Latin American Journal
of Aquatic Mammals
www.lajamjournal.org

Online ISSN: 2236-1057

Report of the Working Group on Population Parameters and Demography of *Tursiops truncatus* in the Southwest Atlantic Ocean

Pedro F. Fruet[†,‡,*], Paula Laporta[§,¶] and Paulo A.C. Flores[#]

[†]Museu Oceanográfico 'Prof. Eliézer de Carvalho Rios', Universidade Federal do Rio Grande. Caixa Postal 379, 96200-580 Rio Grande, RS, Brazil

[‡]Laboratório de Ecologia e Conservação da Megafauna Marinha (EcoMega), Instituto de Oceanografia, FURG. Av. Itália km 8, 96201-900 Rio Grande, RS, Brazil

[§]Yaqu-pacha Uruguay. Orinoco s/n and San Luis, C.P. 22, Punta del Diablo, Rocha, Uruguay

[¶]Centro Universitario Regional del Este. Universidad de la República. Intersección Ruta Nacional no. 9 y Ruta Nacional no. 15, 27000 Rocha, Uruguay

[#]Centro Mamíferos Aquáticos – CMA, ICMBio, MMA – CMA SC. Rod. Maurício Sirotsky Sobrinho, s/n, km 02, Jurerê, 88053-700 Florianópolis, SC, Brazil

*Corresponding author, email: pfruet@gmail.com

Article Info

Manuscript type	Article
Article history	
Received	22 November 2011
Received in revised form	16 September 2012
Accepted	11 February 2014
Available online	29 December 2016

Responsible Editor: Carlos Olavarría

Citation: Fruet, P.F., Laporta, P. and Flores, P.A.C. (2016) Report of the Working Group on Population Parameters and Demography of *Tursiops truncatus* in the Southwest Atlantic Ocean. *Latin American Journal of Aquatic Mammals* 11(1-2): 71-78. http://dx.doi.org/10.5597/lajam00217

Introduction

This report provides a summary of information on age, reproduction, survival and abundance estimates of some populations of common bottlenose dolphins (*Tursiops truncatus*) – hereafter referred to as bottlenose dolphins – in the Southwest Atlantic Ocean. For such purpose we surveyed the literature and compiled the information available from peer-reviewed scientific articles, master's and doctoral theses as well as 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.* The meeting was held in Cassino Beach, Rio Grande, Brazil between 21-23 May 2010. Personal communications provided during the meeting were also included to complement this report. Each discussed topic followed the geographical sub-divisions established during the Workshop (see Fruet *et al.*, 2016 Introduction, this volume): a) northern Brazil; b) northeastern Brazil; c) southeastern Brazil; d) southern Brazil and Uruguay and e) Argentina.

Age structure of stranded and incidentally-caught dolphins

Only three studies have reported the age structure of common bottlenose dolphins in the Southwest Atlantic Ocean (SWAO). The age structure of 74 bottlenose dolphins stranded between 1905 and 1998 along the coast of southern Brazil (Santa Catarina State (SC), n = 13; Rio Grande do Sul State (RS), n = 58); Uruguay (n = 1) and northern Argentina (n = 2) (48°55'S-57°41'S) were assessed by Barreto (2000; 2016 this volume). Based on counting of the growth layer groups (GLGs) (Perrin and Myrick, 1980) in the dentine of decalcified and stained longitudinal-sections of teeth, Barreto (2000; 2016 this volume) reported individuals ranging from less than one year (aged '0') up to 26 years. Many of them (55.4%) were young dolphins (0-4 years old). Males (n = 22) ranged from 0 to 26 whereas females (n = 23) from 0 to 22 years. Most males were young (59.1%) unlike females, where the majority (69.6%) were older individuals (> 5yrs), and we found that this difference was statistically significant (Fisher Exact test, $p < 0.05$). Also counting dentine GLGs, Siciliano *et al.* (2007) reported the age structure of 29 bottlenose dolphins collected between 1987-1997 in southeastern Brazil (18°25'S-25°45'S). The study relied on individuals from incidental captures, strandings and museum collections from Espírito Santo (ES) (n = 1), Rio de Janeiro (RJ) (n = 9), São Paulo (SP) (n= 13) and Paraná (PR) (n = 6) states. Their estimated ages ranged from zero (less than one year old) to 26yrs, with 72.4% of the sample consisting of sub-adult (4-8yrs) and adult (≥ 9yrs) dolphins. Males (n = 9) ranged from 0 to 18yr and females (n = 7) from 0 to 17yrs, whereas individuals of undetermined sex (n = 18) ranged 0.5-26yrs, and the majority of animals for both sexes were older (60% for males and 62.5% for females).

