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First estimate of common bottlenose dolphin (*Tursiops truncatus*) (Cetacea, Delphinidae) abundance off Uruguayan Atlantic coast

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Abstract. The common bottlenose dolphin *Tursiops truncatus* is often observed throughout the oceanic coast of Uruguay. Historically, its distribution was wider, including the estuary of the Río de la Plata, but currently its occurrence seems to be restricted mainly to the Uruguayan Atlantic coast (Rocha Department). Conflicting interests and tradeoffs between conservation and development are being generated in Uruguay. On one hand, the establishment of protected areas, responsible tourism and sustainable fisheries are promoted, while on the other hand, foreign exploitation of natural resources and development of mega-infrastructure in coastal zone are facilitated. In this work, we provide the first estimate of bottlenose dolphin's abundance along the Uruguayan Atlantic coast. These results can be used as baseline information for monitoring population trends and guiding conservation actions for bottlenose dolphins in Uruguay. Mark-recapture models were applied to data of photo-identified animals with long-lasting natural marks. Total population size estimates of 63 individuals (95% CI = 54–74) and 61 (95% CI = 53–73) were obtained from closed and open population models, respectively. Although the estimates are within the range of values obtained for other coastal bottlenose dolphin populations in the Southwest Atlantic Ocean, as well as other regions of the world, it is lower than the values reported for populations inhabiting open habitats. This small population is probably vulnerable to non-natural removals, environmental and demographic stochasticity. Therefore, precautionary actions are recommended given the planned development for this coastal region.

Resumen. La tonina *Tursiops truncatus* es comúnmente observada a lo largo de la costa oceánica de Uruguay. Históricamente su distribución era más amplia, incluyendo el estuario del Río de la Plata, pero actualmente su ocurrencia parece estar restringida principalmente a la costa atlántica uruguaya (Departamento de Rocha). Conflictos de intereses y compromisos entre conservación y desarrollo están siendo generados en Uruguay. Por un lado, se promueve el establecimiento de áreas protegidas, el turismo responsable y la pesca sustentable, mientras que por otro lado se facilita la inversión extranjera para la explotación de recursos naturales y el desarrollo de emprendimientos de mega-infraestrucutra en la zona costera. En este trabajo brindamos la primera estimación de abundancia de las toninas que habitan la costa atlántica uruguaya. Estos resultados pueden ser utilizados como información de base para monitorear tendencias poblacionales y guiar acciones de conservación para las toninas en Uruguay. Modelos de marca-recaptura fueron aplicados a datos de individuos foto-identificados con marcas naturales de larga duración. El tamaño total de la población fue estimado en 63 individuos (IC 95% = 54-74) y 61 (IC 95% = 53-73) individuos para los modelos de población cerrada y abierta, respectivamente. A pesar de que estas estimaciones están dentro del rango de valores de otras poblaciones costeras de toninas en el Océano Atlántico Sudoccidental, así como de otras regiones del mundo, éstas son menores a las estimaciones halladas para poblaciones que ocurren en hábitats abiertos. Esta pequeña población es probablemente vulnerable a remociones no naturales, y a la estocasticidad ambiental y demográfica. Por lo tanto, se recomiendan acciones precautorias dado los planes de desarrollo para esta región costera.

