



## Report of the Working Group on Habitat Use of *Tursiops truncatus* in the Southwest Atlantic Ocean

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### Introduction

The common bottlenose dolphin (*Tursiops truncatus* Montagu, 1821), hereafter referred to as bottlenose dolphin, is a cosmopolitan species that is found in coastal and pelagic environments of tropical and temperate oceans (Wells and Scott, 2008). The bottlenose dolphin is often recorded on coastal areas, being one of the best-studied cetaceans, and exposed to several threats linked to anthropogenic activities (chemical pollution, boat traffic, interaction with fisheries, to name a few) (Connor *et al.*, 2000).

Within the Southwest Atlantic Ocean (SWAO), many studies have focused on the bottlenose dolphin in the past few years. However, those studies have not covered its entire distribution range, and the studied areas involved distinct survey efforts. Knowledge of a species' habitat use is essential to guide management as areas where vital activities take place need to be identified in order to implement adequate management actions (Krausman, 1999).

The present review aimed to compile information about the habitat use patterns of bottlenose dolphins within the SWAO (4°N-56°S, 25°W-67°W) including the northern portion of Brazil (see Fruet *et al.*, 2016 Introduction, this volume) based on available literature. Personal communications provided by specialists were also included. Information includes both systematic and opportunistic surveys. Here, we provide a summary of the available information on the topic, a temporal analysis of survey effort allocation, as well as a spatial analysis indicating the areas where survey effort allowed the identification of

resident or seasonally resident populations. In addition, we also highlighted areas with few studies or gaps of information where survey effort should be concentrated in order to enhance the knowledge of the species and guide an integrated management strategy.

### Material and methods

The SWAO was divided into two zones, which were analyzed separately: 1) insular and oceanic and 2) coastal. As more specific data were available in the coastal zone, it was further divided into five regions: 2.1) northern Brazil; 2.2) northeastern Brazil; 2.3) southeastern Brazil; 2.4) southern Brazil and Uruguay and 2.5) Argentina (Figure 1) (see more details of division criteria in Fruet *et al.*, 2016 Introduction, this volume). Information from Uruguay was divided in La Plata River and Atlantic coast subareas due to differences in survey effort and occurrence of bottlenose dolphins (Laporta *et al.*, 2016 this volume).

### Data sources

A total of 28 peer-reviewed articles, one undergraduate monograph, three master's and four doctoral theses, one technical report, two books, eleven book chapters, six abstracts from congresses, six personal communications and 13 working papers presented during the *First Workshop on the Research and Conservation of Tursiops truncatus: Integrating knowledge about the species in the Southwest Atlantic Ocean*, held in Rio Grande, Rio Grande do Sul State (RS), Brazil in 21-23 May 2010, were used as source of data.

### Adopted definitions

#### Survey effort

We considered systematic surveys as those which had bottlenose dolphins as target species, were conducted in the same study area throughout the year, and which survey effort covered all seasons of the year (even if only during one single year) or the same seasons during two or more years. We considered as opportunistic surveys those which came from studies focused on different target species (*e.g.* general cetacean monitoring surveys), those focused on bottlenose dolphins but with a reduced survey effort (not covering all seasons for at least a year or if time-limited, *e.g.* a month or less), or if the study area changed between surveys (*e.g.* data from seismic ships).

#### Habitat use

We defined habitat use as the way an animal or population uses its habitat behaviorally (*e.g.* foraging, reproduction), regardless of season and how the animals move within the space (modified from Litvaitis *et al.*, 1994; Krausman, 1999).

#### Preference areas

A preference area was considered an area that shows highest frequency of sightings or greater density of animals in relation to other areas within the study area (Krausman, 1999).

#### Movement

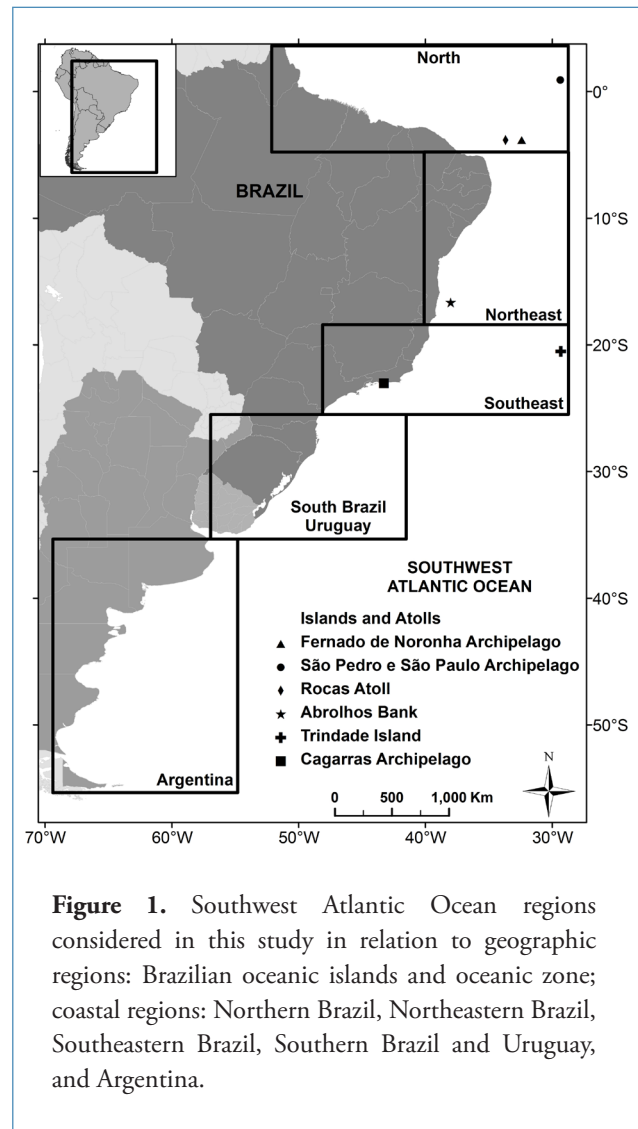
We defined movement as the displacement of an identified animal between different study areas. The movement was characterized by the distance traveled and the time interval between the animal recaptures. Animal recapture refers to a photographic capture of an identified individual in the same area or in different areas over time. It could be used as a proxy to the connectivity of two or more areas.

#### Resident, partially resident and seasonally resident populations

Different definitions were used by the studies considered in this review. In order to standardize a definition of resident population we proposed one based on the studies of Wells (1991), Ballance (1992), Simões-Lopes and Fabian (1999), Zolman (2002) and Hardt *et al.* (2010). We defined a resident population as one in which most identified individuals exhibited year-round presence within the study area limits. A partially resident population was considered when individuals were present during three seasons of the year within the study area. A seasonal resident population was defined as one in which individuals were present at the same specific seasons during consecutive years within the study area limits. Transient animals were considered those that were observed during only one season or only once during the study period, within the study area limits.

#### Site fidelity

The concept of site fidelity as the trend of an animal to occupy an area or to return to a previously occupied area for a certain time period (White and Garrot, 1990) was used to reinforce the residency of a population, characterized when an identified individual was recorded in the same study area on different occasions.



**Figure 1.** Southwest Atlantic Ocean regions considered in this study in relation to geographic regions: Brazilian oceanic islands and oceanic zone; coastal regions: Northern Brazil, Northeastern Brazil, Southeastern Brazil, Southern Brazil and Uruguay, and Argentina.