The data presented by Barreto (2000; 2016 this volume) and Siciliano *et al.* (2007) suggest significant different patterns in the age structure of stranded bottlenose dolphins between southern and southeastern Brazil (Fisher Exact test, $p < 0.05$). The mortality in the southern region seems to be skewed towards young male individuals. In contrast, in the southeastern region, stranded animals were mostly older dolphins, irrespective of sex. Likely explanations for such differences are difficult to formulate, but this dissimilarity could be partially due to a higher bycatch rate in southern Brazil, where incidental captures are skewed towards immature male dolphins (Fruet *et al.*, 2012). These results should, however, be taken as preliminary, particularly because the dataset from both regions contains a mix of individuals that died of natural and fisheries-related causes; the sample size in the southeastern area is small and therefore stochasticity may account for much of this pattern.

Reproduction

Bottlenose dolphins have delayed sexual maturation and low reproductive capacity, despite slight variations in reproduction parameters among populations. Reproductive seasonality also varies among populations, and latitude seems to play a key role in birth rates and seasonality (Wells and Scott, 2009). In the SWAO, reproduction data of bottlenose dolphins are scarce and some parameters are unknown, especially for the offshore or oceanic populations. Most information on reproduction is available for coastal bottlenose dolphins in southern Brazil.

Age at sexual maturity

Little information on age and length at sexual maturity is available for the SWAO. An approach using the northeast Atlantic inshore population as a reference for estimating the length of sexual maturity of stranded dolphins in southern Brazil has been undertaken (Fruet *et al.*, 2012). It was estimated that males and females longer than 318cm and 278cm, respectively, are sexually mature. In the Patos Lagoon Estuary preliminary results from the tracking of four females since birth showed that two primiparous females were eight and 10 years old, suggesting that sexual maturity was attained, respectively, at ages seven and nine, or earlier (Fruet *et al.*, 2015*a*).

Inter-birth interval

Hoffmann (2004) provided the first information on inter-birth interval of bottlenose dolphins in the SWAO, based on data collected across a seven-year photo-identification study in the Tramandaí River, southern Brazil. Reproductive history of two females (each one having given birth to three dolphins) resulted in a mean inter-birth interval of 2.8yrs, ranging between 2 and 3.5yrs (Hoffmann, 2004). Recently, Fruet *et al.* (2015*a*), using data collected systematically between December 2004 and March 2013, reported 37 inter-birth intervals for 24 photo-identified females in the Patos Lagoon Estuary, southern Brazil, approximately 320km south of the Tramandaí River. Inter-birth interval varied between one and six years (mean = 2.3yrs). Although the mean birth interval is likely underestimated due to the relatively short time data series (nine years), birth intervals of two years (58.3% of intervals) appear to be common in this population.

Birth Rate and Fecundity

For the Patos Lagoon Estuary population, Fruet *et al.* (2015*a*), based on a dataset of photo-identification collected systematically over 8.2yrs, estimated fecundity at 11% by using the ratio between the number of newborn females (assuming 1:1 sex ratio) and the minimum number of mature females in the population (identified through historical photo-identification data). The result found is consistent with values reported for other populations of bottlenose dolphins worldwide (*e.g.* Wells and Scott, 1990; Kogi *et al.*, 2004). Using the same dataset, mean annual birth rate (calculated as the proportion of calves born to the total population size) was estimated at 9% for the Patos Lagoon population (Fruet *et al.*, 2015*a*), a result similar to that of the bottlenose dolphins from Moray Firth, Scotland (Wilson *et al.*, 1999) and Fiordland, New Zealand (Haase and Schneider, 2001).

Birth Seasonality

Bottlenose dolphins inhabiting estuaries of southern Brazil (28°28'S-32°19'S) apparently have a well-defined reproductive seasonality. For Tramandaí River, Hoffmann (2004) estimated the birth date of eight individuals based on seven years of photo-identification data, covering the period 1996-2003. The approximate birth date was set based on the first sighting of a known female with a calf. Births occurred in two distinct seasons: late autumn and spring. Based on two years of photo-identification (2007-2008), Daura-Jorge (2011) also reported a higher number of births in spring for the resident population of bottlenose dolphins from Laguna, SC. For Patos Lagoon Estuary, Fruet *et al.* (2015*a*) estimated slightly different birth dates for 57 neonates of 32 known females based on 8.2yrs of photo-identification data. Birth date was calculated as the midpoint between the last sighting of a known female without young and the first sighting with a neonate within a 45-day period. It was concluded that births in the Patos Lagoon population occur in pulses, with a peak (78.9%) between late spring and mid-summer. Birth pulses coincided with months of higher surface water temperatures in the estuary (range 21.7– 25.3°C), with a sudden drop in births when the water temperature started to decrease. The results compiled for the SWAO support previous observations of bottlenose dolphins inhabiting coastal areas in similar latitudes (*e.g.* Haase and Schneider, 2001; Thayer *et al.*, 2003), where births take place mostly during warm months. Differences on the approach used to estimate date of birth could be the reason for the slightly different result obtained across studies. Data from populations inhabiting the extreme ranges of the distribution of bottlenose dolphins in the SWAO will help to elucidate whether latitude plays an important role in their reproduction cycle.