Introduction

The common bottlenose dolphin, *Tursiops truncatus* (Montagu, 1821), hereafter referred to as bottlenose dolphin, is distributed in tropical and temperate waters around the world (Perrin, 2009). Coastal populations of bottlenose dolphins are frequently small (generally < 200 individuals) and highly resident in protected estuarine habitats (*e.g.* Scott *et al.*, 1990; Wilson *et al.*, 1999; Fruet *et al.*, 2011). Populations inhabiting open habitat, however, are potentially larger (generally between 200-1000 individuals) and exhibit a lower degree of residency (*e.g.* Bearzi *et al.,* 1997; Defran and Weller, 1999; Read *et al.*, 2003). In the Southwest Atlantic Ocean (SWAO) there are records of bottlenose dolphins from Amapá State (04°33'N, 37°00'W), northern Brazil to the province of Tierra del Fuego (54°55'S, 67°30'W), southern Argentina (*e.g.* Bastida *et al.*, 2007; Lodi *et al.*, 2016 this volume), but resident coastal populations are particularly found between southern Brazil (Itajaí River, 26°54'S, 48°38'W) and Argentina (San Antonio Bay, 40°50'S, 64°50'W; Lodi *et al.*, 2016 this volume). Along this area, abundance and other life history traits have been estimated for some of the populations inhabiting protected environments as in Patos Lagoon Estuary (Fruet *et al.*, 2012; 2015*a*, *b*) and Santo Antonio Lagoon, southern Brazil (Daura-Jorge *et al.,* 2013) and San Matias Gulf, Patagonia, Argentina (Vermeulen and Cammareri, 2009). On the other hand, studies are scarce for bottlenose dolphins occuring in open coastal environments along the SWAO.

The bottlenose dolphin is the only small cetacean that can be frequently observed in Uruguay, from where scientific information regarding this species is limited to preliminary studies on taxonomy (Pilleri and Gihr, 1972), occasional incidental catches in fishing nets and strandings (Praderi, 1985), sightings (Brownell *et al.,* 1973) and behavioural observations[1]. Despite the lack of systematic studies, documents and annedoctal information suggest that the bottlenose dolphin home range in Uruguayan coast is shrinking. Forty years ago, this species was frequently observed in the estuarine coast of La Plata River, where they are rarely seen today (Lázaro and Praderi, 2000; Bastida *et al.*, 2007; P. Laporta pers. obs.). Currently, the main occurrence area of bottlenose dolphin in Uruguay seems to be the open coast of Rocha Department (34°47'S, 54°32'W - 33°44'S, 53°22'W), especially in La Coronilla/Cerro Verde and Cabo Polonio[2] (Laporta, 2004; 2009). Both areas have been incorporated to the National System of Protected Areas: Cabo Polonio as a National Park (Decree 337/009) and Cerro Verde and La Coronilla Island as an Area of Habitat and/or Species Management (Decree 68/2011). Systematic studies of occurrence and behaviour from land-based surveys indicated that bottlenose dolphins are present year-round, form small groups (between 1 and 25 individuals) and use the coastal areas for their vital activities[2] (Laporta, 2004).

Both estuarine and Atlantic coasts of the country have undergone transformation due to economic expansion, increasing industrial activity, infrastructure development and urban centres (Lemay, 1998; Menafra *et al.*, 2009) and arising potential threats to the ecosystem, including small coastal cetacean populations. Under these circumstances, diverse institutions and organizations have had initiatives to mitigate those problems and to delineate management and conservation plans for natural populations and ecosystems (*e.g.* ECOPLATA[3], FREPLATA[4], PROBIDES[5], C-MCI*Sur*[6] and Republic University). Estimates of population size and trends in abundance, along with information regarding distribution and movement patterns are essential for monitoring human impacts in cetacean populations (*e.g.* Wilson *et al.*, 1999; Hastie *et al.*, 2003). This information is particularly important in areas where various direct and indirect threats to dolphins are increasing (Fury and Harrison, 2008), such is the case of the coastal areas of Uruguay (Menafra *et al.*, 2009). The objective of this study was to provide the first abundance estimate for bottlenose dolphins inhabiting an open area in the Atlantic Uruguayan coast. The results of this study can be used as baseline information to monitor population trends, to guide conservation strategies for the species and to evaluate their effectiveness.