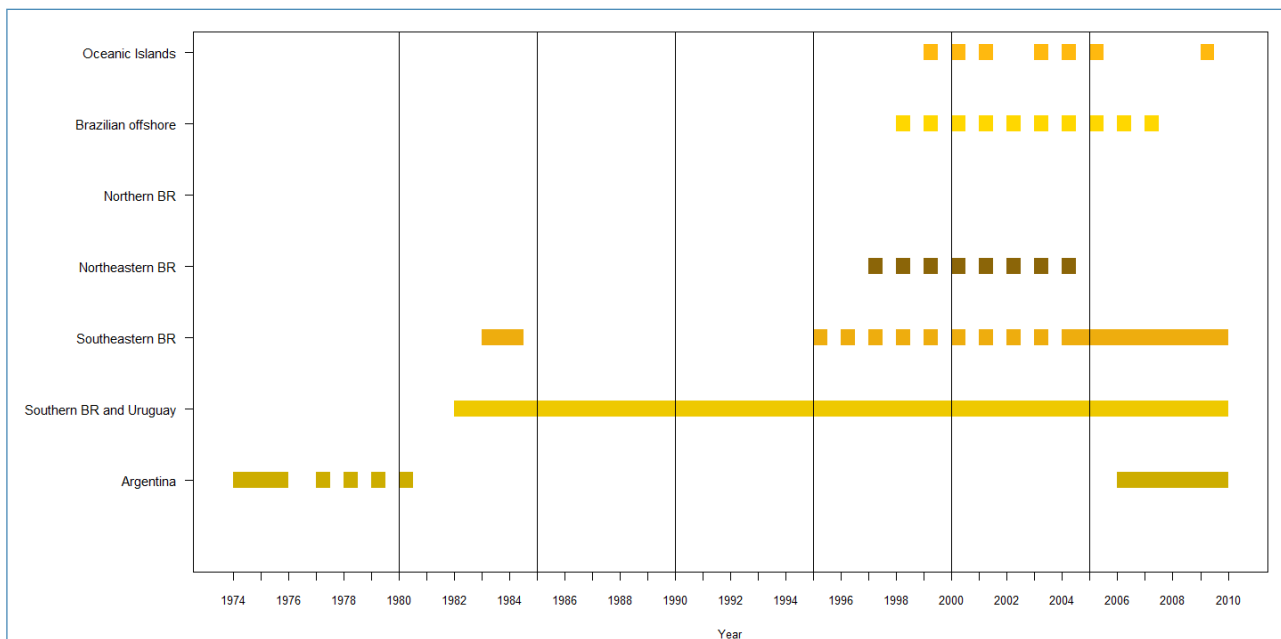
### Data analysis

Available data was compiled in an *Access* database. Survey effort was used for a temporal analysis of effort allocation by region and area. A global synthesis of survey effort was presented encompassing the last 40 years (1970–2010) along with a detailed portrait of the period from 1995 to 2010 (R Development Core Team). The *ArcMap*<sup>TM</sup> (version 9.2, 2006) geographic information system was used to create a base map of residence patterns within the SWAO, as well as maps with a zoom on each region showing localities where habitat use studies of bottlenose dolphin have been carried out.

### Results

#### Spatio-temporal analysis of survey effort

The effort allocated to study bottlenose dolphins was highly variable in space and in time within the SWAO. Of a total of 57 references on habitat use of bottlenose dolphin analyzed, 40 (70%) were from systematic studies and 17 (30%) were from opportunistic studies.



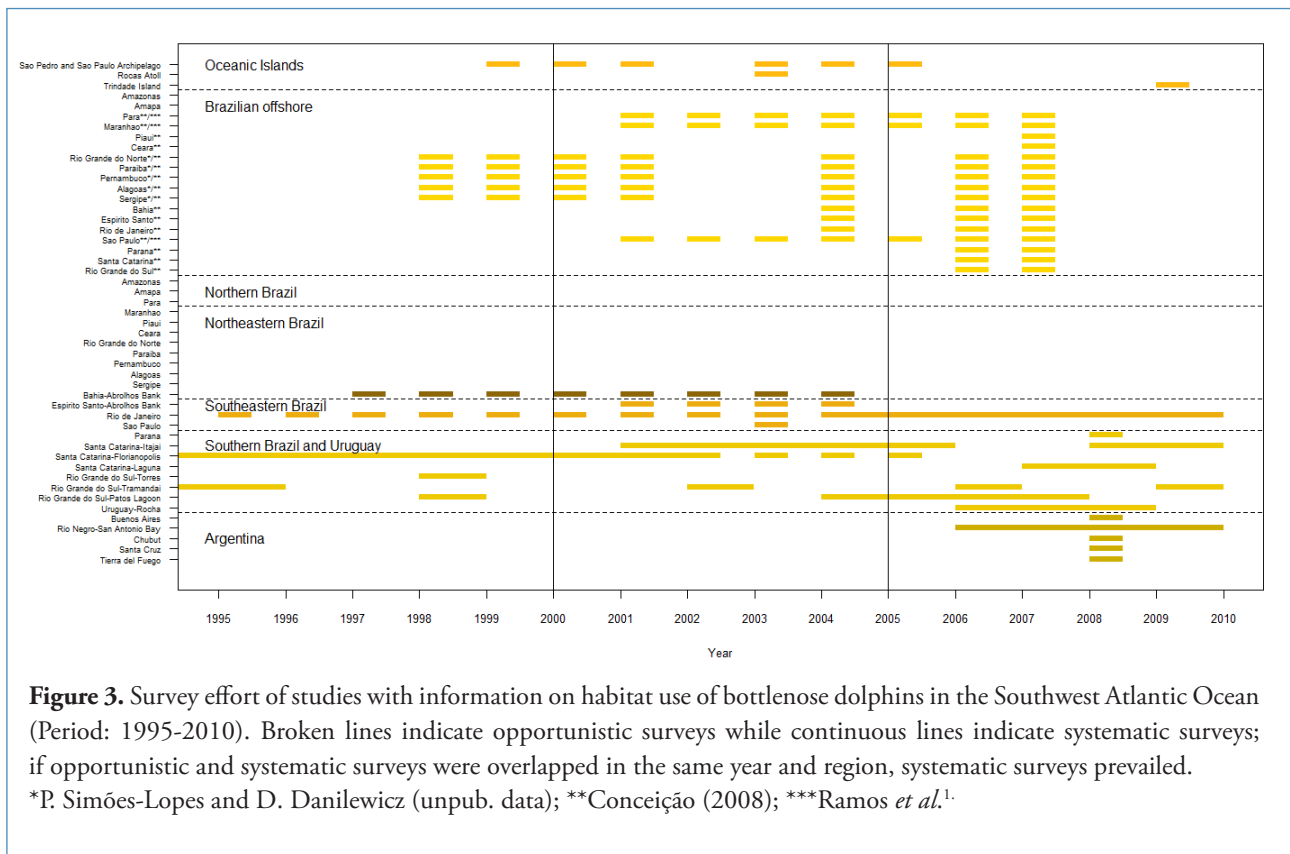
**Figure 2.** Survey effort of studies with information on habitat use of bottlenose dolphins in the Southwest Atlantic Ocean (Period: 1974-2010). Broken lines indicate opportunistic surveys while continuous lines indicate systematic surveys; if opportunistic and systematic surveys were overlapped in the same year and region, systematic surveys prevailed. BR = Brazil

The analysis of effort allocation among the considered regions within the SWAO highlights a complete gap of knowledge regarding bottlenose dolphins' habitat use in northern Brazil (Figure 2), where non-systematic studies were conducted and only one sighting was recorded. Opportunistic records were also predominant in northeastern Brazil, the oceanic islands, Brazilian offshore waters, as well as in northern Argentina (province of Buenos Aires). Although systematic surveys were carried out mostly in southeastern and southern Brazil, as well as in Uruguay and Argentina (Figure 2), in most regions the survey effort only began late in the 1990s, illustrating an important lack of knowledge between 1970 and 1980. Although the study of the species in Argentina began early in the 1970s, it was interrupted until 2006. Greater survey effort regarding habitat use is observed in southern Brazil and Uruguay region (Figure 2).

Survey effort distribution from 1995 to 2010 within each region is illustrated in Figure 3. In this time frame, scarce information regarding bottlenose dolphin habitat use was produced for the oceanic islands and was based mainly on opportunistic surveys. Although the study carried out in São Pedro and São Paulo Archipelago (SPSPA) was considered as opportunistic based on the adopted definition, the area has been annually monitored since 1999; however, not always the same seasons were surveyed each year. Survey effort in the Brazilian offshore region was also characterized by opportunistic surveys but some of them were repeated periodically covering many Brazilian states. Most surveys were targeting different species (*e.g.* common minke whale,

*Balaenoptera acutorostrata*) or were conducted from seismic vessels.

