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Long-term site fidelity and residency patterns of bottlenose dolphins (*Tursiops truncatus*) in the Tramandaí Estuary, southern Brazil

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Abstract. The occurrence of common bottlenose dolphins (*Tursiops truncatus*) in Tramandaí Estuary, southern Brazil, is described based on a photo-identification study conducted between January 2009 and February 2010. A total of 128 survey days were conducted with an average observation effort of 2.6 hours per day (SD = 0.6). Approximately 2050 photographs were taken from a shore land location at the mouth of the estuary. A total of nine dolphins were identified, including three calves. The dolphins were observed during all seasons, with a greater frequency during fall (79.3% of the days) and winter (60.7% of the days). The summer presented the lowest occurrence (2.4% of the days) of dolphins. During the entire study period, the maximum number of individuals sighted in any given day ranged from one to seven (average = 2.8 dolphins; SD = 1.35; n = 51). The residence indices, based on the resighting frequency of dolphins during the study period, ranged from 0.02 to 0.24 (average = 0.13; SD = 0.08; n = 9). However, most of the animals (67%) were resighted in over five months during a year and could be classified as residents. Long-term site fidelity was detected by resightings of four dolphins for over 18 years. These data combined reinforce the importance of the Tramandaí Estuary for the common bottlenose dolphins in the region and highlight the need for local conservation efforts to guarantee the long-term persistence of these coastal populations.

Resumo. A ocorrência dos botos, *Tursiops truncatus,* no estuário do rio Tramandaí, sul do Brasil, é descrita com base em um estudo de fotoidentificação conduzido entre janeiro de 2009 e fevereiro de 2010. No total, foram realizados 128 dias de observação, com um esforço médio de 2,6 horas por dia (DP = 0,6). Aproximadamente 2050 fotografias foram obtidas a partir de ponto fixo às margens da desembocadura do estuário. Nove indivíduos foram identificados, incluindo três filhotes. Os botos foram observados ao longo de todas as estações do ano, com uma maior frequência nos meses de outono (79,3% dos dias) e inverno (60,7% dos dias). O período de verão foi marcado pela frequência extremamente baixa (2,4% dos dias) dos indivíduos. Ao longo de todo o período de estudo, o número máximo de botos observados dentro do estuário, em um mesmo dia, variou de um a sete (média = 2,8 botos; DP = 1,35; n = 51). O grau de residência dos indivíduos, estimado a partir da frequência dos reavistamentos ao longo do período de estudo, variou de 0,02 a 0,24 (média = 0,13; DP = 0,08; n = 9). Contudo, a maioria dos indivíduos (66,7%) foram reavistados em mais de cinco meses ao longo do ano, podendo ser classificados como residentes. Um alto grau de fidelidade ao local foi também evidenciado pelo reavistamento de quatro indivíduos ao longo de 18 anos. Em conjunto, estes dados reforçam a importância do estuário de Tramandaí para os botos na região e destacam a necessidade de esforços de conservação local para garantir a sobrevivência a longo prazo destas populações costeiras.

Introduction

The common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821), is found in temperate and tropical waters around the world, including coastal and oceanic regions (Wells and Scott, 2009). Coastal populations often occur in discrete locations either seasonally or year around (Wilson *et al.*, 2004). In coastal waters of southern Brazil, a few resident populations are known to occur and their presence is strongly associated with estuaries and river systems (Simões-Lopes and Fabian, 1999; Mattos *et al.*, 2007; Peterson *et al.*, 2008; Fruet *et al.*, 2011). In some of these areas, a unique cooperative association between the coastal groups of bottlenose dolphins and the artisanal fishery of mullets (*Mugil* spp.) has been described (Pryor *et al.*, 1990; Simões-Lopes, 1991; Simões-Lopes *et al.*, 1998; Zappes *et al.*, 2011; Daura-Jorge *et al.*, 2012). Due to its foraging cooperation with artisanal fishermen, the common bottlenose dolphin has currently both social and economic importance in southern Brazil (Simões-Lopes *et al.*, 1998; Zappes *et al.*, 2011) and has been declared a 'Natural Heritage' species in the region[1].

Nevertheless, common bottlenose dolphins inhabiting coastal waters in southern Brazil are potentially threatened by several human activities, including gillnet fishery, boat traffic and pollution[2] (*e.g.* Siciliano, 1994; Van Bressem *et al.*, 2007; Fruet *et al.*, 2010; Daura-Jorge and Simões-Lopes, 2011; Zappes *et al.*, 2011). Therefore, monitoring studies of these coastal populations are important to detect possible population trends or changes in the dolphins' habitat use over the years.