Materials and methods

Study area

The study area comprised a 20km long and 2.5km wide strip along the coast of Uruguay, between La Coronilla (33°51'S, 53°28'W) and Punta del Diablo (34°01'S, 53°32'W) (Rocha Department), totalizing approximately 50km^2 (Figure 1). This area includes La Coronilla/Cerro Verde (33°38'S, 53°24'W), where sighting frequency of bottlenose dolphins is highest in Uruguay (Laporta, 2004). The study area is characterised by open bays with sandy beaches intersected by several rocky points (Panario and Gutiérrez, 2006). Rocha Department holds many artisanal fishing villages and is

[1]García, R., Lázaro, M., Leguisamo, J. and Rodríguez, L. (1994) Identificación individual de *Tursiops truncatus* en la localidad de Santa Lucía del Este, Depto. Canelones, Uruguay. Pages 92-93 *in* Abstracts, *6a Reunión de Especialistas de Mamíferos Acuáticos de América del Sur*, 24-28 October, Florianópolis, Brazil.

[2]Laporta, P., Trimble, M. and Zamisch, V. (2006) Management and conservation plan for bottlenose dolphin (*Tursiops truncatus*) population in the first marine protected area proposed in Uruguay. *Technical Report for National Directorate of Aquatic Resources,* 845/2006. Montevideo, Uruguay. 15 pp.

[3]ECOPLATA. A Uruguayan multi-institutional approach to integrated coastal zone management. It is a long-term initiative (1997 to present) resulting from an agreement between different ministries and the Republic University.

[4]FREPLATA. 'Environmental Protection of the Rio de la Plata and its Maritime Front: Pollution Prevention and Control and Habitat Restoration.' It is a binational project between Argentina and Uruguay.

[5]PROBIDES. 'Program for Biodiversity Conservation and Sustainable Development of the Eastern Wetlands of Uruguay'. It is composed of the municipalities of Maldonado and Rocha, Cerro Largo, Treinta y Tres and Lavalleja, the Ministry of Housing, Planning and Environment and the Republic University.

[6]C-MCI*Sur*. Interdisciplinary Center of Coastal Management of the Southern Cone.

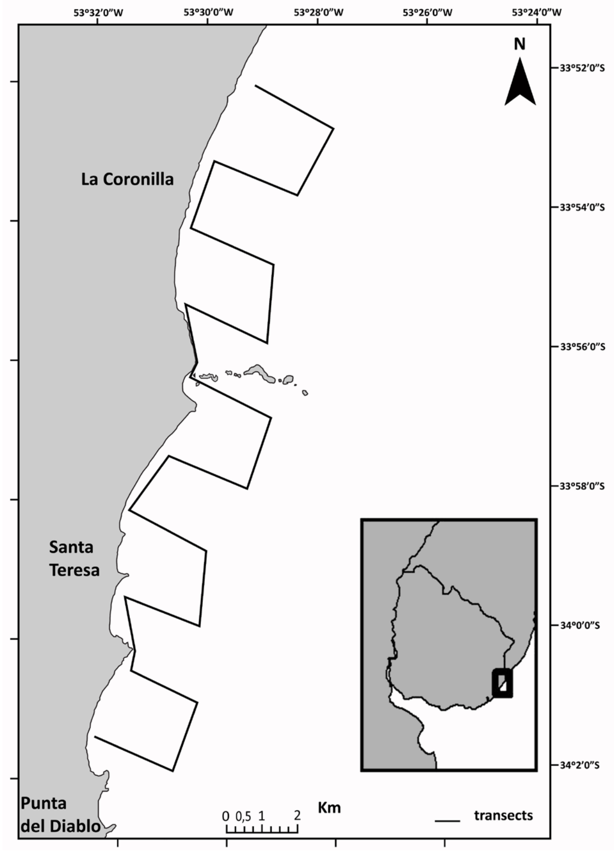

Figure 1. Study area showing the line transects surveyed between January and May 2008 for abundance estimates of bottlenose dolphins (*Tursiops truncatus*) inhabiting the waters of La Coronilla/Punta del Diablo (Rocha Department), Uruguayan Atlantic coast.

considered relatively undeveloped with extensive agricultural activities and low impact tourism.

