http://dx.doi.org/10.5597/lajam00160

Residence patterns of the Guiana dolphin *Sotalia guianensis* in Babitonga bay, south coast of Brazil

Fernando A. S. Hardt[1,2,*], Marta J. Cremer[2], Antonio J. Tonello Junior[2] and Paulo C. A. Simões-Lopes[1,3]

Abstract: Photo-identification and video-identification techniques were applied to study the residence of *Sotalia guianensis* in the Babitonga Bay, north coast of Santa Catarina State. From November 2000 to February 2003 a photo-identification effort was conducted trough 21 months, with additional video-identification conducted from August 2003 to August 2004, totalizing 34 months of identification effort. Fifty-one different animals were identified with residence rates varying from 2.9% (n = 1 sighting) to 67.6% (n = 23 sightings). During the four years it was founded that more than 30% (n = 16) of identified individuals were observed during three years, and 25% (n = 13) only were seen within one year. Considering previous studies, the longest period of residence reached eight years for one individual. Due to the high rates of resightings observed for most of the animals and the small percentage of animals only seen once, it is clear that *S. guianensis* is resident year-round in the studied area.

Resumo: Técnicas de foto e de vídeo-identificação foram aplicadas objetivando estudar a residência de *Sotalia guianensis* na Baía da Babitonga, litoral norte de Santa Catarina. De novembro de 2000 a fevereiro de 2003 um esforço de foto-identificação foi conduzido através de 21 meses, somado a um esforço adicional de vídeo-identificação, conduzido de agosto de 2003 a agosto de 2004, totalizando 34 meses de esforço total de identificação. Cinqüenta e um animais foram identificados com diferentes taxas de residência, variando de 2,9% (n = 1 observação) á 67,6% (n = 23 observações). Durante os quatro anos verificou-se que mais de 30% (n = 16) dos indivíduos identificados foram observados por um período de três anos, e 25% (n = 13) foram observados apenas no período de um ano. Considerando estudos anteriores, o mais longo período de residência atingiu oito anos para um indivíduo. As altas taxas de recapturas observadas para a maioria dos animais e a pequena porcentagem de animais observados em apenas uma ocasião evidenciam a residência anual de *S. guianensis* na área estudada.

Keywords: photo-identification, video-identification, residence patterns, *Sotalia guianensis*, Babitonga Bay.

Introduction

It is known that residence and habitat use patterns in dolphins may vary from one region to another (Ballance, 1990). It has been suggested that the variations with regard to the number of resident individuals are related to changes in the distribution of food resources (Wells *et al.*, 1980; Shane *et al.*, 1986; Ballance, 1992). Photo- and video-identification techniques have been used on a large scale to follow such displacements and to determine fidelity to some areas (Scott *et al.*, 1990; Simões-Lopes *et al.*, 1999; Zolman, 2002; Rossi-Santos *et al.*, 2007).

Sotalia guianensis has a continuous distribution, from Nicaragua, Central America to Florianópolis, Santa Catarina State, Brazil (Simões-Lopes, 1988; Carr and Bonde, 2000; da Silva et al, 2010 this volume). This species is classified as 'Data Deficient', according to the IUCN (Reeves *et al.*, 2003), which calls attention to the relevance of long-term studies. Some resident populations are found along the Brazilian coast, like in the Caravelas River Estuary (Rossi-Santos *et al.*, 2007; 2011), Guanabara Bay (Pizzorno, 1999; Azevedo *et al.*, 2007), Cananéia Estuary (Santos, *et al.*, 2001; Oshima *et al.*, 2010), and Norte Bay (Flores, 2003). Variable degrees of residence have been observed for some individuals (Pizzorno, 1999; Santos *et al.*, 2001; Flores, 2003). Previous studies showed that Babitonga Bay is an important shelter area for the species, where the population shows evidence of residence (Cremer, 2000).

The knowledge of how a population uses its habitat is considered a key issue for the elaboration and implementation of species conservation strategies and for supporting works of environmental assessment (Primack and Rodrigues, 2001). This work aims to analyze the residence patterns of *S. guianensis* in the Babitonga Bay, Santa Catarina.