Although line-transect and mark-recapture are the main methods for assessing cetacean abundance, important data can be obtained through land-based monitoring (Aragones *et al.*, 1997; Dawson *et al.*, 2008). Photo-identification, a technique that uses natural marks of free-ranging cetaceans, has been one of the main techniques for individual recognition of animals (*e.g.* Würsig and Würsig, 1977; Würsig and Jefferson, 1990). For small populations, photo-identification is a powerful tool that allows estimating the total number of animals using an area, even without the implementation of the mark-recapture techniques (Gunnlaugsson and Sigurjónsson, 1990).

The common bottlenose dolphins from the Tramandaí Estuary, southern Brazil, have been studied through photo-identification since 1991[3] (*e.g.* Simões-Lopes and Fabian, 1999; Hoffmann, 2004; Moreno *et al.*, 2008). Some identified individuals have been sighted in the study area for over 13 years (Simões-Lopes and Fabian, 1999). In this study, we report the number of individuals and residency patterns of common bottlenose dolphins inhabiting the Tramandaí Estuary, based on a one-year photo-identification study. Using these data, in conjunction with previous information, we discuss some of the implications of these results for management strategies.

Material and Methods

Study area

The Tramandaí Estuary (29°58'S, 50°07'W) is one of the few breaks along the long and exposed sandy coastline off Rio Grande do Sul, southern Brazil. The estuary channel has a width of around 10 meters with an average depth of 2.19 ± 1.11 meters at the mouth of the river (Hoffmann, 2004; Figure 1).

The environmental conditions of the estuary can vary greatly over a short period of time, due to abrupt changes in wind velocity and direction. The salinity is also influenced by variation in tides and freshwater river input (Schwarzbold and Schäfer,

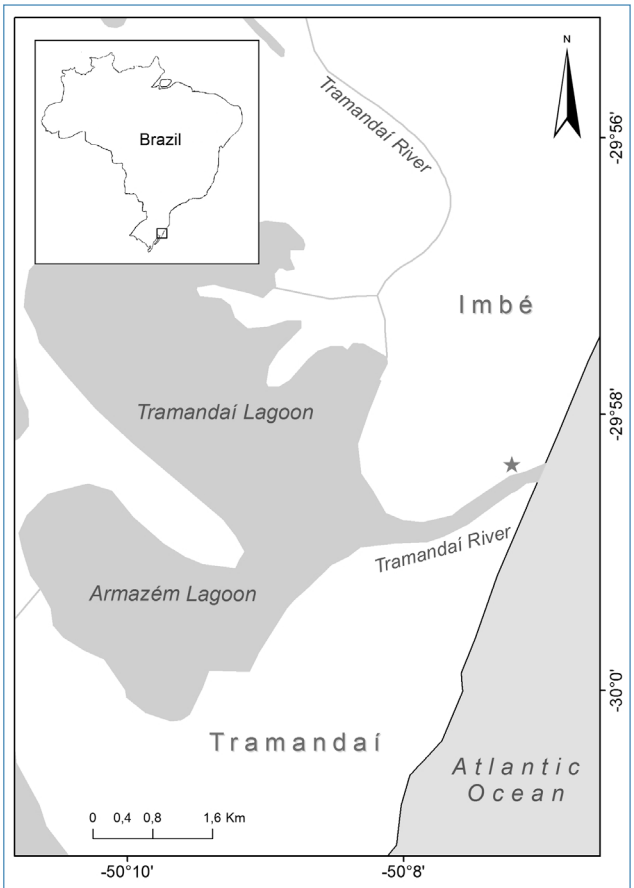

Figure 1. The study area in the northern coast of the Rio Grande do Sul State, southern Brazil. The 'star' indicates the location of the land-based observations in the Tramandaí Estuary.

[1]County Decree number 49 of the city of Imbé, January 31st, 1990, states *Tursiops truncatus* as city's natural heritage.

[2]Moreno, I.B., Ott, P.H., Tavares, M., Oliveira, L.R., Borba, M., Driemeier, D., Nakashima, S.B., Heinzelmann, L.S., Siciliano, S. and Van Bressem, M-F. (2008) Mycotic dermatitis in common bottlenose dolphins (*Tursiops truncatus*) with a confirmed record of lobomycosis disease. Paper SC/60/DW1 presented at the 60th annual meeting of the *Scientific Committee of the International Whaling Commission*, Santiago, Chile, 1-3 June 2008.