Surveys and photo-identification

Between January and May 2008 photographic-identification (photo-id) surveys were conducted following pre-defined transects both parallel and perpendicular to the coast along the study area (Figure 1). Surveys were conducted only under calm weather conditions (Beaufort Sea State ≤ 3) onboard either a 3.7m or a 4.2m long inflatable boat powered with 25hp and 40hp outboard motors, respectively. Once a group of dolphins was sighted, we slowly approached them and attempted to obtain dorsal fin photographs of each individual (Würsig and Jefferson, 1990) using a digital reflex camera equipped with an 80-400mm (1:5-6.3D) zoom lens. Aiming at obtaining at least one good quality photograph of each individual (*e.g.* Wilson *et al.*, 1999), as many photographs as possible were randomly taken of individual dolphins' dorsal fins, regardless of the presence of conspicuous marks. We remained with a group until photographs of all individuals were supposedly taken or until dolphins disappeared. Thereafter, the boat resumed the transect line.

Photograph analyses and individual identification

Each photograph was classified in relation to its quality as excellent, medium and poor. Photographs were excellent when the dorsal fin was well exposed, occuppying a large proportion of and oriented parallel to the frame, in sharp focus and without water droplets (*e.g.*Wilson *et al.*, 1999). Photographs not meeting these criteria (medium and poor quality photos) were excluded from the analysis.

Individual identification was made using only natural long-lasting marks such as cuts, nicks and deformations (*e.g.* Würsig and Würsig, 1977). Other mark types such as little scars or injuries were used only to assist in differentiating unmarked animals within groups. After each survey, individually identified animals with long-lasting marks were included in a catalogue. Photo-identified individuals of the subsequent surveys, which did not match previously catalogued animals, were added to the catalogue. Otherwise, they were considered as a recapture. The validation of resightings and inclusion of new individuals in the catalogue were made by consensus of two experienced researchers after the analysis of excellent dorsal fin photographs. Finally, a matrix of presence and absence representing the capture history of each identified individual along all surveys was constructed.

Marked animals abundance estimates

Conventional mark-recapture models for closed and open population were applied to photo-id data to estimate abundance of bottlenose dolphins. Those models operate under assumptions about population nature and how it is sampled. Violations of those assumptions can lead to biased estimates (Seber, 1982), thus it is important to explore and validate them or to select appropriate models to relax those assumptions that are not met (Begon *et al.*, 1996). Closed population mark-recapture models assume that: (1) events of births and deaths, immigration and emigration do not occur during the study period; (2) all individuals in the population have the same probability of capture; (3) marks are not lost during the sampling period; (4) marked individuals will be correctly recognized upon recapture; and (5) the capture of an animal does not affect its subsequent probability of recapture. On the other hand, in mark-recapture models for open populations, additions (births and/or immigrants) to the population and permanent losses (deaths and/or emigrants) from the population can occur during the study period. For open population models, assumptions (2), (3), (4) and (5) are also required and other two are incorporated: (6) all marked individuals in the population that are alive on a given sampling occasion have the same probability of surviving to the next sampling occasion; (7) all samples are instantaneous and each release is made immediately after the sample.

Data selection

Photo-identification data collected between January and May 2008 were used to estimate abundance using mark-recapture models for open and closed populations. In both cases, the same data set was used for comparison purposes, with each photo-identification session (sampling day) considered as a sample occasion. For open population models, time intervals between sampling sessions were specified as days. Data on consecutive days were pooled to guarantee independence between captures (Wilson *et al.*, 1999). Discovery curves were plotted for all animals encountered during the study as well as for animals with long-lasting marks only (Wilson *et al.*, 1999).