Methods

Study Area

Babitonga Bay is located in the north of Santa Catarina State, southern Brazil (26º02'S to 26º28'S and 48º28'W to 48º50'W) comprising an area of approximately 160km², with 20km in length and a maximum width of 5km (Figure 1). It is connected to the Atlantic Ocean through a deep channel of about 1.7km width. Its surroundings consist of mangrove vegetation, covering approximately 6200ha, and margins of sand banks and rocks. The bay receives many rivers but is considered a homogenous estuary (IBAMA, 1998). The average depth is 6m reaching a maximum of 28m near to main channel of the San Francisco do Sul harbor. The maximum tide variation is about 2.3m according to the tide table of San Francisco do Sul harbor.

[1] Programa de Pós-Graduação em Zoologia, Universidade Federal do Paraná
[2] Laboratório de Nectologia, Departamento de Ciências Biológicas, Universidade da Região de Joinville, C.P. 110, 89240-000, São Francisco do Sul, SC, Brasil
[3] Laboratório de Mamíferos Aquáticos, Departamento de Ecologia e Zoologia, Universidade Federal de Santa Catarina, C.P. 5102, 88040-970, Florianópolis, SC, Brasil
* Corresponding author, e-mail: fehardt@yahoo.com.br

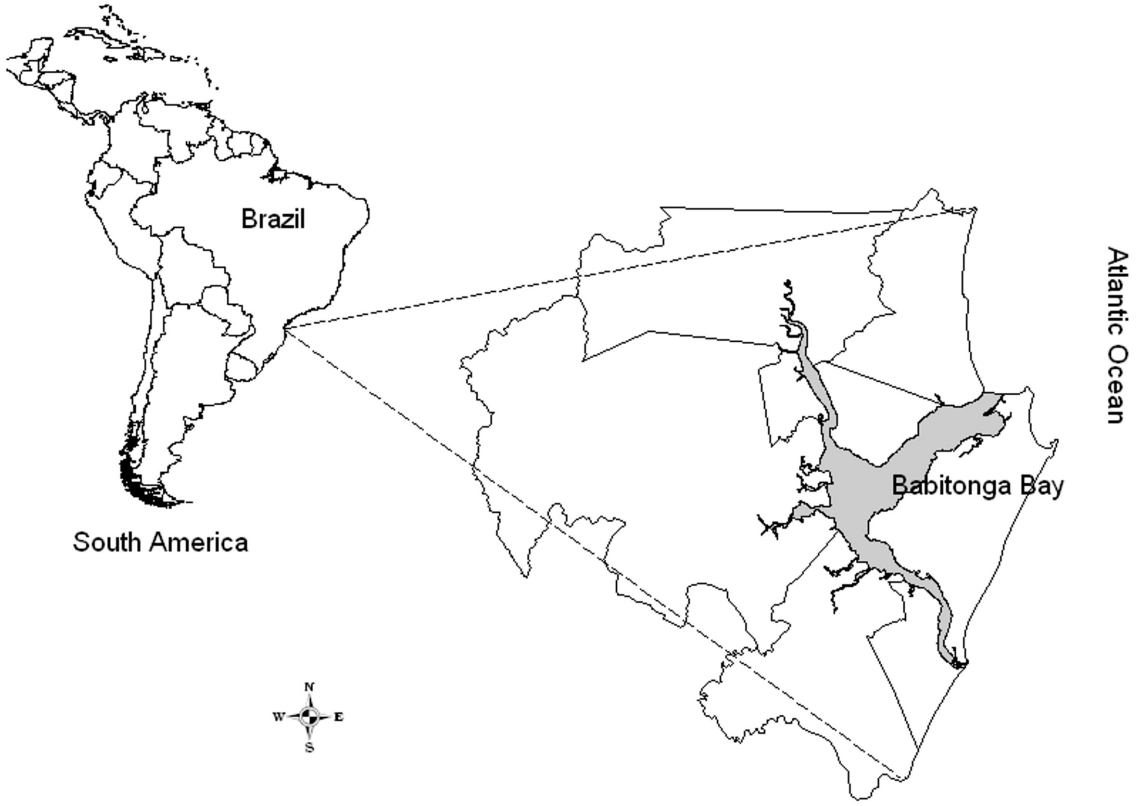

Figure 1. Babitonga Bay, Santa Catarina State, southern region of Brazil.