Survival

Survival probability for bottlenose dolphin in the SWAO was first estimated for the resident population of Laguna. Applying seasonal mark-recapture (MR) data collected over two sampling years to Cormack-Jolly-Seber (CJS) open population models, Daura-Jorge *et al.* (2013) estimated an annual apparent survival of 0.917 (95% CI = 0.876-0.961). Later, applying eight years of video-identification data to mark-resight models, Lodi *et al.* (2014) estimated an apparent survival probability of 0.64 (95% CI = 0.51–0.75) for bottlenose dolphins that seasonally use the Cagarras Archipelago, RJ. Most recently, Fruet *et al.* (2015*a*, *b*), analysing photo-identification data collected systematically over eight years, estimated sex- (for adults only) and age-specific (calf, juveniles and adults) apparent survival rates for the Patos Lagoon Estuary population. Using Pollock's robust design models, the authors found higher annual apparent survival for adult females (0.97, 95% CI = 0.91–0.99) than for adult males (0.88, 95% CI = 0.75–0.94) and juveniles (0.83, 95% CI = 0.64–0.93) (Fruet *et al.*, 2015*b*). Based on CJS models, first and second year annual calf survival were estimated at 0.84 (95 % CI = 0.72–0.90) and 0.86 (95 % CI = 0.74–0.94), respectively (Fruet *et al.*, 2015*a*).

Survival estimate in Cagarras Island is among the lowest for wild bottlenose dolphins worldwide (Fortuna, 2006; Currey *et al.*, 2008; Silva *et al.*, 2009; Mansur *et al.*, 2012; Daura-Jorge *et al.*, 2013; Fruet *et al.*, 2015*b*). Lodi *et al.* (2014) discuss that such a low survival probability could represent both a gradual abandonment of the study area or a high mortality outside this area. In contrast, the apparent adult survival estimates for Laguna and Patos Lagoon Estuary bottlenose dolphin populations are close to the values reported in the literature where overall adult survival probabilities ranged from 0.92 to 0.97 (Wells and Scott, 1990; Corkrey *et al.*, 2008; Currey *et al.*, 2008; Silva *et al.*, 2009). The disparity found between adult survival estimates for Laguna (0.917) and Patos Lagoon Estuary (females = 0.97; males = 0.88) populations is likely reflecting differences in study length and other methodological differences. For example, for the Laguna population, survival was derived considering young and adult dolphins of both sexes jointly in the dataset, while for Patos Lagoon Estuary survival estimates were stratified by sex and age class. This is supported by the fact that Fruet *et al.* (2015*b*) found similar adult survival estimates to those reported for the Laguna population when derived survival probabilities excluding the effect of sex (0.93; 95% CI = 0.89–0.95). In addition, it is well known for most mammal species that age-specific mortality is U-shaped, declining from birth to sexual maturity, then rising in adulthood, possibly after some delay and sometimes with post-reproductive survival (*e.g.* Caughley, 1966). Therefore, mixing young and adult animals in the dataset could also lead survival probability downwards.

Lifespan

Barreto (2000) provided the first information on the age structure for stranded bottlenose dolphins in SWAO. By counting the GLGs in the dentine of stranded animals in RS, Brazil, maximum ages of 26yrs for males and 21yrs for females were reported (Barreto, 2000; 2016 this volume). Later, Siciliano *et al.* (2007) also reported a 26yrs old dolphin on the coast of PR, but of unknown sex. Together, these studies accounted for 82 individuals, and most of them (77.2%) did not exceed half of the maximum age estimated for the species (more than 50yrs; Hohn *et al.*, 1989). On the other hand, the