[3]Tabajara, L. (1992) Aspectos da relação pescador-boto-tainha no estuário do Rio Tramandaí – RS. Pages 17-49 *in* Padilha, E. and Trindade, H. (Eds) *Concurso Botos do rio Tramandaí: trabalhos premiados.* Prefeitura Municipal de Tramandaí and Universidade Federal do Rio Grande do Sul, Porto Alegre, Brazil.

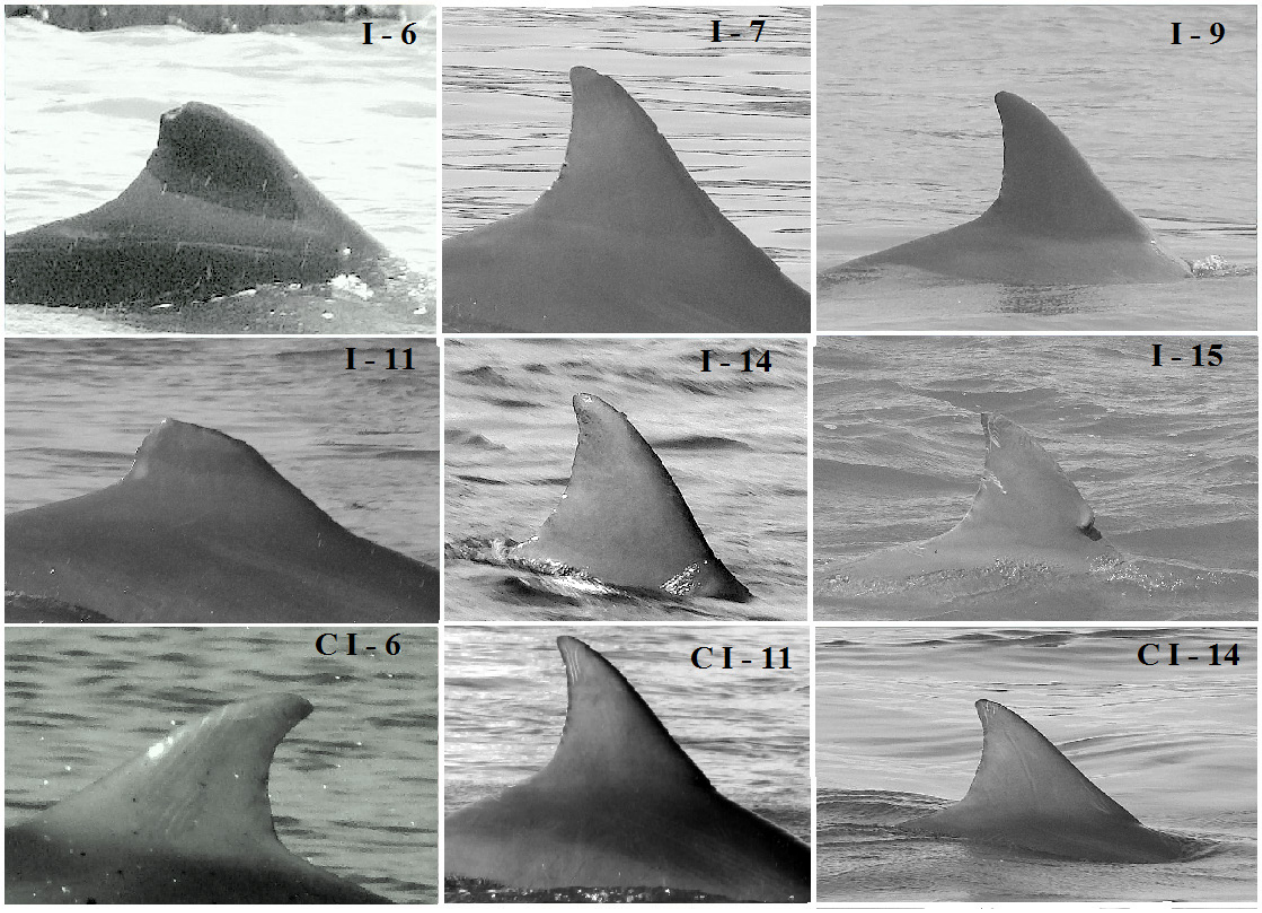

Figure 2. Common bottlenose dolphins (*Tursiops truncatus*) identified in the Tramandaí Estuary, southern Brazil, between January 2009 and February 2010.