Regarding coastal regions, just one sighting was recorded in northern Brazil. In the Abrolhos Bank (northeastern to the southeastern regions of Brazil), opportunistic sightings of bottlenose dolphin were recorded during surveys of humpback whale (*Megaptera novaeangliae*). Information on habitat use for the species in southeastern Brazil was systematically collected around Cagarras Archipelago since 2004 and around Arraial do Cabo between 1983 and 1984, both in Rio de Janeiro State (RJ) (Figure 3). In the coast of Paraná State (PR, southern Brazil) little information has been collected since 2008. In southern Brazil region, systematic studies were conducted in Itajaí River and Florianópolis Island, both in Santa Catarina State (SC), during nine and 10 years, respectively. In RS, while Torres is one of the areas with the least information about habitat use of bottlenose dolphins, discontinuous studies in Tramandaí River, less than 100km south, were conducted for seven years; this is the area with greatest opportunistic survey effort (13 years) for southern Brazil, considering studies before 1995. In Patos Lagoon Estuary discontinuous systematic studies regarding occurrence, abundance estimates and behavior of bottlenose dolphins were carried out from 1977 to 2002 inside the estuary (*e.g.* Castello and Pinedo, 1977; Dalla Rosa, 1999; Mattos *et al.*, 2007). Since 2006, efforts have been conducted to study habitat use of the species inside and on the adjacent marine coast of the estuary. In Uruguay, systematic studies regarding bottlenose dolphins started in 2002, however,



habitat use information is only available since 2006. Similarly, in Argentina, early studies started in 1974 and lasted until 1980. Later, since 2006, a new systematic study on habitat use began in southern areas of Patagonia.

Since 2004, several systematic studies regarding residence and movement patterns, distribution in relation to environmental and physiographic variables and other habitat use aspects have been carried out in Cagarras Archipelago, Itajaí and Patos Lagoon (southern Brazil), Uruguayan Atlantic coast and San Antonio Bay (Argentina).

### Habitat use patterns

In the coastal zone, the habitat use of the species is characterized by 1.6 to 50m deep waters. In oceanic islands, sightings related with water depth and distances from shore were recorded in Rocas Atoll, SPSPA and Trindade Island showing greater frequency on depths between 5 and 200m. Most offshore sightings were recorded up to the 400m isobaths<sup>1</sup> but occurrence in deeper waters has been recorded in 4017m (Conceição, 2008).

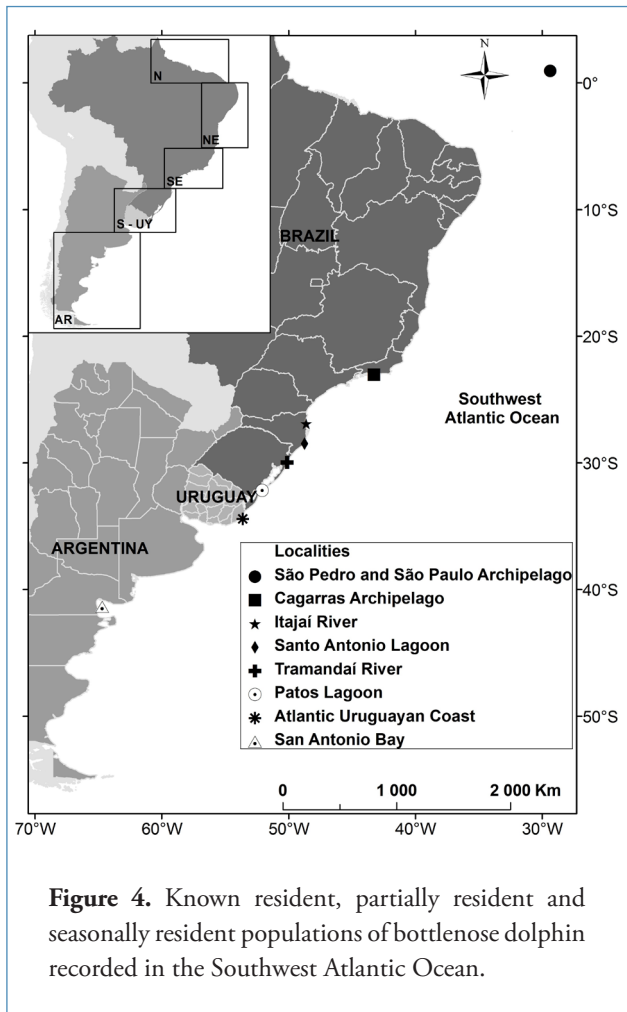
Within the SWAO, the occurrence of bottlenose dolphin is associated with bays, coastal islands, estuarine habitats and exposed beaches (see Lodi *et al.*, 2016 Report of the Working Group on Distribution, this volume). The association with estuarine systems is mainly observed to the south of Florianópolis Island. The presence of Guiana dolphins (*Sotalia guianensis*) within estuarine systems from Florianópolis Island to the north was suggested as a possible explanation for the absence of bottlenose dolphins in this ecosystem type<sup>2</sup>. Nevertheless, the species is also found in pelagic waters associated with oceanic islands, atolls and over the continental slope edge, showing plasticity to use different environmental conditions.

### Resident, partially resident and seasonally resident populations

The systematic studies undertaken until the present resulted in the identification of some resident and seasonally resident populations (Figure 4). Resident populations are found in estuarine regions, river mouths and coastal lagoons in SC and RS (Brazil). Partially resident populations were recorded along the open coast of Uruguay and in gulfs and

<sup>1</sup>Ramos, R., Poletto, F., Moreira, S., Erber, C., Dafferner, G., Freitas, R., Figna, V., Miranda, C., Alencastro, P., Carneiro, A., Fortes, R., Rinaldi, G., Demari e Silva, E. and Barbosa, M. (2010) Família Delphinidae: Outros pequenos golfinhos. Pages 649-728 in Ramos, R.M.A., Siciliano, S. and Ribeiro, R. (Orgs) *Monitoramento da biota marinha em navios de sismica: seis anos de pesquisa (2001-2007)*. Everst Tecnologia em Serviços / PGS Investigação Petrolífera Ltda., Vitória, Espírito Santo, Brazil. [Available in <http://ramosetal2010.blogspot.com>].

<sup>2</sup>Santos, M.C.O., Rosso, S. and Ramos, R.M.A. (2010) Bottlenose dolphins (genus *Tursiops*) in southeastern Brazil: insights on geographic variation based on skull morphology. Working Paper 51 presented during the *First Workshop on the Research and Conservation of Tursiops truncatus*, 21-23 May 2010, Rio Grande, RS, Brazil.



bays of Argentina. In Itajaí River and Cagarras Archipelago seasonally resident populations were identified.

Even if a large amount of information is available for southeastern and southern Brazil and Uruguay, there is no information about the number of populations which inhabit this region. Furthermore, despite the knowledge that some animals are moving between adjacent areas, little is known concerning the reproductive connectivity between populations.

### Movements

Movements of identified individuals between study areas were reported for various coastal regions of the SWAO, with the exceptions of the north and northeastern regions where no data is available. Movements were reported along various study areas of the southeastern Brazilian coast, along coastal areas of southern Brazil, between southern Brazil and Uruguay, as well as between coastal areas of Argentina. Movements ranged between 65 and 314km.

Overall, the studies suggest a strong relationship between the species' habitat use patterns and seasonal movements depending on the availability and distribution of prey species. However, in-depth studies of the species' habitat use patterns in relation to prey distribution and factors that

enhance prey availability are still lacking. Such studies are strongly encouraged as this information is essential in order to identify priority areas in which vital activities take place for conservation purposes.

## Overview by region of SWAO

### 1 Islands and oceanic zones

#### 1.1 Brazilian oceanic islands

Information on bottlenose dolphin's habitat use is only available for SPSPA, one of the five oceanic islands of Brazil. In Rocas Atoll and Trindade Island opportunistic sightings were recorded and information of habitat use is restricted to a few sightings. In Fernando de Noronha no information on habitat use is available (see Lodi *et al.*, 2016 Report of the Working Group on Distribution, this volume).