Mark-recapure models for open population

The superpopulation POPAN model (Schwarz and Arnason, 1996; Arnason and Schwarz, 1999), a derivative of the open population Jolly-Seber model (Jolly, 1965; Seber, 1965), was used to estimate abundance (Jolly, 1965; Seber, 1965; 1982). POPAN estimates the superpopulation size (N), which considers that the total number of animals available for capture in the area within the study period is representative of a component of a larger population (the "superpopulation"). This parameterization also includes parameters as apparent survival rate (Φ), the probability of capture (p) and the probability that members from the "superpopulation" unavailable for capture during a certain time enter the population under study between sampling sessions (b). In addition, this approach accounts for the correction of animals from the superpopulation that are unavailable for capture during the study period. A set of models was considered letting Φ, p, and b probabilities to be constant (.) or vary in time (t) between sampling sessions. Departure from model assumptions was specifically assessed by selecting the full time-variant model and running a parametric bootstrapping approach of goodness-of-fit test (GOF) with 1500 iterations in Program MARK (White and Burnham, 1999). The parameter *c-hat* was then estimated by dividing the deviance estimated from the original data by the mean of simulated deviances, and this value was used to adjust for overdispersion in the data. The most parsimonious model was selected based on the Quasi-Akaike's Information Criterion adjusted for small sample sizes (QAICc) (Burnham and Anderson, 2002).

Mark-recapure models for closed population

The number of recognizable dolphins in the population was also estimated through mark-recapture models for closed populations (Otis *et al.,* 1978; Seber, 1982) by running the program CAPTURE (Otis *et al.*, 1978; Rexstad and Burnham, 1991) directly from Program MARK (White and Burnham, 1999). CAPTURE compares the null model (M_0) to a set of other models that incorporate time and behavioral dependence and individual heterogeneity in capture probabilities (M_t, M_b, M_h) and a combination of them (M_{th}, M_{tb}, $M_{hb,}$ M_{tbh}). Models containing behavioral responses were discarded because we assumed *a priori* that there were no reactions to the capture procedure involving the photo-id technique (mark and recapture), since dolphins do not need to be handled for marking.

Total population size estimation

Total population size was calculated dividing the estimated number of individuals with long-lasting marks (*N*) by the estimated proportion of marked individuals in the population (θ). Variance was calculated using the delta method (Seber, 1982), as modified by Wilson *et al.* (1999). Theta was estimated from the arithmetic mean of the proportion of animals with long-lasting marks in the population, considering all photo-id sessions.

$$\hat{\theta} = \frac{\sum_{i=1}^{k} \frac{I_i}{T_i}}{k}$$

where: *Ii* is the number of dolphins with long-lasting marks in group *i*; *Ti* is the total number of photo-identified dolphins in group *i*; *k* is the number of groups photographed.

The small group size, the variety of skin markings (*e.g.* tooth rakes or skin alterations) and dorsal fin shapes made it possible to distinguish unmarked individuals in each group.

The variance of total population size was estimated following Wilson *et al.* (1999):

$$\mathrm{var}(\hat{N}_{\mathrm{total}}) = \hat{N}_{\mathrm{total}}^2 \times \left(\frac{\mathrm{var}(\hat{N})}{\hat{N}^2} + \frac{1-\hat{\theta}}{n\hat{\theta}} \right)$$

where n is the total number of dolphins used for the estimations.

Coefficient of variation for total population size was calculated as:

$$CV(N_T) = \sqrt{(CV(\hat{N}))^2 + (CV(\hat{\theta}))^2}$$

The 95% confidence interval for total population size was constructed assuming a log-normal approximation (Burnham *et al.*, 1987).

Results

Photo-identification

Twelve boat surveys were carried out to photo-identify bottlenose dolphins in the study area, totalizing 90h of observation effort (Table 1). A total of 47 groups of dolphins were sampled. Group size varied between 1 and 25 individuals (mode = 6, mean = 7, SD = 5.3). A total of 2818 photographs were taken during the study period, 1606 (57%) of which were considered of excellent quality. From the analysis of these pictures, 31 dolphins with long-lasting marks in the dorsal fin could be identified. Most individuals were seen more than once and 10 dolphins (29%) were photographed only once.