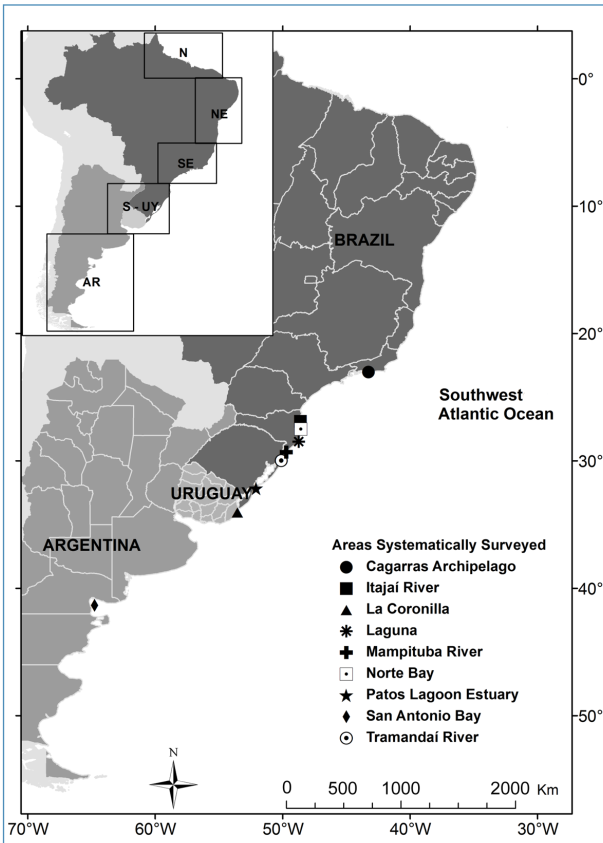

Figure 1. Areas where systematic studies with common bottlenose dolphins (*Tursiops truncatus*) have been conducted in the Southwest Atlantic Ocean. N = north Brazil, NE = northeastern Brazil, SE = southeastern Brazil, S-UY = southern Brazil and Uruguay, AR = Argentina.

mean age of stranded adult dolphins (> 8yrs) (n = 36; mean = 16yrs; SD = 4.6) is close to the expected average lifespan of 20 years or less for wild bottlenose dolphins in the northwest Atlantic Ocean[1]. Most recently, the recovered carcasses of three frequently sighted females in the Patos Lagoon Estuary since 1976 provided the opportunity to estimate their age. Ages of two females were estimated at 40, and the oldest at 44 years old by counting GLGs in their teeth dentine and cement (Fruet *et al.*, 2015*a*), nearly doubling the maximum age previously reported for female bottlenose dolphins in the SWAO.

Abundance

Although there has been some progress in the estimation of abundance, this information is limited to local groups of dolphins inhabiting enclosed environments and reliable total population size estimations are still lacking for many regions along the SWAO, including some areas systematically

[1]Duffield, D.A. and Wells, R.S. (1991) Bottlenose dolphins: Comparison of census data from dolphins in captivity with a wild 'population'. Pages 11-15 *in* Proceedings, *18th Annual IMATA Conference*, 4-9 November 1990, Chicago, IL, USA.

Table 1. Summary of available abundance estimates for bottlenose dolphin populations across the SWAO. Minimum number of identified animals (M_{t+1}) is also shown for regions where no abundance estimates are available. For studies providing successive temporal abundance estimates, the lowest and largest values are reported here. UN = unavailable; MR = mark-recapture; LN = line transect. *Only marked individuals reported. #Study targeted to the Guiana dolphin but yielded data on bottlenose dolphin.

Region	Study Area	Season	Period	Effort (days)	Platform	Method	Population Model	M_{t+1}	Abundance (95% CI)	Source
SE	Cagarras Archipelago	Winter/Spring	2004	11	Boat	MR	Mark-resight	UN	38 (33-42)	Lodi *et al.* (2014)
			2010	11				UN	4 (3-6)	
S-UY	Itajaí River	Year-round	Aug 2008 – Apr 2010	13	Land	MR	M_t	10	12 (10-17)	Demassiano and Barreto[2,*]
S-UY	Norte Bay	Year-round	1994-2005	226	Boat	MR	-	39	-	Flores and Fontoura (2006)[3]
S-UY	Laguna	Year-round	1991	UN	Land	MR	Jolly-Seber	UN	51	Simões Lopes and Fabian (1999)
S-UY	Laguna	Winter	2008	6	Boat	MR	Robust Design	UN	59 (49-72)	Daura-Jorge *et al.*, (2013)
S-UY	Laguna	Fall	Apr-May 2009	6	Boat	MR	M_o	34	50 (40-62)	Daura-Jorge and Simões Lopes (2016 this volume)
						LT	-	-	61 (39-95)	
S-UY	Mampituba River	Year-round	Nov 1998 - Nov 1999	UN	Land	MR	-	9	-	Bernardi (2000)
S-UY	Tramandaí River	Year-round	Jan 2009 - Feb 2010	128	Land	MR	-	9	-	Giacomo and Ott (2016 this volume)
S-UY	Patos Lagoon Estuary	Winter	Jun-Aug 1998	18	Boat	MR	M_{th}	42	83 (78-88)	Dalla Rosa (1999)
S-UY	Patos Lagoon Estuary	Fall-Spring	Apr-Aug 2011	11	Boat	MR	Robust Design	59	88 (82-94)	Fruet *et al.* (2015*b*)
S-UY	La Coronilla, Uruguay	Summer-Fall	Jan-May 2008	12	Boat	MR	M_{th}	31	63 (54-74)	Laporta *et al.* (2016 this volume)
							POPAN		61 (53-72)	
AR	San José Gulf	Year-round	Aug 1974-Mar 1976	150	Boat and land	MR	-	53	-	Würsig and Würsig (1977)
AR	Buenos Aires Province	UN	UN	UN	UN	MR	-	30	-	Bastida and Rodriguez (2003)
AR	San Antonio Bay	Late Spring	Sept 2008	UN	Boat and land	MR	M_{th}	44	83 (73-112)	Vermeulen and Cammareri (2009)
AR	Coastal area	Year-round	1999-2000 2003-2007	33	Aircraft	LT	-	-	34 (22-51)	Coscarella *et al.* (2011)