##### 1.1.1 São Pedro and São Paulo Archipelago

From June 1999 to June 2001 and from December 2003 to February 2005, a total of seven expeditions (each ranging from 13 to 27 days of duration) were conducted to the SPSPA. Eighty-six daily surveys were carried out around the archipelago and a total of 17 different animals were identified, five of which were resighted in multiple years and one of which was observed systematically over the entire period of study (Moreno *et al.*, 2009; Ott *et al.*, 2009), suggesting that some animals present high site fidelity. Bottlenose dolphins were recorded within the whole study period and at least three identified individuals were continuously observed since 2005<sup>3</sup>.

The studies reported that sightings were mainly concentrated within a radius of approximately 3.8km around the archipelago, with a greater preference for the eastern side during the morning (before 10:00h) (Moreno *et al.*, 2009; Ott *et al.*, 2009). The archipelago is part of the mountain chain of the Mid-Atlantic Ridge with surrounding depths up to 4000m. In this area, the dolphins have been observed mainly at depths between 20 and 200m, very close to the islands<sup>4</sup>, using it as a feeding area (Moreno *et al.*, 2009; Ott *et al.*, 2009).

Results of a preliminary large scale genetic analysis of samples from different parts of Brazil support the hypothesis that the population that inhabits the archipelago is small and isolated (Moreno *et al.*, 2009; Ott *et al.*, 2009).

##### 1.1.2 Rocas Atoll

A total of four opportunistic sightings were recorded around the Rocas Atoll from 2003 to 2004. Animals were observed in waters 20 to 30m deep located between 100m and up to 6km from the island (Baracho *et al.*, 2007). Though the sightings were opportunistic in nature, there is information obtained from researchers conducting long-term monitoring of other species in the area that bottlenose dolphins are sporadically observed around the atoll<sup>5</sup>.

<sup>3</sup>P. Ott, pers. comm., 11 November 2012

<sup>4</sup>L. Milmann, pers. comm., 13 November 2012

<sup>5</sup>T. de Godoy, pers. comm., 27 March 2013

### 1.1.3 Trindade Island

During an opportunistic survey conducted around the Trindade Island, three groups of bottlenose dolphins were recorded, two in December 2009 and one in February 2010 (Carvalho and Rossi-Santos, 2011). The three sightings took place in waters 5 to 35m deep, at distances varying between 70 and 300m from the coast of the island (Carvalho and Rossi-Santos, 2011).

## 1.2 Oceanic zones

Since 1998, the Brazilian offshore region has been surveyed by different projects. All the surveys reported information that improve our knowledge of bottlenose dolphins' habitat use, as well as identify areas where survey effort must be concentrated in future studies targeting the species. Nonetheless, few opportunistic records of bottlenose dolphin exist for Uruguayan and Argentinean oceanic regions (see Lodi *et al.*, 2016 Report on the Working Group on Distribution, this volume). No information about habitat use in those areas is available.

### 1.2.1 Brazilian oceanic region

A total of four cruises were carried out to study common minke whale (*Balaenoptera acutorostrata*) between Rio Grande do Norte (RN) and the Sergipe states (4°33'S, 36°50'W-10°32'S, 36°00'W) from 1998 to 2001. During those surveys, 54 groups of bottlenose dolphins were recorded along the continental shelf, up to 200m deep and only four sightings were made up to the 400m isobath<sup>6</sup>.

Three other surveys were conducted on board of the bulk carrier vessel *N/M Frotargentina* covering the offshore region linking different Brazilian states: i) January-February 2004 from São Paulo (SP) to RN states, ii) August 2006 from RS to RN states and iii) January-March 2007 from RS to Pará states. From these three study periods, a total of 39 sightings were recorded from shallow to deep waters (ranging from 14 to 4017m depth) (Conceição, 2008).

In addition, a total of 76 groups of bottlenose dolphin were sighted during monitoring conducted onboard seismic vessels between October 2001 and January 2007<sup>1</sup>. The monitoring covered the area between 01°20'N (Pará/Maranhão Basin) and 27°10'S (Santos Basin). Sightings were more frequent in higher latitudes (20°S-27°S), accounting for 63% of the groups (n = 48) observed. In mid latitudes (10°S-19°S) 25% of the groups (n = 19) were recorded, and finally only 11% of the groups (n = 9) were detected in lower latitudes (01°N-09°S). A preference for the isobaths of 50-100m, comprising 50.7% of the sightings, was observed. However, sightings were recorded at depths ranging from 25 to 1501m, although one sighting was registered at 2757m depth. Occurrence was predominant during summer (43%) and autumn (29%)<sup>1</sup>. However, survey effort was not corrected to take into account the effort that varied by season.

## 2 Coastal zones

### 2.1 Northern Brazil

The northern region is characterized by a complete lack of information on habitat use patterns for bottlenose dolphins. Only one sighting was found in the literature (see Lodi *et al.*, 2016 Report of the Working Group on Distribution, this volume). However, this reflects a lack of systematic research effort towards cetacean species in the region and not necessarily a discontinuity of the species' distribution.

### 2.2 Northeastern Brazil

Along the northeastern coast of Brazil, information regarding bottlenose dolphins' habitat use patterns is scarce. The only available information comes from data collected in studies directed towards humpback whales (Rossi-Santos *et al.*, 2006).

During all systematic surveys conducted between July and November from 1997 to 2004 to study the ecology of humpback whale around the Abrolhos Bank region (which comprises the coastal area of southern Bahia State and northern Espírito Santo State) 151 sightings of three odontocete species were recorded. Only 9% of these sightings (n = 18) were of bottlenose dolphins. Nevertheless, bottlenose dolphins were the most widely distributed species, occurring in areas with varying depths (median = 23m; range 23 to 65m) and from the Abrolhos Archipelago surroundings to the southern edge of the Abrolhos Bank, within 11 and 70km from shore (Rossi-Santos *et al.*, 2006). Due to the low frequency of occurrence, an in-depth analysis of seasonality of occurrence and movement patterns is not yet possible.