Data collection and analysis

A 5m aluminum boat equipped with a 60Hp outboard engine was used. Between November 2000 until August 2003 photo-identification was conducted using a Canon EOS5 photographic camera with 100-300mm zoom lenses, color films ASA 200 and 400 and only in good luminosity condition (between 0900h to 1500h). Considering previous studies, the fieldwork was mainly carried out in the two known areas of concentration of this species in the bay (see Cremer, 2000).

Only photographs of high quality (better definition, focus, clearness and proximity) were used to define natural marks in the animals' dorsal fins. For the photographic analysis, 2.5x eyecup lenses were used. Analyses were carried out with two or more experienced researchers in 1h or less to avoid observer fatigue, which could interfere with the analysis. The best photograph of each animal was enlarged, printed and scanned, and used as a 'standard photograph' for the elaboration of the digital photographic catalogue. The catalogue included the description of natural marks used for the individual identification in the different parts in which the dorsal fin was divided for easier recognition.

Between August 2003 and August 2004, video-identification with a digital video camera (mini-DV) Sony DCR-TRV33 with 2x optical lenses was used, with the digital zoom turned off. Zoom approaches of the animals' dorsal fin were made according to Sanino and Yañez (2001). Usually, framing distance remained open to ensure the possibility of capturing images with better resolutions, considering that animals showed up in an unexpected way. All the images were first divided in stretches according to better framing and definition and selected from the original Mini-DV tapes. The images from the camera were transferred through a Universal Serial Bus (USB) cable to an edition center. The best selected stretches were analyzed through the software AdobePremiére 6.0® for the transformation of the stretches into pictures. Each stretch resulted in a variable number of pictures. The best pictures of each stretch were recorded as photographs in the Joint Photographic Experts Group (JPEG)® file format. Then photographs were edited and improved with the software Adobe Photoshop 7.0® following the methodology of Sanino and Yañez (2001). These images were compared with those of the catalogue for identification of new and previously identified animals. The images were inserted in the catalogue considering marks description to compare photographs with similar characteristics (Zolman, 2002).

The residence of *S. guianensis* in the Babitonga Bay was analyzed in two different ways: through residence levels and through residence rates. Residence levels were analyzed following an adaptation of the terms proposed by Würsig and Jefferson (1990), Ballance (1990), Simões-Lopes and Fabian (1999) and Zolman (2002) for *Tursiops truncatus*. The analysis of residence levels were based

on the seasonal presence or absence of individually identifiable dolphins in the area. A year was divided into four seasons: summer (January-March), autumn (April-June), winter (July-September) and spring (October-December). Dolphins identified in the area in all four seasons (regardless of year), were considered as residents (R). Dolphins identified in the study area in three different seasons were considered as partially resident (PA-R). Those animals observed exclusively in the same season in consecutive years were considered as seasonal residents (S-R), and those identified in only one or two consecutive seasons were considered as non-residents (N-R). Residence rates were adapted from Simões-Lopes and Fabian (1999). To estimate the residence rates, we looked at the number of times that an identified animal was seen throughout the studied period. In this way a table of monthly presence and absence of animals was elaborated. The residence rates of the individuals (considered as the number of resighted individuals divided by the number of months) were expressed in percent (%).

Results

Photo- and video-identification were conducted over a period of 34 months in which 51 different animals were identified. A total of 2707 photographs with 13.5% (n = 367) of useful photographs were taken. The video-identification consisted of nine hours and 36 minutes of footage, with 552 stretches selected, 41.6% of which were useful for individual identification. The images edition (stretches selection, edition center and image treatment) had a length of 52.1h. The curve of newly identified dolphins became asymptotic in both the photo- and video identification studies suggesting that the population was well sampled throughout the studied period (Figure 2).