[2]Demessiano, K.Z. and 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*: Integrating knowledge about the species in the Southwest Atlantic Ocean*, 21-23 May 2010, Rio Grande, Brazil.
[3]Flores, P.A.C., Zago, L. and Wells, R.S. (2010) Insights on residency and skin disorders on bottlenose dolphins (*Tursiops truncatus*) off Baia Norte, Santa Catarina State, southern Brazil. Working Paper 64 presented during the *First Workshop on the Research and Conservation of* Tursiops truncatus*: Integrating knowledge about the species in the Southwest Atlantic Ocean*, 21-23 May 2010, Rio Grande, Brazil.

studied. Lack of information is especially evident for open coastal areas and offshore waters. While photo-identification effort has been carried out at some sites (*e.g.* Florianópolis and surroundings, Itajaí, Mampituba and Tramandaí rivers in southern Brazil), methodological constraints, especially regarding reduced surveyed area and/or platform used, prevent the estimation of total abundance in these areas, and direct count of distinct animals is the only available information (Table 1, Figure 1). Nevertheless, below we present a brief discussion on abundance estimates for regions where this information is available.

Cagarras Archipelago, RJ, Brazil

Lodi *et al.* (2014) conducted weekly video-identification boat-based surveys between 2004 and 2012 to investigate a series of ecological aspects of the insular population of bottlenose dolphins in Cagarras Archipelago. The sampling effort was concentrated during austral winter and spring, according to the seasonal presence of bottlenose dolphins in the area (Barbosa *et al.*, 2008). Applying the Poisson-log normal mark–resight model, which incorporates additional data on the number of unmarked individuals, abundance estimates varied from a maximum of 38 individuals in 2004 (SE = 2.33; 95% CI = 33–42) to a minimum of four individuals in 2010 (SE = 0.65; 95% CI = 3–6). The data showed a clear negative trend in abundance until 2011 and 2012, when no dolphins were sighted in the Archipelago.

Laguna, Santa Catarina, Brazil

Based on boat surveys, Daura-Jorge and Simões-Lopes (2016 this volume) compared two commonly used abundance estimation methods (MR and line-transect) in assessing the abundance of the resident populations of bottlenose dolphins in Laguna, southern Brazil. The MR and line-transect model analyses resulted in an abundance of 50 individuals (95% CI = 40-62) and 61 individuals (95% CI = 39-95), respectively. The population size of 50 individuals estimated by MR models is very similar to the 51 individuals reported 20 years ago by Simões-Lopes and Fabian (1999) in the same area, who estimated the population size by the ratio between the total number of identified individuals and the proportion of marked dolphins in 52 groups sampled. Despite the differences in the methods used in these studies (*e.g.* equipment and statistical models) these data suggest a stable population during the last 20 years (see Daura-Jorge *et al.*, 2013 for details).

Patos Lagoon Estuary, RS, Brazil

Applying closed-population MR models for photo-identification data, Dalla Rosa (1999) estimated 83 dolphins (95% CI = 78-88) inhabiting the Patos Lagoon Estuary in 1998. Recently, Fruet *et al.* (2015*b*) conducted a MR analysis using eight years (2005–2012) of photo-identification data to estimate abundance and some demographic parameters of Patos Lagoon bottlenose dolphin population. Total abundance estimates did not exceed 88 individuals and were very similar to the values found by Dalla Rosa (1999) a decade earlier, suggesting a relative stable dolphin population over the last 14 years. High levels of bycatch in relation to this small population size have been reported in the surrounding areas of Patos Lagoon Estuary since 2002 (Fruet *et al.*, 2012) and the impacts of such deterministic pressure in this very small population should be looked closely. Future successive abundance estimations will help to elucidate population trends over large periods.

Uruguay

Laporta *et al.* (2016 this volume) presented the first abundance estimate of bottlenose dolphins in the Uruguayan coast for La Coronilla, Rocha Department, an open coastal area. Boat-based surveys for photo-identification were conducted between January and May 2008. Using MR models for closed and open populations, abundance was estimated at 63 (95% CI = 54-74) and 61 (95% CI = 53-73) individuals, respectively (corrected for the proportion of unmarked dolphins). Abundance estimates produced by both MR models were very similar regarding point abundance estimates and precision.

Argentina

Two abundance estimates are available in Argentina. Closed-population MR analysis based on photo-identification data collected in Natural Protected Area of San Antonio Bay (NPABSA), northeastern Patagonia, resulted in an abundance estimation of 83 dolphins (95% CI = 73-112), including the proportion of unmarked individuals in the population (Vermeulen and Cammareri, 2009). On the other hand, Coscarella *et al.* (2011) used a strip-transect model from aircraft survey data and estimated only 34 dolphins (95% CI= 22-51) for a greater coastal area in Argentina, that partially overlapped with that surveyed by Vermeulen and Cammareri (2009). The upper bound of the confidence interval (51 individuals) obtained by the strip-transect survey study (Coscarella *et al.,* 2011) is slightly above the minimum number of identified animals (44 individuals) found by the MR approach (Vermeulen and Cammareri, 2009). Nevertheless, it is clear that the abundance estimates for central Argentina are inconsistent and should be reviewed carefully prior to inferring population decline based solely on direct count of recognized individuals from past photo-identification data (see Coscarella *et al.*, 2011).