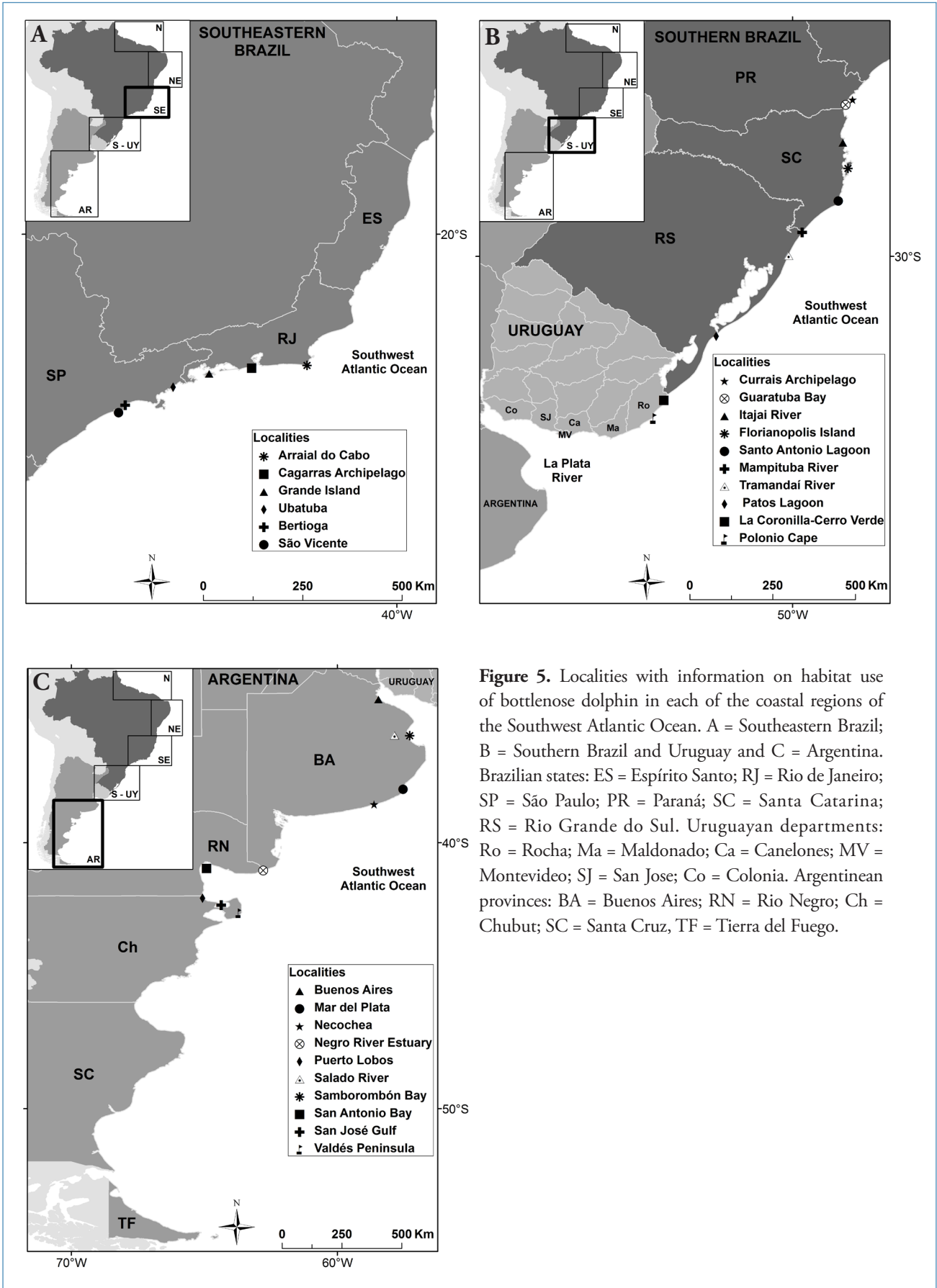
### 2.3 Southeastern Brazil

Opportunistic and systematic studies were carried out in southeastern Brazil. The study conducted in Abrolhos Bank also included the southeastern region (see Figure 3 and Figure 5A). The opportunistic studies were compiled for RJ (Lodi, 2016 this volume). Two systematic studies were conducted in the region, a short-term study carried out in 1983-1984 in Arraial do Cabo<sup>7</sup> and a midterm study conducted in Cagarras Archipelago, which reports in-depth information regarding population size, habitat use, residence and movements patterns (*e.g.* Lodi *et al.*, 2009; 2014).

A summarization in Lodi (2016 this volume) shows the potential patterns and trends of the distribution of bottlenose dolphins using the data gathered in a compilation between 1980 and 2010. Data heterogeneity does not allow in-depth analysis of habitat use patterns. However, the highest frequency of records (61.2%, n = 76) was found in the northern area of RJ. The species was recorded in every month, but with a

<sup>6</sup>P. Simões-Lopes and D. Danilewicz, unpub. data

<sup>7</sup>Gomes, L.A. (1986) Análise sobre a ocorrência de *Tursiops truncatus* na região de Arraial do Cabo (Rio de Janeiro, Brasil). Pages 122-131 in Castello, H.P. and Waiss, I.R. (Eds) Acta, *Primera Reunión de Trabajo de Expertos en Mamíferos Acuáticos de América del Sur*. 25-29 June 2004, Buenos Aires, Argentina.



**Figure 5.** Localities with information on habitat use of bottlenose dolphin in each of the coastal regions of the Southwest Atlantic Ocean. A = Southeastern Brazil; B = Southern Brazil and Uruguay and C = Argentina. Brazilian states: ES = Espírito Santo; RJ = Rio de Janeiro; SP = São Paulo; PR = Paraná; SC = Santa Catarina; RS = Rio Grande do Sul. Uruguayan departments: Ro = Rocha; Ma = Maldonado; Ca = Canelones; MV = Montevideo; SJ = San Jose; Co = Colonia. Argentinean provinces: BA = Buenos Aires; RN = Rio Negro; Ch = Chubut; SC = Santa Cruz, TF = Tierra del Fuego.

higher frequency during the austral summer (50.8%, n=63) (Lodi, 2016 this volume).

In Arraial do Cabo (22°57'S, 42°01'W), a total of 29 field surveys (717h of effort) were conducted between April 1983 and 1984, and 130 groups of bottlenose dolphins were observed. Sightings were more frequent during autumn and winter. In general, dolphins were using the coastal area, but some sightings were also recorded up to 8km from the shore. The area presented high bathymetric variability, but the dolphins were seen mainly in areas of 4 to 50m deep<sup>6</sup>.

The mid-term systematic study was conducted at the Cagarras Archipelago from 2004 to 2012 (e.g. Barbosa *et al.*, 2008; Lodi and Monteiro-Neto, 2012; Lodi *et al.*, 2014). The Cagarras Archipelago is located approximately three kilometers from Ipanema Beach and comprises three main islands (Das Palmas, Cagarras Grande and Comprida), three small islands and seven rocky outcrops. Search effort was mainly distributed within the insular complex which was covered homogeneously, while in the adjacent area effort was limited and restricted to a 1km radius<sup>8</sup> (Lodi *et al.*, 2014). The animals showed a preference for the mainland side of the archipelago, being frequently observed using the rocky shore of the protected side of Comprida Island and the channel which connects the protected waters with the open sea<sup>8</sup> (Barbosa *et al.*, 2008). Bottlenose dolphins occur mainly during austral winter and spring in the Cagarras Archipelago and sporadically during the rest of the year (Barbosa *et al.*, 2008; Lodi *et al.*, 2014).

Site fidelity was characterized with data collected from 65 field expeditions carried out from August to November in 2004 and 2006, August to October in 2007, 2008 and 2009 and August to November in 2010, totaling 229h of effective observation of bottlenose dolphins. Video-identified animals showed high site fidelity (sightings  $\geq 5$ ): 70% in 2004, 72% in 2006, 80% in 2007, 100% in 2008 and 2010 giving support to define a seasonally resident population in the area. Of the 29 individuals video-identified, 68.9% were considered to be resident for at least one of the four study years, and one individual was observed during the whole study period<sup>9</sup> (Lodi *et al.*, 2008; Lodi, 2009; Lodi *et al.*, 2009; Lodi and Tardin, 2013).

A higher number of adults (estimated body length  $\geq 2.5$  m) was recorded in the Cagarras Archipelago during the austral summer and autumn, in contrast to the low number of calves (up to 1/2 of adult size) observed<sup>8</sup>. Observations of calves are common in the austral winter and spring, which are also the seasons with higher frequency of sightings, and this supports the hypothesis that the archipelago may be used as a nursing or calving area by bottlenose dolphins during this particular time of the year (Lodi, 2009; Lodi and Monteiro-Neto, 2012).

Regarding the species movement patterns, evidence of displacement comes from two reports within the southeastern Brazil region, one from Cagarras Archipelago and another from SP. Eight individuals from the Cagarras Archipelago catalogue were resighted in November 2005 in a group of more than 20 animals (including calves) at Jorge Grego Island in Ilha Grande Bay (23°21'S, 44°15'W). The straight line distance between the two sightings is approximately 100km to the south (Lodi *et al.*, 2008). In SP, a female often observed at Ubatuba and Bertioaga was found dead in 2003 at São Vicente, indicating a movement of 250km to the south (Santos *et al.*, 2010).

#### 2.4 Southern Brazil and Uruguay

Systematic studies of the species are being carried out in multiple areas along the coast of southern Brazil and Uruguay (Figure 5B). The species is usually associated with the mouth of estuarine systems and lagoons, as well as bays, coastal islands and exposed beaches. (e.g. Simões-Lopes and Fabian, 1999; Mattos *et al.*, 2007; Hoffmann *et al.*, 2008; Laporta *et al.*, 2016 this volume).