Abundance estimates of marked population

The discovery curves increased steeply in the first seven surveys and showed a tendency towards stabilization as the survey effort increased (Figure 2). The plateau was reached in the 10^{th} survey.

Bootstrapping approach for GOF resulted in an estimated *c-hat* of 1.12, which can be interpreted as a weak evidence for overdispersion in the data. The most parsimonious model contained constant capture probability and survival, with temporal variation in the probability of entrance. Model selection indicates about 99.9% of support to the data for this model; therefore no model averaging was necessary. Under

Table 1. Summary of survey effort for bottlenose dolphins (*Tursiops truncatus*), specifying number of boat surveys, photo-identification sessions and number of identifications per month, between January and May 2008, in La Coronilla/Punta del Diablo, Rocha, Uruguay.

	Jan	Feb	Mar	Apr	May	Total
N° of boat surveys	2	1	3	3	3	12
Survey effort (h)	21.3	4	26.2	21	17.2	90
N° of groups photographed	14	3	14	10	6	47
N° of identifications	22	11	25	18	15	91

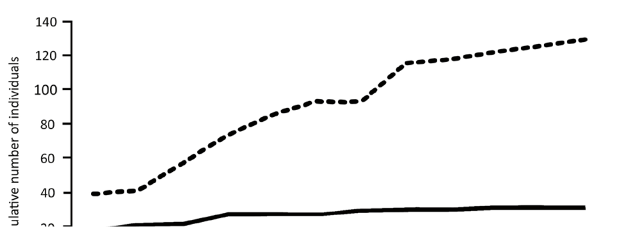

Figure 2. Discovery curve of bottlenose dolphins (*Tursiops truncatus*) showing the number of identified individuals against the cumulative number of dolphins encountered during the study. Dotted line is the curve for all animals. Continuous line is the curve for animals with long-lasting marks only in La Coronilla/Punta del Diablo coast between January and May 2008.

the selected model (Table 2), the POPAN formulation of Jolly–Seber provided an estimate of 35 (95% CI = 29–41) marked individuals using the waters of La Coronilla – Punta del Diablo. Capture probability was 0.30 (95% CI = 0.23–0.38). Daily survival probability was close to one. However, daily survival rates are not biologically meaningful for a long-lived species as bottlenose dolphins and the implications of this parameter estimate were not discussed. Probabilities of entrance were zero or not estimated properly (unrealistic CIs) for all sampling sessions. Both closed and open population models estimated similar numbers of dolphins with long-lasting marks. The model with the best fitting as selected by CAPTURE, which considers individual heterogeneity and temporal variation in capture probabilities (M_{th}), estimated the marked population size as 36 individuals (95% CI = 33–50). Capture probabilities varied from 0.08 to 0.47 between sampling sessions and averaged 0.25 (SD = 0.15) (Table 3).

Total population size estimation

After adjusting the estimate for the proportion of marked animals in the population (θ = 0.57) (Table 3), the total population size was estimated as 63 (95% CI = 54–74) and 61 (95% CI = 53–72) individuals from closed and open population models, respectively (Table 3).

Discussion

This study presents the first abundance estimates of bottlenose dolphins inhabiting the Rocha Department coast off Uruguay, an open coastal habitat in the Southwest Atlantic Ocean. Relatively high recapture rates (70%) and precision (maximum CV was 0.12) in abundance estimates were obtained, demonstrating that the study area is suitable for the implementation of an effective long-term population monitoring with relatively low cost. The results can be used as a baseline for monitoring trends in abundance of this population.