For all studied populations in the SWAO, abundance was estimated using MR models applied to photo-identification data or, in few cases, using line-transect methods. We noticed that in some circumstances surveys were apparently conducted without adequate experimental design. Such limitation might yield biased estimates, thus compromising comparison between estimates and precluding population trend analyses that represent crucial information to evaluate the conservation status of these populations. Photo-identification catalogues are available for a considerable number of locations and must be used to provide abundance estimates despite inadequate experimental designs.

Recommendations

This review shows the lack of basic information regarding the population parameters of bottlenose dolphin along the SWAO, although the existence of ongoing catalogues of photo-identified individuals and information and biological samples collected from stranded carcasses along the area. Clearly it is crucial to use existing datasets to estimate those population parameters and to establish a coordinated inter-institutional research program to better understand the ecology of bottlenose dolphins in the region. Specifically, we highly recommend to (in no order of importance):

1. Estimate the age and determine the sex from bottlenose dolphins' teeth deposited in scientific collections along the SWAO. Such effort is critical to allow a more robust analysis that would help to understand the mortality patterns of bottlenose dolphins in the SWAO;

2. From thus aged animals, to use adequate models to reliably estimate the mean life span of bottlenose dolphins;

3. Organize and analyze current photo-identification catalogues in areas where population parameters are lacking such as in Norte Bay and adjacent coastal waters (SC), open coastal areas of RS (southern Brazil) and Argentina;

4. Estimate reproductive data from populations where long-term photo-identification data are available, as well as from stranded carcasses. Special attention should be given to estimate the age of attainment of sexual maturity or age of first reproduction (from photo-identification data);

5. Estimate sex-specific adult survival and abundance to infer on population trends. Specifically, for those locally adapted populations where long-term mark-recapture data are accessible, we suggest the use of open-population or robust-design models to estimate both parameters. On the other hand, for populations inhabiting large areas, like the open coast, where individuals presumably have greater home ranges (and recapture rate is low), line-transect and distance sampling may be more feasible to estimate abundance. Simultaneous surveys could be conducted to cover larger areas;

6. Estimate population trends for populations where long-term data are available. Although linear regression and statistical power analysis are easily accessible, we strongly recommend the use of a Bayesian approach to conduct such analysis.

Acknowledgments

The authors thank C. Olavarría, R. Currey, M. Cantor and E.R Secchi for their critical and constructive comments on the manuscript. We also thank J.C. Di Tullio for technical support.

References

Barbosa, M.M.C., Cruz, F.S. and Lodi, L. (2008) Comportamento e organização de grupo do golfinho-flíper, *Tursiops truncatus* (Cetacea, Delphinidea) no Arquipélago das Cagarras, Rio de Janeiro. *Revista Brasileira de Zoociências* 10(3): 213–220.

Barreto, A.S. (2000) *Variação craniana e genética de* Tursiops truncatus *(Cetacea, Delphinidae) na costa Atlântica da América do Sul*. Ph.D. Thesis. Fundação Universidade Federal do Rio Grande. Rio Grande, Brazil. 112 pp.

Barreto, A.S. (2016) Growth of the skull of the bottlenose dolphin, *Tursiops truncatus*, in the Southwest Atlantic Ocean. *Latin American Journal of Aquatic Mammals* 11(1-2): 199-211. http://dx.doi.org/10.5597/lajam00229

Bastida, R. and Rodríguez, D. (2003) *Mamiferos Marinos de Patagônia y Antartida.* Vazquez Mazzini Editors, Buenos Aires, Argentina. 206 pp.

Bernardi, L.R. (2000) *Estudo ecológico e comportamental do boto-da-tainha,* Tursiops truncatus *Montagu, 1821 (Cetacea, Delphinidae) na foz do rio Mampituba, Torres, RS*. M.Sc. Thesis. Universidade Federal do Rio Grande do Sul. Porto Alegre, Brazil. 103 pp.