In PR, a total of eight opportunistic sightings of bottlenose dolphins were recorded along the coastal area. The habitat use was characterized by depths ranging from 5 to 30m around the Currais Archipelago (25°44'S, 48°21'W) and at the mouth of Guaratuba Bay (25°52'S, 48°34'W). Information obtained from interviews with local fishermen suggests that the bottlenose dolphin is commonly observed during the winter at the estuary of Guaratuba Bay, which might be related to the occurrence of mullet *Mugil* sp. in the area<sup>10</sup> (Monteiro-Filho *et al.*, 1999).

Along the coast of SC different studies have been conducted (Figure 2) and information is available for Itajaí, Florianópolis Island and Laguna<sup>11,12</sup> (Simões-Lopes and Fabian, 1999; Flores and Fontoura, 2006; Wedekin *et al.*, 2008; Daura-Jorge *et al.*, 2012). The study of Flores and Fontoura (2006) in Florianópolis Island was part of a systematic study carried out between February 1993 and December 2002. Although the target species was the Guiana dolphin, all observations of bottlenose dolphins were systematically recorded in the entire study area and in all seasons during the entire period. For that reason this study was considered here as systematic for the species.

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<sup>10</sup>Domit C., Weber Rosas, F.C., Rosso-Londoño, M.C., Ougo, G., Bracarense, A.P.F.R., Domiciano, I.G., Beloto, N. and Monteiro-Filho, E.L.A. (2010) Ocorrência de *Tursiops truncatus* (Montagu, 1821) no litoral do estado do Paraná, no período de 1997/1999 e 2007/2009. Working Paper 15 presented during the *First Workshop on the Research and Conservation of Tursiops truncatus in the Southwest Atlantic Ocean*, 21-23 May 2010, Rio Grande, RS, Brazil.

<sup>11</sup>Da Silva, T.T., Flores, P.A.C. and Barreto, A.S. (2010) Matching photo-identified bottlenose dolphins between two coastal areas off Santa Catarina State, south Brazil. Working Paper 62 presented during the *First Workshop on the Research and Conservation of Tursiops truncatus in the Southwest Atlantic Ocean*, 21-23 May 2010, Rio Grande, RS, Brazil.

<sup>12</sup>Demessiano, K.Z. e Barreto, A.S. (2010) Estimativa populacional de *Tursiops truncatus*, da Foz do Rio Itajaí, SC, a partir da técnica de foto-identificação e de modelos de marcação-recaptura. Working Paper 42 presented during the *First Workshop on the Research and Conservation of Tursiops truncatus in the Southwest Atlantic Ocean*. 21-23 May 2010, Rio Grande, RS, Brazil.

<sup>8</sup>L. Lodi, pers. comm., 20 October 2012

<sup>9</sup>Lodi, L. (2010) Padrão de residência de *Tursiops truncatus* (Cetacea, Delphinidae) no Arquipélago das Cagarras, Rio de Janeiro, sudeste do Brasil. Working Paper 05 presented during the *First Workshop on the Research and Conservation of Tursiops truncatus in the Southwest Atlantic Ocean*, 21-23 May 2010 Rio Grande, RS, Brazil.



The study conducted in Itajaí suggested the presence of a seasonally resident population occurring mainly during the winter<sup>12</sup>. However, the animals were not observed in the area since the beginning of the dredging of the channel in 2006<sup>12,13</sup>. Later in the same year, dolphins were sighted again at the mouth of Itajaí River and between August 2008 and April 2010 a total of 10 individuals were identified in 13 days of survey and point out the existence of a small seasonally resident population, although some animals were observed in two and three seasons. It was estimated that between 11 and 18 individuals use this area with a higher frequency during winter. The downstream portion of the river (mean depth of 8m) was preferred, even though they were also observed in adjacent waters. To date, the photo-identification catalogue is composed of 14 individuals<sup>12</sup>.

The studies conducted in Florianópolis Island (Flores and Fontoura, 2006; Wedekin *et al.*, 2008) reported a high number of individuals, but scarce information on habitat use patterns is available. Besides, the species' habitat use patterns in the area support the tendency of habitat plasticity commonly observed for this species. The coastal lagoons in the vicinity of Laguna City present a resident population (Simões-Lopes and Fabian, 1999; Daura-Jorge *et al.*, 2012).

Information regarding the species' habitat use and seasonality of occurrence in SC coastal waters is available from two independent studies which covered the region of Florianópolis Island (Flores and Fontoura, 2006; Wedekin *et al.*, 2008). During this period, 226 boat-based surveys were carried out in North Bay and bottlenose dolphins were commonly observed in the area primarily in the outer coast of the island, with few sightings in the inner coast. Sightings were frequent in winter and rare in summer. Animals of all age classes were observed, but 55.6% of the groups were formed by adults only (Flores and Fontoura, 2006). A total of 39 individuals were photo-identified in the area<sup>11, 14</sup>.

The other study (Wedekin *et al.*, 2008) compiled opportunistic sightings of the species between 1989 and 2005. The authors reported 71 sightings of bottlenose dolphins. The species was observed using the protected waters (North and South bays), as well as open areas off the eastern portion of Florianópolis Island, and the continental portions in the northern and southern limits of the island. Groups were also observed using the internal channels of both bays and the shallow areas adjacent to the mangroves of Saco Grande, Ratonés and Itacorubi.

The coastal system composed by Santo Antônio, Imaruí and Mirim lagoons, adjacent to the town of Laguna (SC), has a small and resident population of bottlenose dolphins,

whose distribution seems to be restricted to the lagoon system (Simões-Lopes and Fabian, 1999; Daura-Jorge, 2011). Between 1989 and 1991, the groups were mainly concentrated around the mouth of the channel between the lagoon system and the sea, especially during autumn and winter. A total of 26 individuals were identified, from which 88.5% were considered to be residents (Simões-Lopes and Fabian, 1999). From 2007 to 2009, the intensive utilization of this channel was continuously recorded, though bottlenose dolphins were also observed throughout the lagoon system. However, at the Imaruí and Mirim lagoons the sightings were occasional and not sufficient to define the home range limits (Daura-Jorge, 2011). In addition, despite the same survey effort along the coastal area, animals were not observed outside of the lagoon system farther than 1km from the mouth of the channel. The lagoon system presents shallow waters (mean=2m), although the area where dolphins concentrate, the connection channel, is up to 10m deep (Daura-Jorge, 2011). Thus, the distribution pattern was heterogeneous, with a well-defined core area. The largest individual home range was 51.4 and 70.6km<sup>2</sup>, depending of the method used (Daura-Jorge, 2011). The authors also did not observe seasonal fluctuations and determined that the use of areas inside the lagoon system was related to the tides and the dolphins' feeding strategies. The home range at the internal side of the lagoon system is larger at the end of the flooding tide and the beginning of the low tide. Individual home range sizes vary among the animals depending on whether they cooperate or not with beach-casting fishermen (Daura Jorge, 2011). The population size varied between seasons (Daura-Jorge *et al.*, 2012), which could be explained by ecological factors that determine prey availability. The mullet, which is an important item of the dolphins' diet, shows local spatial patterns of occurrence and temporary emigration (Vieira and Scalabrin, 1991). Mullet and Atlantic white croaker (*Micropogonias furnieri*) use estuarine systems for their development to maturity. It is known that between April and May (which corresponds to austral autumn) adults form large schools of mullet in the estuary and initiate reproductive migration in coastal areas (Vieira and Scalabrin, 1991). Similarly, mature individuals of Atlantic white croaker begin their reproductive migration to the ocean during austral spring (Castello, 1986).

In Mampituba River mouth, located in Torres (northern RS), land based observations were carried out between August 1998 and November 1999. A total of seven individuals were identified whose presence varied from two to 13 months in the study area<sup>15</sup>.

<sup>13</sup>Britto, M.K. and Barreto, A.S. (2010) Effects of human activities on the behavior of bottlenose dolphins (*Tursiops truncatus*) in the Itajaí River mouth. Working Paper 39 presented during the *First Workshop on the Research and Conservation of Tursiops truncatus in the Southwest Atlantic Ocean*, 21-23 May 2010, Rio Grande, RS, Brazil.