Satisfying assumptions of mark-recapture models

The high recapture rates of individuals identified through the use of good quality photographs of dorsal fins with conspicuous long-lasting marks seem to have satisfied assumptions of proper detection of mark loss/gain and mark recognition on recaptures (false positives/negatives). Particularly for closed population models, the use of data collected on the main occurrence area of bottlenose dolphin

Table 2. Model selection and results for the mark-recapture analysis of bottlenose dolphins (*Tursiops truncatus*) at Uruguayan Atlantic coast using POPAN formulation. For each model the number of parameters (No. Par.), a relative measure of fit (QDev – the relative deviance), and the quasi-Akaike's Information Criterion with a 2nd-order correction for small sample sizes (QAICc) are shown. Notation: Φ = apparent survival; *p* = capture probability; (.) = constant; t = time-dependence; β = probability of entry.

Model	QAICc	Delta QAICc	QAICc Weight	Model Likelihood	No. Par.	QDev
Φ(.) p(.) β(t) N	330.0	0.00	0.999	1.000	14	116.3
Φ(.) p(t) β(t) N	344.1	14.11	0.001	0.001	25	93.9
Φ(t) p(.) β(t) N	356.9	26.85	0.000	0	24	110.5
Φ(t) p(t) β(t) N	388.7	58.73	0.000	0	35	92.7

Table 3. Capture-recapture abundance estimates of common bottlenose dolphins (*Tursiops truncatus*) in La Coronilla/Punta del Diablo coast between January and May 2008 using closed and open population models. The number of dolphins with long-lasting marks in the population (*N*), estimated by M_{th} and POPAN models, the mark rate (θ) and total population size N_T are also shown. M_{t+1} = the number of animals marked during the experiment; SE = standard error; CV = coefficient of variation; CI = 95% confidence interval; p = probability of capture and SD = standard deviation.

Model	M_{t+1}	N	SE(N)	CV(N)	CI (95%)	θ	SE(θ)	CV(θ)	N_T	CV (N_T)	CI (95%)	p	SD(p) or CI (95%)
M_{th}	31	36	3.96	0.11	33–50	0.57	0.03	0.05	63	0.12	54–74	0.08 – 0.47	0.15
POPAN		35	2.69	0.08	29–41				61	0.09	53–72	0.30	0.23–0.38

in Uruguay and over a relatively short period of time (five months) increased the chances of meeting the population closure assumption. This is sustained by the high resighting rates and the pattern of the discovery curves, which indicates that nearly all marked individuals in the Uruguayan Atlantic coast were captured during the study period.

Low abundance of bottlenose dolphins in Uruguay

The abundance estimates obtained for bottlenose dolphins in the Uruguayan Atlantic coast, from both open and closed population models, indicate that the population is very small. Although we are sampling a small fraction of their home range, there are strong evidences suggesting that the abundance estimates are representative of the entire population inhabiting the Uruguayan Atlantic coast. Evidence includes multiple resightings of sixteen (55%) of the 29 identified dolphins in Cabo Polonio/Valizas coast and in La Paloma, approximately 65km and 100km to SW of La Coronilla/Punta del Diablo, respectively. In addition, no new individual was added to the catalogue of marked animals during land-based and boat photo-id surveys carried out in these areas in 2008 (Laporta, 2009).

The abundance estimated here is similar in number to other estuarine or coastal populations of bottlenose dolphins from the SWAO. The size of those populations was estimated at 58 to 88 individuals in San Antonio Lagoon and Patos Lagoon Estuary, southern Brazil, respectively (Daura-Jorge *et al.*, 2013; Fruet *et al.*, 2015*a*) and at 83 dolphins in San Antonio Bay, Argentina (Vermeulen and Cammareri, 2009). These values are also within the range reported for other coastal bottlenose dolphin populations inhabiting protected environments around the world, *e.g.* 66 individuals in Doubtful Sound, New Zealand (Williams *et al.,* 1993); 129 individuals in Moray Firth, Scotland (Wilson *et al.*, 1999); 100 individuals in Sarasota, USA (Wells and Scott, 1990). However, abundance estimates for populations inhabiting open coastal habitats are expected to be considerably larger, *e.g.* 286 individuals in Sanibel, USA, for an area of $140km^2$ (Shane, 1987) and 356 individuals in California (Dudzik, 1999) for an area smaller in range ($32km^2$) than our study area ($50km^2$). This substantial disparity might be related to differences in threats, dynamics and ecological requirements of populations as well as different carrying capacity between coastal and offshore environments.