Caughley, G. (1966) Mortality patterns in mammals. *Ecology* 47: 906–918. http://dx.doi.org/10.2307/1935638

Corkrey, R., Brooks, S.P., Lusseau, D., Parsons, K., Durban, J.W., Hammond, P.S. and Thompson, P.M. (2008) A Bayesian capture-recapture population model with simultaneous estimation of heterogeneity. *Journal of the American Statistical Association* 108(504): 948-960. http://dx.doi.org/10.1198/016214507000001256

Coscarella, M., Dans, S.L., Degrati, M., Garaffo, G. and Crespo, E.A. (2011) Bottlenose dolphins at the southern extreme of the south-western Atlantic: local population decline? *Journal of the Marine Biological Association of the United Kingdom* 92(Special Issue 8): 1843-1849. http://dx.doi.org/10.1017/S0025315411001901

Currey, R.J.C., Dawson, S.M., Slooten, E., Schneider, K., Lusseau, D., Boisseau, O.J., Haase, P. and Williams, J.A. (2008) Survival rates for a declining population of bottlenose dolphins in Doubtful Sound, New Zealand: an information theoretic approach to assessing the role of human impacts. *Aquatic Conservation: Marine and Freshwater Ecosystems* 19(6): 658-670. http://dx.doi.org/10.1002/aqc.1015

Dalla Rosa, L. (1999) *Estimativa do tamanho da população de botos,* Tursiops truncatus*, do estuário da Lagoa dos Patos, RS, a partir da foto-identificação de indivíduos com marcas naturais e da aplicação de modelos de marcação-recaptura*. M.Sc. Thesis. Fundação Universidade Federal do Rio Grande. Rio Grande do Sul, Brazil. 104 pp.

Daura-Jorge, F. (2011) *Quantos? Onde? Como? Múltiplos aspectos ecológicos de uma população do boto-da-tainha (*Tursiops truncatus*) em Laguna, sul do Brasil: implicações para conservação*. Ph.D. Thesis. Universidade Federal do Paraná. Paraná, Brazil. 264 pp.

Daura-Jorge, F.G. and Simões-Lopes, P.C. (2016) Mark-recapture *vs.* line-transect abundance estimates of a coastal dolphin population: a case study of *Tursiops truncatus* from Laguna, southern Brazil. *Latin American Journal of Aquatic Mammals* 11(1-2): 133-143.
http://dx.doi.org/10.5597/lajam00222

Daura-Jorge, F., Ingram, S.N. and Simões-Lopes, P.C. (2013) Seasonal abundance and adult survival of bottlenose dolphins (*Tursiops truncatus*) in a community that cooperatively forages with fishermen in southern Brazil. *Marine Mammal Science* 29(2): 293–311.
http://dx.doi.org/ 10.1111/j.1748-7692.2012.00571.x

Flores, P.A.C. and Fontoura, N.F. (2006) Ecology of marine tucuxi, *Sotalia guianensis*, and bottlenose dolphin, *Tursiops truncatus*, in Baía Norte, Santa Catarina State, southern Brazil. *Latin American Journal of Aquatic Mammals* 5(2): 105-115.

Fruet, P.F., Kinas, P.G., Da Silva, K.G., Di Tullio, J.C., Monteiro, D.S., Dalla Rosa, L., Estima, S.C. and Secchi, E.R. (2012) Temporal trends in mortality and effects of bycatch on common bottlenose dolphins, *Tursiops truncatus*, in southern Brazil. *Journal of the Marine Biological Association of the United Kingdom* 91: 1-12.
http://dx.doi.org/10.1017/S0025315410001888

Fruet, P.F., Genoves, R.C., Möller, L.M., Botta, S. and Secchi, E.R. (2015*a*). Using mark-recapture and stranding data to estimate reproductive traits in female bottlenose dolphins (*Tursiops truncatus*) of the Southwestern Atlantic Ocean. *Marine Biology* 162(3): 661–673.
http://dx.doi.org/10.1007/s00227-015-2613-0

Fruet, P.F., Daura-Jorge, F.G., Möller, L.M., Genoves, R.C. and Secchi, E.R. (2015*b*) Abundance and demography of bottlenose dolphins inhabiting a subtropical estuary in the Southwestern Atlantic Ocean. *Journal of Mammalogy* 96(2): 332–343. http://dx.doi.org/10.1093/jmammal/gyv035

Fruet, P.F., Laporta, P., Di Tullio, J.C., Secchi, E.R., Morteo, E., Tezanos-Pinto, G., Möller, L., Marmontel, M. and Palacios, D.M. (2016) Introduction to the Special Volume on *Tursiops* in the Southwest Atlantic Ocean. *Latin American Journal of Aquatic Mammals* 11(1-2): 1-15.
http://dx.doi.org/10.5597/lajam00212

Giacomo, A.B. and Ott, P.H. (2016) Long-term site fidelity and residency patterns of bottlenose dolphins (*Tursiops truncatus*) in the Tramandaí Estuary, southern Brazil. *Latin American Journal of Aquatic Mammals* 11(1-2): 155-161.
http://dx.doi.org/10.5597/lajam00224

Haase, P.A. and Schneider, K. (2001) Birth demographics of bottlenose dolphins, *Tursiops truncatus*, in Doubtful Sound, Fjordland, New Zealand: preliminary findings. *New Zealand Journal of Marine and Freshwater Research* 35(4): 675-680. http://dx.doi.org/ 10.1080/00288330.2001.9517034

Hoffmann, L.S. (2004) *Um estudo de longa duração de um grupo costeiro de golfinhos* Tursiops truncatus *(Montagu, 1821) (Cetacea, Delphinidae) no sul do Brasil: Aspectos de sua biologia e bioacústica*. Ph.D. Thesis. Universidade Federal do Rio Grande do Sul. Porto Alegre, RS, Brazil. 273 pp.