1984). Sea-surface temperatures in the region range along the year from 13°C to 25°C, with a mean of 18°C (Avila *et al.*, 2009).

The estuary has many marine fish species that use the area at some stage of their life cycle; for example when growing or spawning (Silva, 1982; Ramos and Vieira, 2001). In this area, mullets are abundant, especially during autumn and they are one of the most exploited species used by local fishermen and also by the dolphins in the estuary (Simões-Lopes and Fabian, 1999; Zappes *et al.*, 2011).

Data collection and analysis

Land-based observations of common bottlenose dolphins were conducted between January 2009 and February 2010 from shore on the margin of the mouth of the Tramandaí Estuary. These observations included photographic surveys that were conducted three days a week, lasting on average 2.6 hours per day (SD = 0.6). Observations were conducted mainly in the morning, usually between 08:00h and 11:00h.

Photographs were taken using a digital camera with 15x optical image stabilization zoom. Dolphins were identified from photographs based primarily on the size, location, and pattern of nicks and notches on the trail edge of the dorsal fin (Würsig and Würsig, 1977; Würsig and Jefferson, 1990). Body scarring and pigmentation patterns were also used as complementary features to identify individuals. Both left and right-side photographs were analyzed. Approximately 2050 photographs were taken and the best image of each dolphin was compiled into a catalog of all identified individuals from the study area. Digital manipulation of photographs was performed using a computer program (Picasa 3© 2003-2009 Google Inc.), to adjust color and image overlay. When individuals exhibited similar dorsal fins, the dorsal fin ratio was also used to double-check the identifications (Defran *et al.*, 1990).

To investigate the long-term residence of dolphins in the region, photographs taken in the Tramandaí Estuary by other authors (*e.g.* Tabajara, 1992; Simões-Lopes, 1995; Hoffmann, 2004), between 1991 and 2004, were also examined. We used two measures to investigate the residency patterns of the common bottlenose dolphin. First, we counted the number of days each marked individual had been identified during the study period (January 2009-February 2010), defined as a residence index. Secondly we analyzed the degree of multi-year residency (*i.e.* long-term site fidelity) using a large period data set (1991-2010). In the first analysis, a 'year-round resident' was defined as a dolphin resighted in more than five months during a year; a 'seasonal resident' as a dolphin

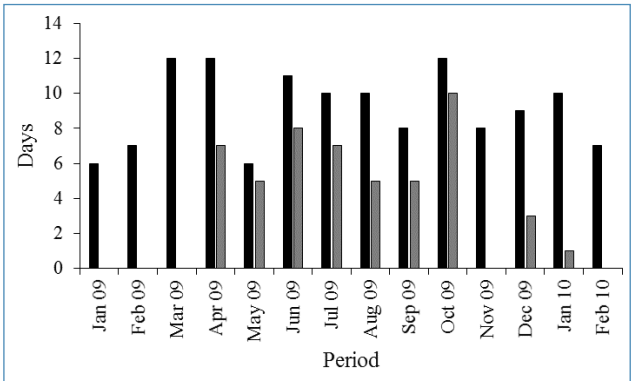

Figure 3. Total sampling effort (in black) and sightings (in gray) of common bottlenose dolphins in the Tramandaí Estuary, southern Brazil, between January 2009 and February 2010.

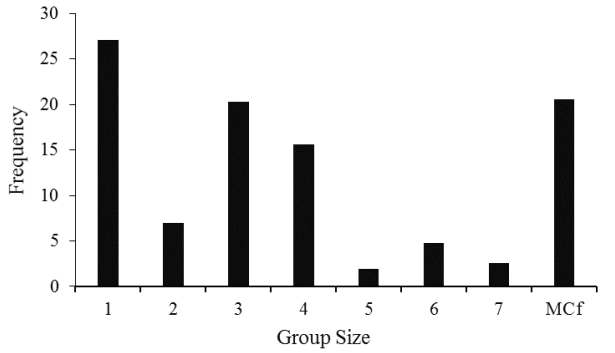

Figure 4. Frequency of group size of common bottlenose dolphins (*Tursiops truncatus*) in the Tramandaí Estuary, southern Brazil, between January 2009 and February 2010. MCf = Mother and calf pair.