According to the residence levels, 19 animals (37.2%) were considered as residents (R), 9 (17.5%) were observed during three consecutive seasons and were considered as partially residents (PA-R), 5 (9.8%) were seasonal residents (S-R) and 16 (31.3%) were considered as non residents (N-R) of which seven (43.8%) were only seen once (Table 1). The residence rates varied from 2.9% (1 sighting) to 67.6% (23 sightings). Two identified animals were present throughout the five analyzed years, with residence rates of 67.6% and 58.5%, respectively. These high residence rates remained similar in both the photo- and the video-identification periods. Analyzing the animals' occurrence throughout the four years, it was observed that 16 animals (31.3%) were present in the area throughout three years, with residence rates equal or higher than 15%. Thirteen (25.4%) animals were recorded only during one year.

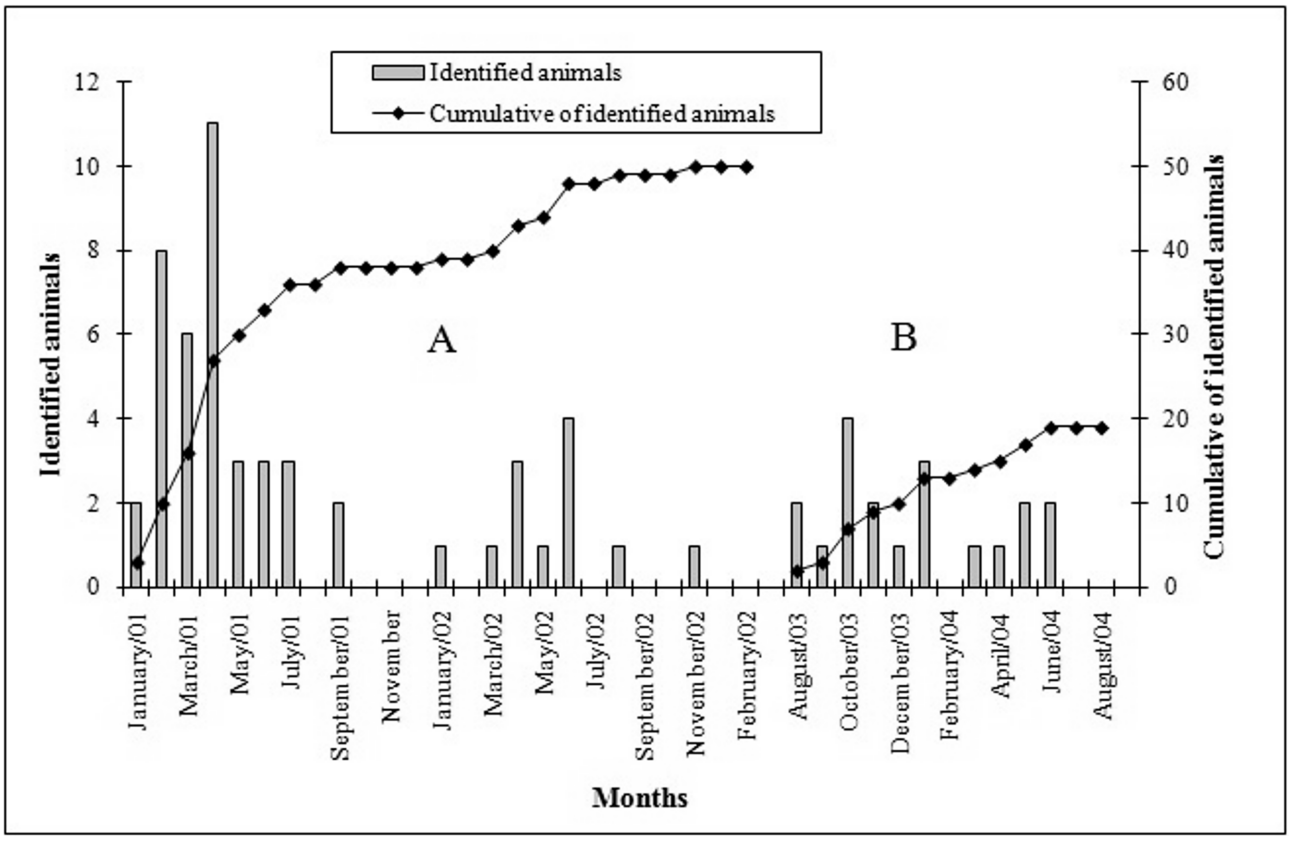

Figure 2. Curves of newly identified dolphins (*Sotalia guianensis*) with photo- (A) and video-identification (B) techniques in the Babitonga Bay, Santa Catarina State, southern Brazil.

Discussion

Considering the high number of animals seen in the Babitonga Bay and the small percentage of animals observed only once, it became clear that *S. guianensis* has a regular occurrence throughout the year in the study area. Most of the identified animals (n = 38; 74.5%) were observed in the area in more than two years and more than one third of the animals (n = 16; 31.3%) were found in Babitonga Bay for three years or more. Similar residence levels for *S. guianensis* had been also observed in other localities. In Guanabara Bay, Pizzorno (1999) observed that 32 animals were resident for a period of three years, and Santos *et al.* (2001) observed that 16 animals lived throughout two years in Cananéia Estuary. In Norte Bay, Santa Catarina, 23 animals were observed during a period of 4.8yr (Flores, 1999). In Caravelas, Northeastern Brazil, Rossi-Santos *et al.* (2007) identified 58 animals, with a three years residence for seven individuals.

