto Baleia Jubarte interns and staff, especially Marcia Engel and Uilson 'Lixinha' Farias for strong logistic support, Aracruz Celulose for funding this project and Petrobras, oficial sponsor of the Instituto Baleia Jubarte. Simone Rondinelli and Felipe Penin helped with initial photo-id analysis. We also thank Flavio Lima Silva and Andre Silva Barreto for constructive criticism in the present manuscript, Tatiana Leal for graphic design support and Luciana Araújo for text revision. Ann Pulsford and three anonymous referees helped to improve this manuscript.

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Submitted 4 August 2006. Accepted 1 November 2006.