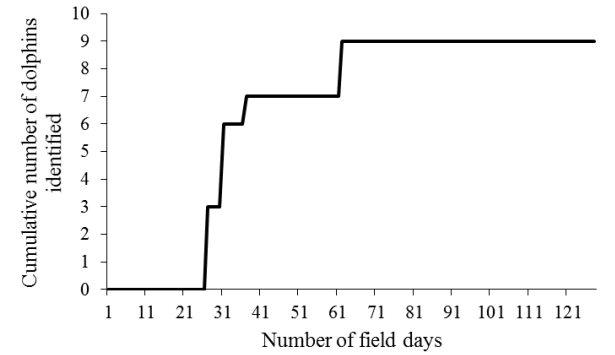

Figure 5. Discovery curve for individually identified common bottlenose dolphins in the Tramandaí Estuary, southern Brazil, between January 2009 and February.

resighted between three and five months, and a 'transient' was defined as a dolphin resighted less than two months during a one-year period (Ananias *et al.*, 2008). In the second analysis, 'multi-year resident' was considered as a dolphin recorded in at least two different years in the region.

Results

From January 2009 to February 2010, 128 days were dedicated to searching for common bottlenose dolphins in the Tramandaí Estuary, totaling 335 hours of observation effort. The number of sampling days was similar in all four austral seasons: summer (December-February; n = 39), autumn (March-May; n = 30), winter (June-August; n = 31) and spring (September-November; n = 28).

During this period, nine individuals were identified, of which three were calves (dolphin identification numbers: I-6, Calf I-6, I-7, I-9, I-11, Calf I-11, I-14, Calf I-14 and I-15; Table 1, Figure 2). Dolphins were present in 51 days (40%), during all seasons, with a greater frequency in autumn (79% of days) and winter (61%), followed by spring (45%) and summer (3%) (Figure 3). The maximum number of dolphins observed simultaneously within the estuary ranged from one to seven individuals (mean = 2.8 dolphins, SD = 1.35, n = 51). During a total of 52 hours and 24 minutes of effective observation of dolphins in the estuary, most of the time the individuals were sighted alone (27% of the time), in mother-calf pairs (21%), or in trios (20%) (Figure 4).

The trend of the discovery curve (Figure 5) suggests that an appropriate sampling effort was executed, and that a relatively small number of dolphins use the area. The residence index of the common bottlenose dolphins photo-identified within the estuary ranged from 0.02 to 0.24. Most individuals (55%) showed a degree of residence equal to or greater than 0.14. Of the six adult dolphins identified, five were classified as 'year-round residents' and one as 'seasonal resident'. On average, each adult dolphin was sighted 6.5 out of the 13 months of the study (range 3-8 months; Table 1). In addition, five dolphins were considered 'multi-year residents' based on the analyses of our images to those collected in previous studies (Tabajara, 1992; Simões-Lopes, 1995; Hoffmann, 2004). This long-term analysis revealed that four dolphins (I-6, I-7, I-9 and I-11) have been using the Tramandaí Estuary for at least 18 years (Table 1).

Discussion

Long-term site fidelity of common bottlenose dolphins has been observed for many coastal populations around the world, showing considerable variation among populations in their degree of residence and home ranges (*e.g.* Shane *et al.*, 1986; Wells and Scott, 1999; O'Brien *et al.*, 2010; Fruet *et al.*, 2011). Although periods of residence over 13 years have been previously reported for bottlenose dolphins in the Tramandaí Estuary (*e.g.* Simões-Lopes and Fabian, 1999; Moreno *et al.*, 2008), the results presented here extend this period to at least 18 years. This is probably one of the longest documented records of a residence time of common bottlenose dolphins in Brazilian waters.

Most of the dolphins also showed a high degree of residency within a year, and were classified as 'year-round residents' in the Tramandaí Estuary. However, the animals exhibited a

Table 1. Residence patterns of nine bottlenose dolphins (*Tursiops truncatus*) photo-identified in the Tramandaí Estuary, southern Brazil, between January 2009 and February 2010 (n = 128 days). Residence categories used in this study follow Ananias *et al.* (2008), whereas the long-term residence pattern was defined based on the comparison with previous studies (1 = Tabajara, 1992; 2 = Simões-Lopes, 1995; 3 = Hoffmann, 2004; 4 = this study).