Considering previous studies (Cremer, 2000), it has been stated that two animals, 'Peninha' and 'Cut', lived in the area for more than seven and eight years, respectively, showing a long term residence. This was also observed in Norte Bay, where 13 animals were observed to reside periods that varied from three to 10yr (Flores, 2003). Site fidelity or year-round residence patterns have been also registered in other coastal species of dolphin such as the common bottlenose dolphin *T. truncatus* in high latitudes (Wursig and Wursig, 1977; Wursig and Harris, 1990; Williams *et al.*, 1993; Wilson, 1995; Feinholz, 1996; Simões-Lopes and Fabian, 1999; Zolman, 2002). Williams *et al.* (1993) and Wilson (1995) confirmed the long-term residence of more than 60 bottlenose dolphins in New Zealand and Scotland, respectively. In some cases, long-term residence patterns are very expressive in *T. truncatus*. Simões-Lopes and Fabian (1999) registered the same individuals for more than 13yr in Tramandaí, Southern Brazil. Wells *et al.* (1987) recorded 18yr of residence for Florida dolphins, USA, and Connor and Smolker (1985) more than 20yr of residence for Shark Bay dolphins, in Australia.

The residence of *S. guianensis* in Babitonga Bay, as well as the observations made for Norte Bay (Flores, 2003), indicates that those areas probably provide sufficient food supply for the population during the entire year. The results presented here show that Babitonga Bay represents an important area for a small population of *S. guianensis*, with some individuals using the area throughout the year.

Acknowledgements

We thank the 'Projeto Cetáceos da Babitonga' group for their collaboration in collecting the field data. The authors are also grateful for the financial and institutional support given by the Universidade da Região de Joinville, through their 'Fundo de Apoio à Pesquisa'. We wish to thank two anonymous reviewers for their valuable comments. The first author is very grateful for the financial support given by the Coordenação de Aperfeiçoamento de Pessoal de Nivel Superior-CAPES, in the 2003 to 2005 period. P.C. Simões-Lopes received a research grant from the Brazilian Research Bureau (CNPq/PQ, proc: 304698/2006-7).

References

Azevedo, A.F., Oliveira, A.M., Viana, S.C. and van Sluys, M. (2007) Habitat use by marine tucuxis (*Sotalia guianensis*) (Cetacea: Delphinidae) in Guanabara Bay, south-eastern Brazil. *Journal of the Marine Biological Association of the United Kingdom* 87: 201-205. http://dx.doi.org/10.1017/S0025315407054422

Ballance, L.T. (1990) Residence patterns, group organization, and surfacing associations of bottlenose dolphins in Kino Bay, Gulf of California, Mexico. Pages 267-283 *in* Leatherwood, S. and Reeves, R.R. (Eds) *The Bottlenose Dolphin*. San Diego Academic Press, San Diego.