Hohn, A.A., Scott, M.D., Wells, R.S., Sweeney, J.C. and Irvine, A.B. (1989) Growth layers in teeth from known-age, free ranging bottlenose dolphins. *Marine Mammal Science* 5(4): 315-342.
http://dx.doi.org/10.1111/j.1748-7692.1989.tb00346.x

Kogi, K., Hishii, T., Imamura, A., Iwatani, T. and Dudzinski, K.M. (2004) Demographic parameters of Indo-Pacific bottlenose dolphins (*Tursiops aduncus*) around Mikura Island, Japan. *Marine Mammal Science* 20(3): 510-526.
http://dx.doi.org/10.1111/j.1748-7692.2004.tb01176.x

Laporta, P., Fruet, P. and Secchi, E. (2016) First estimate of common bottlenose dolphin (*Tursiops truncatus*) (Cetacea, Delphinidae) abundance off Uruguayan Atlantic coast. *Latin American Journal of Aquatic Mammals* 11(1-2): 144-154.
http://dx.doi.org/10.5597/lajam00223

Lodi, L., Cantor, M., Daura-Jorge, F. and Monteiro-Neto, C. (2014) A missing piece from a bigger puzzle: declining occurrence of a transient group of bottlenose dolphins off Southeastern Brazil. *Marine Ecology* 35: 516–527.
http://dx.doi.org/10.1111/maec.12108

Perrin, W.F. and Myrick Jr, A.C., Eds (1980) *Age determination of toothed whales and sirenians*. International Whaling Commission, Cambridge, UK.

Siciliano, S., Ramos, R.M.A., Di Beneditto, A.P.M., Santos, M.C.O., Fragoso, A.B., Lailson Brito Jr, J.L., Azevedo, A.F., Vicente, A.F.C., Zampirolli, E., Alvarenga, F.S., Barbosa, L. and Lima, N.R.W. (2007) Age and growth of some delphinids in south-eastern Brazil. *Journal of the Marine Biological Association of the United Kingdom* 87(1): 293–303.
http://dx.doi.org/10.1017/S0025315407053398

Silva, M.A., Magalhães, S., Prieto, R., Santos, R.S. and Hammond, P.S. (2009) Estimating survival and abundance in a bottlenose dolphin population taking into account transience and temporary emigration. *Marine Ecology Progress Series* 392: 263-276. http://dx.doi.org/10.3354/meps08233

Simões-Lopes, P.C. and Fabian, M.E. (1999) Residence patterns and site fidelity in bottlenose dolphins, *Tursiops truncatus* (Montagu) (Cetacea, Delphinidae) off Southern Brazil. *Revista Brasileira de Zoologia* 16(4): 1017-1024.
http://dx.doi.org/10.1590/S0101-81751999000400012

Thayer, V.G., Read, A.J., Friedlaender, A.S., Colby, D.R., Hohn, A.A., Mclellan, W.A., Pabst, D.A., Dearolf, J.L., Bowles, N.I., Russel, J.R. and Rittmaster, K.A. (2003) Reproductive seasonality of western Atlantic bottlenose dolphins of North Carolina, U.S.A. *Marine Mammal Science* 19(4): 617-629. http://dx.doi.org/10.1111/j.1748-7692.2003.tb01120.x

Vermeulen, E. and Cammareri, A. (2009) Residency patterns, abundance and social composition of bottlenose dolphins (*Tursiops truncatus*) in Bahía San Antonio, Patagonia, Argentina. *Aquatic Mammals* 35(3): 379-386. http://dx.doi.org/10.1578/AM.35.3.2009.379

Wells, R.S. and Scott, M.D. (1990) Estimating bottlenose dolphin population parameters from individual identification and capture-release techniques. *Report of the International Whaling Commission* (Special issue) 12: 407-415.

Wells, R.S. and Scott, M.D. (2009) Common bottlenose dolphin *Tursiops* spp. Pages 249-255 *in* Perrin, W.F., Würsig, B. and Thewissen, J.G.M. (Eds) *Encyclopedia of Marine Mammals*. 2. ed. Elsevier, Amsterdam, The Netherlands.

Wilson, B., Hammond, P.S. and Thompson, P.M. (1999) Estimating size and assessing trends in a coastal bottlenose dolphin population. *Ecological Applications* 9(1): 288-300. http://dx.doi.org/0.2307/2641186

Würsig, B. and Würsig, M. (1977) Photographic determination of group size, composition and stability of coastal porpoises (*Tursiops truncatus*). *Science* 198: 755-75.