<sup>14</sup>P. Flores, pers. comm., 22 May 2010

<sup>15</sup>Bernardi, L.R. and Freitas, T.R.O. (2000) Uso de fotoidentificação para o reconhecimento individual do boto, *Tursiops truncatus* (Cetacea, Delphinidae) no Rio Mampituba, Torres, RS. Page 13 in Abstracts, *9<sup>th</sup> Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur and 3<sup>rd</sup> Congress of Sociedad Latinoamericana de Mamíferos Acuáticos*, 30 October-3 November 2000, Buenos Aires, Argentina.

In the estuarine portion of Tramandaí River (north of RS), nine individuals were identified, five of which were considered as resident. Based on information collected by different studies, three animals have been observed in the area for at least 18 years (Simões-Lopes, 1995; Hoffmann, 2004; Giacomo and Ott, 2016 this volume). During 1996, 2002 and 2003, a total of 1446 hours of direct observation were made and eight adult dolphins were identified (Hoffmann *et al.*, 2008). Individuals were observed monthly throughout the year with a heterogeneous spatial distribution pattern. Bottlenose dolphin habitat use varied with group size. Usually groups were significantly larger in open areas than in restricted channels or passages, which could be related to different foraging techniques being used between these areas (Hoffmann *et al.*, 2008). During 2009 and 2010, the dolphins were also observed year-round but with a higher frequency in autumn and winter months, which corresponds to the mullet season in the area (Giacomo and Ott, 2016 this volume).

In the estuarine portion of Patos Lagoon, south of RS, boat surveys were carried out between January and November 1998 and from December 2004 to December 2012, showing a high resighting rate of identified individuals within years (>85%) (Dalla Rosa, 1999; Fruet *et al.*, 2015). Currently the population comprises approximately 88 (95% CI = 82-94) individuals inhabiting the Patos Lagoon Estuary (Fruet *et al.*, 2015).

Between September 2006 and July 2009, a habitat use study covered the internal area of the estuary and the coastal adjacent waters (20km to the north and to the south of the estuary mouth) (Di Tullio *et al.*, 2015). A total of 136 groups of bottlenose dolphins were observed in 69 surveys. A higher density of animals at the mouth of the estuary was observed during the spring and autumn, which is probably related to the mullet and Atlantic white croaker seasons, respectively (Di Tullio *et al.*, 2015).

Inside the estuary the higher densities of bottlenose dolphin were observed in areas with steep slopes in the vicinity of the estuary's mouth. In the adjacent coastal area, the density of animals decreased with the distance from the estuary's mouth. However, more distant areas were also used, up to 2000m from the coastline. In the coastal zone, the animals showed preference for the surf zone, in waters up to 4m deep (Di Tullio *et al.*, 2015).

Along the coast of Uruguay, in the estuary of La Plata River in Carrasco Beach (department of Montevideo), daily sightings of bottlenose dolphins were recorded in December 1949 and March 1950. Their movement patterns were mainly concentrated along the shore,  $\leq 200\text{m}$  off the coastline<sup>16</sup>. During the same period, artisanal fishermen were capturing large amounts of juveniles of the family Sciaenidae, a prey item that can be related to the presence of bottlenose dolphin<sup>16</sup>.

At La Coronilla Beach and Polonio Cape (department of Rocha), Atlantic coast of Uruguay, habitat use studies were

carried out from 2007 to 2009 in each area, totaling 52 surveys. All sightings were recorded up to 500m from shore, in waters up to 4m depth, with a preference for the vicinity of stream mouths and rocky shores, and in areas with higher turbidity<sup>17</sup> (Laporta, 2009).

The photo-identification catalogue for this area (La Coronilla and Polonio Cape) started in 2006. It is comprised of 39 different individuals, 62% of which were considered to be resident or partially resident. La Coronilla presented the highest rates of occurrence and resightings of identified animals<sup>18</sup> (Laporta, 2009; Laporta *et al.*, 2016 this volume). The high resighting rates between years (79% to 91.7%) indicate a resident population which exhibits large and frequent movements along the coastal area of Uruguay and extending into southern Brazil. The population was estimated at 61 (CI 95% = 53-73; CV = 0.1) individuals with a home range at least 130km<sup>2</sup> (Laporta *et al.*, 2016 this volume).

Regarding the movement patterns of the species, there is data available for PR, SC and RS states, and Uruguay. Two animals previously identified at North Bay were re-identified at the mouth of Itajaí River (northern SC), representing a movement of at least 100km<sup>11</sup>. Another dolphin also identified at North Bay in 2001, and observed over three consecutive years, was re-identified in Itajaí River in 2006 and 2009<sup>11</sup>. The last record of movement between these two areas was of an animal identified in 2003 at North Bay, which was re-identified in Itajaí River river in 2006 and 2009<sup>11</sup>. Another record for SC comes from an animal identified in Laguna that was resighted in Guaratuba (PR), approximately 270km to the north (Daura-Jorge and Simões-Lopes, 2008).

Movement was also recorded for four resident animals of the Imbé/Tramandaí region, RS. Two males moved 219km and a female moved 82km to the north of the Tramandaí Estuary<sup>19</sup>. One animal of unknown sex moved 314km to the south and 82km to the north. The movements occurred between Imbé/Tramandaí region and the area in front of the Mostardas Lighthouse (to the south), and from Mostardas up to Torres (to the north)<sup>19</sup>.

Despite the movements previously reported, Möller *et al.*<sup>19</sup> and Simões-Lopes and Fabian (1999) considered that the animals using the Imbé/Tramandaí region and Laguna belong to distinct populations. The same authors report that

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<sup>17</sup>Laporta, P., Di Tullio, J.C. and Secchi, E.R. (2010) Uso do habitat do boto *Tursiops truncatus* (Montagu, 1821) em La Coronilla e Cabo Polonio (Rocha, Uruguai). Working Paper 65 presented during the *First Workshop on the Research and Conservation of Tursiops truncatus in the Southwest Atlantic Ocean*, 21-23 May 2010, Rio Grande, RS, Brazil.

<sup>18</sup>Laporta, P., Fruet, P.F., Di Tullio, J.C. e Secchi, E.R. (2010) Padrão de residência e movimentos do boto *Tursiops truncatus* na costa atlântica uruguaia e o sul do Brasil. Working Paper 56 presented during the *First Workshop on the Research and Conservation of Tursiops truncatus in the Southwest Atlantic Ocean*, 21-23 May 2010, Rio Grande, RS, Brazil.

<sup>19</sup>Möller, L.M., Simões-Lopes, P.C., Secchi, E.R. e Zerbini, A.N. (1994) Uso de fotoidentificação no estudo do deslocamento de botos *Tursiops truncatus* (Cetacea Delphinidae) na costa sul do Brasil. Pages 24-28 in *Actas, 6º Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur*, 24-28 October, Florianópolis, SC, Brazil.

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<sup>16</sup>R. Bastida, pers. comm., 21 May 2010

the movements of bottlenose dolphins in southern Brazil are probably related to the search for prey species as they are concomitant with the annual migration of the mullet, even though Möller *et al.*<sup>19</sup> do not dismiss the possibility of these interchanges being associated to gene flow between groups occurring in adjacent waters.

The population of bottlenose dolphins occurring off the coast of Uruguay demonstrated high year-round mobility between La Coronilla and Polonio Cape<sup>18</sup>. Twenty (51%) of the 39 photo-identified animals were observed many times in both locations. A total of 94 movements of 17 individuals were observed between Uruguay and the area adjacent to Patos Lagoon. The movements occurred from March to October in 2006, 2007 and 2008. This pattern of movement is probably related to habitat heterogeneity and prey distribution and was independent of sex and age class<sup>18</sup> (Laporta, 2009). Movements occurred outside the breeding season and accompanied the fluctuations in temperature and salinity of La Plata River and the Atlantic Ocean water masses, as well as mullet and Atlantic white croaker migration<sup>18</sup> (Laporta, 2009).

## 2.5 Argentina

This area presents studies since 1974 in the north (province of Buenos Aires) (Bastida *et al.*, 2007) as well as in the Patagonia region (*e.g.* Würsig and Würsig, 1979). A gap of information exists between 1980 and 2006, when systematic studies of residence, abundance and behavior started at San Antonio Bay in San Matias Gulf (province of Rio Negro)<sup>20</sup> (Figure 5C).