Ballance, L.T. (1992) Habitat use patterns and ranges of bottlenose-dolphin in the Gulf of California, Mexico. *Marine Mammal Science* 8: 262-274. http://dx.doi.org/10.1111/j.1748-7692.1992.tb00408.x

Carr, T. and Bonde, R.K. (2000) Tucuxi (*Sotalia fluviatilis*) occurs in Nicaragua, 800km of its previously known range. *Marine Mammal Science* 16: 447-452. http://dx.doi.org/10.1111/j.1748-7692.2000.tb00936.x

Connor, R.C. and Smolker, R.A. (1985) Habituated dolphins (*Tursiops* sp.) in western Australia. *Journal of Mammalogy* 66: 398-400. http://dx.doi.org/10.2307/1381260

Cremer, M.J. (2000) *Ecologia e conservação de* Sotalia fluviatilis guianensis *(Cetacea, Delphinidae) na Baía de Babitonga, litoral norte de Santa Catarina.* M.Sc. Thesis. Universidade Federal de São Carlos. São Carlos, Brazil. 226 pp.

da Silva, V.M.F., Fettuccia, D., Rodrigues, E. da S., Edwards, H., Moreno, I.B., Moura, J.F., Wedekin, L.L., Bazzalo, M., Emin-Lima, N.R., Carmo, N.A.S., Siciliano, S. and Utreras B., V. (2010) Report of the Working Group on Distribution, Habitat Characteristics and Preferences, and Group Size. *Latin American Journal of Aquatic Mammals* 8(1-2): 31-38. http://dx.doi.org/10.5597/lajam00151

Feinholz, D.M. (1996) *Pacific coast bottlenose dolphins (*Tursiops truncatus gilli*) in Monterey Bay, California.* M.Sc. Thesis. San Jose State University. San Jose, CA, USA. 120 pp.

Flores, P.A.C. (2003) *Ecology of the marine tucuxi dolphin (*Sotalia fluviatilis*) in southern Brazil.* Ph.D. Thesis. Pontifícia Universidade Católica do Rio Grande do Sul. Porto Alegre, Brazil. 123 pp.

IBAMA (1998) Proteção e controle de ecossistemas costeiros: Manguezal da Baía da Babitonga. In *Coleção Meio Ambiente*, Brasília: Ibama [Série Estudos de Pesca, no. 25.]

Oshima, J.E.F., Santos, M.C.O., Bazallo, M., Flores, P.A.C. and Pupim, F.N. (2010) Home ranges of Guiana dolphins (*Sotalia guianensis*) (Cetacea: Delphinidae) in the Cananéia estuary, Brazil. *Journal of the Marine Biological Association of the United*

Kingdom 90(8): 1641-1647. http://dx.doi.org/10.1017/S0025315410001311

Pizzorno, J.L.A. (1999) *Estimativa populacional do boto-cinza,* Sotalia fluviatilis*, na Baía de Guanabara, por meio de catálogo de fotoidentificação.* M.Sc. Thesis, Universidade Federal Rural do Rio de Janeiro. Rio de Janeiro, Brazil. 165 pp.

Reeves, R.R., Smith, B.D., Crespo, E.A. and Notarbartolo di Sciara, G. (2003) Dolphins, whales and porpoises: 2002– 2010 *(Conservation Action Plan for the World's Cetaceans). IUCN/SSC Cetacean Specialist Group.* Switzerland: IUCN. http://dx.doi.org/10.2305/IUCN.CH.2003.SSC-AP.2.en

Rossi-Santos, M.R., Wedekin, L.L. and Monteiro-Filho, E.L.A. (2007) Residence and site fidelity of *Sotalia guianensis* in the Caravelas River Estuary, eastern Brazil. *Journal of the Marine Biological Association of the United Kingdom* 87: 207-212. http://dx.doi.org/10.1017/S0025315407055683

Primack, R.B. and Rodrigues, E. (2001) *Biologia da Conservação*. E. Rodrigues, Londrina.