Dolphin #	Nº of resighting days	Residence index	No. of resighting months	Residence pattern	
				Present study (Jan 2009-Feb 2010)	Long-term (1991-2010)
I-6	3	0.02	3	Seasonal resident	1, 2, 3, 4*
Calf I-6	3	0.02	3	-	4
I-7	18	0.14	8	Year-round resident	1, 2, 3, 4*
I-9	20	0.16	8	Year-round resident	1, 2, 3, 4*
I-11	31	0.24	7	Year-round resident	1, 2, 3, 4*
Calf I-11	29	0.23	7	-	4
I-14	18	0.14	7	Year-round resident	3, 4*
Calf I-14	11	0.09	5	-	4
I-15	11	0.09	6	Year-round resident	4

* Dolphins considered as multi-year residents.

seasonal pattern, with higher occurrence during autumn and winter. This result supports findings from previous studies (*e.g.* Simões-Lopes *et al.*, 1998). During autumn and winter the seasonal migration of mullets takes place, which is one of the main prey items consumed by common bottlenose dolphins in the region (Milmann, 2011). By contrast, dolphins were almost completely absent in the estuary during summer. We hypothesize that this absence could be related to lower prey availability or an increase in human recreational activities during this time of the year. Despite lacking data to test the latter hypothesis, a previous study suggested that the absence of dolphins in the area during the summer could be related to human disturbance (Simões-Lopes and Fabian, 1999).

Although most of the common bottlenose dolphins from the Tramandaí Estuary were classified as 'year-round residents' (*sensu* Ananias *et al.*, 2008), the most frequent animal was recorded during 31 of the 128 days (24%) during the study. In addition, some of the dolphins classified as 'multi-year residents' were not regularly observed in different years over a decade (1991-2010). This suggests that some individuals have a seasonal or discontinuous occurrence in the estuary and highlights the difficulty of classifying residence patterns based on a single criterion. For example, I-6, an easily recognizable female (Figure 2) called 'Catatau' by the fishermen, has been recorded in the estuary during multiple years since 1991 by different authors (Tabajara, 1992; Simões-Lopes *et al.*, 1998; Hoffmann, 2004). This individual showed the lowest residence index (0.02) during the present study and was classified as 'seasonal resident'; the same animal also presented a strictly seasonal occurrence in previous years (Hoffmann, 2004). However, another female (I-11, Figure 2), called 'Geraldona' by the fishermen, that also showed a characteristic seasonal pattern of occurrence some years ago (Hoffmann, 2004), had the highest residence index (0.24) in the present study.

Our results revealed a considerable degree of intra- and inter-annual variability in the use of the area by the individuals. In addition, the low sighting frequencies and long intervals between resightings of some well-marked animals clearly suggest that common bottlenose dolphins use the Tramandaí Estuary only as part of a more extensive range. However, an interesting aspect is the almost constant number of individuals found throughout the years. The available data collected since 1991 by different authors (*e.g.* Tabajara, 1992; Simões-Lopes *et al.*, 1998; Hoffmann, 2004; this study) reveals that, although some changes in group composition occurred (*i.e.* births and maybe deaths), an average of nine dolphins (including calves) has been commonly recorded over the years.

Long-distance movements (around 100 to 300km) of some photo-identified individuals between the Tramandaí Estuary and other estuaries in southern Brazil were already reported[4] (*e.g.* Simões-Lopes and Fabian, 1999; Hoffmann, 2004). In fact, photo-identification and molecular data suggest that the common bottlenose dolphins distributed over the different estuaries in southern Brazil (*i.e.* Laguna, Mampituba, Tramandaí and Patos Lagoon) are part of a larger population (*i.e.* a metapopulation, Simões-Lopes and Fabian, 1999; Fruet *et al.*, 2014).

[4]Möller, L.M., Simões-Lopes, P.C., Secchi, E.R. and Zerbini, A.N. (1994) Uso de fotoidentificação no estudo do deslocamento de botos, *Tursiops truncatus* (Cetacea, Delphinidae), na costa sul do Brasil. Pages 5-8 *in* Ximenez, A. and Simões-Lopes, P.C. (Eds) Anais, *6a Reunião de Trabalho de Especialistas em Mamíferos Aquáticos da América do Sul*, 24-28 October 1994, Florianópolis, SC, Brazil.

Therefore, integrated studies addressing these different local units are essential to better understand the dynamics of the common bottlenose dolphins in southern Brazil (Fruet *et al*., 2011). Additionally, the establishment of conservation measures in each estuary, as well as in adjacent regions, seems to be critical to guarantee the long-term persistence of these coastal units, as well as their unique foraging cooperation technique with artisanal fishermen.

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