Between 1974 and 1980, a study of the species was conducted in the Necochea and Samborombón Bay, province of Buenos Aires<sup>16</sup>. A total of 30 individuals were photo-identified and habitat preferences were observed, with animals seen more frequently in the Samborombón Bay than in the more southern areas<sup>16</sup>. Despite this presence, the study had to be suspended due to the diminishing number of sightings along the coast of Mar del Plata including the whole northern area of the province of Buenos Aires<sup>16</sup>.

Between 1974 and 1976, other studies were conducted at the San José Gulf, Valdés Peninsula (province of Chubut) (Würsig and Würsig, 1977; 1979; Würsig, 1978). During this study, 53 animals were identified (Würsig and Würsig, 1977), and at least 22 of them showed some degree of residency for the area during 1975 (Würsig, 1978). The dolphins were observed year-round but the frequency varied throughout the seasons, with the highest frequencies registered in March, July and November and the lowest in February, May and September. Ten percent of the observed groups contained calves (Würsig, 1978).

In this area, bottlenose dolphins showed preference for shallow waters (< 10m deep) and were not observed in waters deeper than 39m (Würsig and Würsig, 1979). Animals were usually found in shallower areas in the morning and in deeper waters in the afternoon. Furthermore, preference for different water depths varied over the months, with a clear preference for deeper waters in March, July, October and November. While in shallow waters, animals traveled mostly parallel to the coastline whereas in deeper waters animals were mostly observed milling (Würsig and Würsig, 1979). Crespo *et al.* (2008) reported the same preference for shallow waters: from 40 sightings recorded from Buenos Aires to Tierra del Fuego, only nine were observed beyond the 25m isobath.

Between 2006 and 2011, a study was conducted in San Antonio Bay. From a land-based station, bottlenose dolphins sighting frequency varied among the different regions inside the bay, with the northern sector being more frequently visited by the dolphins (Vermeulen and Cammareri, 2009).

In this area, a total of 67 individuals were photo-identified. Results defined 37 individuals (57%) as residents, 22 (34%) as partially residents and 6 (9%) individuals as transients, present only during winter season and/or seen only once (Vermeulen, 2014).

It could furthermore be shown that most of the confirmed females (individuals associated with a calf) were observed to be residents. The total abundance estimates in the region varied with seasons, with the lowest abundance usually found in autumn. This season of low abundance is consistent with the reported peak occurrence of known bottlenose dolphins in the estuary of the Negro River, located approximately 250km northeast of the study area<sup>20</sup>, where they have been reported to engage mostly in feeding activities (Vermeulen *et al.*, 2016). The decrease in abundance in autumn could thus be an indication for bottlenose dolphins leaving the study area at this time of year presumably due to a decrease in prey availability.

Overall, up to 72% of the dolphin groups encountered contained calves and neonates, and these could be seen throughout the year, suggesting that the shallow waters (<10m) of the bay are used by the dolphins as a calving and nursing area (Vermeulen and Cammareri, 2009).

The same resident population was recorded by Svendsen *et al.*<sup>21</sup> during a field survey for cetacean species diversity carried out between June 2006 and November 2007 in a larger area of San Matías Gulf.

Movements of identified individuals on the order of 100 to 150km to the north of Mar del Plata region were recorded<sup>16</sup>. In the province of Buenos Aires, north of Mar del

<sup>20</sup>Vermeulen, E., Cammareri, A. and Failla, M. (2008) A photo-identification catalogue of bottlenose dolphins (*Tursiops truncatus*) in North Patagonia, Argentina: A tool for the conservation of the species. Paper SCJ/60/SM1 presented at the 60th annual meeting of the Scientific Committee of the International Whaling Commission, Santiago, Chile, 1-13 June 2008.

<sup>21</sup>Svendsen, G.M, Dans, L.S., González, R., Crespo, E.A. and Romero, A. (2008) Distribución y caracterización de grupos de mamíferos marinos en el Golfo San Matías. Page 205 in Abstracts, 13<sup>a</sup> Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur and 4th Congress of Sociedad Latinoamericana de Mamíferos Acuáticos, 13-17 October 2008, Montevideo, Uruguay.

Plata, the species could be observed occasionally entering the different channels built to drain water from the lower regions near Salado River. Most of the observations involved solitary animals feeding mainly on mullet<sup>16</sup>.

In the northeastern region of Patagonia, larger distances were covered by at least twenty-four identified dolphins; twenty dolphins identified in the San Antonio Bay were later resighted in the estuary of Negro River (210km north) and four dolphins identified in San Antonio were later re-identified in Puerto Lobos (150km south) (Vermeulen, 2014). As bottlenose dolphins in the estuary of Negro River were only observed during autumn and were always associated with feeding behavior, it was suggested that prey were the main reason for this displacement<sup>20</sup>. The photographs obtained for the region of Blanca Bay (270km north of the estuary of Negro River, 470km north of the San Antonio Bay), and in the San Blas Bay (90km north of the estuary of Negro River and 290km north of San Antonio Bay) allowed for the identification of 17 and five individual bottlenose dolphins respectively (Vermeulen *et al.*, 2016). Of these individuals one was shown to move between Blanca Bay and San Blas Bay (180km), and two other individuals were shown to move between the San Blas Bay, estuary of Negro River and San Antonio Bay (290km; Vermeulen *et al.*, 2016).

Six individuals identified in the region of Valdés Peninsula (central Patagonia) were later observed up to 300km north (Würsig, 1978).

Although the bottlenose dolphin has been recorded for Tierra del Fuego Province (Goodall *et al.*, 2011), no information regarding habitat use patterns is available.

### Conclusions

Coastal populations of bottlenose dolphin are associated to bays, estuaries, lagoons and river mouths, as well as exposed beaches all along the SWAO. Oceanic populations in offshore islands and in pelagic waters are also reported, although those areas presented scarce information on habitat use patterns.

Shallow and coastal waters (1.6 to 50m depth and/or up to 1km from shore) seem to be preferential for many bottlenose dolphin populations, although the preferential depth and distance from coast can vary with the geographic area. In oceanic islands, the species was reported in depths ranging from 5 to 200m and in offshore waters between 14 and 1501m (with localized records in 2757 and 4017m). Depth, distance from coast, turbidity, distances to rocky points and river mouths as well as water temperature and salinity are important factors that determine the habitat use patterns of bottlenose dolphin in some of the areas within SWAO (*e.g.* Laporta, 2009; Di Tullio *et al.*, 2015).

A total of four resident populations were reported in the SWAO. Three of them are along the coast of Brazil (Laguna, Tramandaí and Patos Lagoon) and one in Argentina (San Antonio Bay). One partially resident population is found in Atlantic Uruguayan coast. Cagarras Archipelago and

Itajaí River were reported as harboring seasonally resident populations. No information was available for north and northeastern Brazil.

The movement pattern of identified individuals between adjacent study areas suggests a connection between some populations. Prey availability, habitat heterogeneity and genetic exchange are possible explanatory factors for those movements (*e.g.* Möller *et al.*<sup>19</sup>; Fruet *et al.*, 2014).

Knowledge on bottlenose dolphin habitat use within the SWAO has increased essentially in the last 10 years. Continued effort will allow us to improve our knowledge of the species and enhance its protection. The species is to date considered as Data Deficient in Brazil, Uruguay and Argentina.

### Recommendations

1. Promote systematic studies of the species in the north and northeastern regions of Brazil and increase the survey effort in the offshore region in order to fulfill the knowledge gap in those areas.

2. Improve habitat use characterization in regions where resident, partially and seasonally resident populations exist.

3. In-depth studies of the species habitat use patterns in relation to prey distribution are strongly encouraged as this information is essential in order to identify priority areas for conservation purposes.

4. Intensify the studies of individual identification and promote a systematic comparison between catalogues of the different regions to further investigate the movement patterns within SWAO.

5. Further effort on individual and stock identification, as well as stock structure in coastal areas and oceanic islands is encouraged in order to determine the degree of exchange between these regions and management units.

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