Sanino, G.P. and Yañez J.L. (2001). Nueva técnica de identificacion y estimación de tamaño poblacional en cetáceos, aplicada en delfines nariz de botella, *Tursiops truncatus*, de Isla Choros, IV region de Chile. *Boletin del Museo Nacional de Historia Natural* 80: 30-37.

Santos, M.C.O., Acuña, L.B. and Rosso, S. (2001) Insights on site fidelity and calving intervals of the marine tucuxi dolphin (*Sotalia fluviatilis*) in southern Brazil. *Journal of the Marine Biological Association of the United Kingdom* 81: 1049-1052. http://dx.doi.org/10.1017/S0025315401005045

Scott, M.D., Wells, R.S. and Irvine, A.B. (1990) A long-term study of bottlenose dolphins on the west coast of Florida. Pages 235-244 *in* Leatherwood, S. and Reeves, R. R. (Eds) *The Bottlenose Dolphin*. Academic Press, San Diego, USA.

Shane, S.H., Wells, R.S. and Würsig, B. (1986) Ecology, behavior and social organization of the bottlenose dolphin: a review. *Marine Mammal Science* 2: 34-63. http://dx.doi.org/10.1111/j.1748-7692.1986.tb00026.x

Simões-Lopes, P.C. (1988) Ocorrência de uma população de *Sotalia fluviatilis* (Gervais 1853), (Cetacea, Dephinidae) no limite sul de sua distribuição, Santa Catarina, Brasil. *Biotemas* 1: 57-62.

Simões-Lopes, P.C. and Fabian, M.E. (1999) Residence patterns and site fidelity in bottlenose dolphin, *Tursiops truncatus* (Montagu) (Cetacea, Delphinidae) off Southern Brasil. *Revista Brasileira de Zoologia* 16: 1017- 1024.

Wells, R.S., Irvine, A.B. and Scott, M.D. (1980) The social ecology of inshore odontocetes. Pages 263-317 *in* Herman, L.M. (Ed) *Cetacean behavior: mechanisms and functions*. John Wiley & Sons, New York.

Wells, R.S., Scott, M.D. and Irvine, A.B. (1987). The social structure of free-ranging bottlenose dolphins. Pages 247-305 *in* Genoways, H.H. (Ed) *Current Mammalogy*. Plenum Press, New York.

Williams, J.A., Dawson, S.M. and Slooten, E. (1993) The abundance and distribution of bottlenosed dolphins (*Tursiops truncatus*) in Doubtful Sound, New Zealand. *Canadian Journal of Zoology* 71: 2080-2088. http://dx.doi.org/10.1139/z93-293

Wilson, D.R.B. (1995) *The ecology of bottlenose dolphins in the Moray Firth, Scotland: a population at the Northern extreme of the species' range.* Ph.D. Thesis. University of Aberdeen. Aberdeen, UK. 175 pp.

Würsig, B. and Würsig, M. (1977). The photographic determination of group size, composition, and stability of coastal porpoises (*Tursiops truncatus*). *Science* 198: 755-756. http://dx.doi.org/10.1126/science.198.4318.755

Würsig, B. and Jefferson, T. A. (1990) Methods of photo-identification for small cetaceans. *Report of the International Whaling Commission* Special Issue 12: 43-52.

Würsig, B. and Harris, G. (1990) Site and association fidelity in bottlenose dolphins off Argentina. Pages 361-364 *in* Leatherwood, S. and Reeves, R.R. (Eds) *The bottlenose dolphin*. San Diego Academic Press, San Diego.

Zolman, E.S. (2002) Residence patterns of bottlenose dolphins (*Tursiops truncatus*) in the Stono River estuary, Charleston County, South Carolina, USA. *Marine Mammal Science* 18: 879-893. http://dx.doi.org/10.1111/j.1748-7692.2002.tb01079.x

Received on 2 May 2009. Accepted on 14 July 2010.
Managed by Marcos Santos.