Small populations of bottlenose dolphin had been documented in areas with scarce food resources such as the Turneffe Atoll in Belize (Campbell *et al.*, 2002) and Doubtful Sound in New Zealand, a fiord area with low benthonic productivity in the coastal zone (Williams *et al.*, 1993). The Uruguayan Atlantic coast, on the other hand, is a highly productive ecosystem that sustains the food web that includes several fish species, many of which are of commercial interest (Jaureguizar *et al.*, 2003; 2004) and are prey of bottlenose dolphins in the Southwest Atlantic (Secchi *et al.,* 2016). Several coastal fish species that are important prey for bottlenose dolphins, such as the Atlantic whitemouth croacker (*Micropogonias furnieri*) and the king weakfish (*Macrodon ancylodon*) are extensively overexploited (Haimovici, 1997; Delfino *et al.,* 2003; Pin *et al.,* 2003). It is well-documented that overfishing can regulate the size of some marine mammal populations (*e.g.* Steller sea lion, *Eumetopias jubatus* - Goldsworthy *et al.,* 2003; Hawaiian monk seal, *Monachus schauinslandi* - Lavigne, 2003) and also is probably the main reason for the decline in the encounter rates of common (*Delphinus delphis*) and bottlenose dolphins in eastern Ionian Sea coastal waters (*e.g.* Bearzi *et al.*, 2005; 2006) and in the Adriatic Sea (Bearzi *et al.*, 2004). This reinforces that the decrease in sighting frequency of dolphins in the estuarine coast of Uruguay, as has occurred in the estuarine Argentinean coast, could be related to overfishing and/or habitat degradation (Bastida *et al.,* 2007; Coscarella *et al.*, 2012; Vermeulen and Bräger, 2015).

The small population size estimated for bottlenose dolphin inhabiting the Uruguayan Atlantic coast in this study and its very low genetic variation (Fruet *et al.*, 2014) point to its vulnerability to human-induced impacts, as well as to the effect of both environmental and demographic stochasticity. Incidental capture of small cetaceans has been documented as the main factor affecting dolphin populations around the world (Hall *et al.*, 2000; Read *et al.*, 2006). It seems not to be a serious problem for bottlenose dolphins in the Uruguayan coast[7] (Praderi, 1985), because of the minimal overlap between the distribution of dolphin and artisanal coastal (Franco-Trecu *et al.*, 2009; Zappes *et al.,* 2014) and industrial offshore fishing activities (Domingo *et al.*, 2006). However, bycatch occurs in neighbour areas of southern Brazil (Fruet *et al.*, 2012). Considering the high mobility of this species along the Uruguayan coast (Laporta, 2009) and a potential demographic and genetic connection between dolphins from Uruguay and southern Brazil (*e.g.* Genoves, 2013; Fruet *et al.*, 2014), the fishing-related mortality in southern Brazil could lead to a source-sink effect (Pulliam, 1988; Harrison and Taylor, 1997), potentially affecting the growth rate of the population inhabiting the Uruguayan coast. In this regard, conservation plans should be designed to protect core and adjacent areas to enhance the connectivity between neighbour coastal populations (Fruet *et al.*, 2014).

Conservation implications

The Uruguayan coast has been suffering a rapidly urban development and expansion, including forestry, urban centers and infrastructure, promoting the deterioration of marine and coastal ecosystems (Menafra *et al.,* 2009). Although the Rocha Department coast is considered well preserved, relatively undeveloped with extensive agricultural activities and low tourism impact, it is currently changing due to the expansion of Maldonado (neighbour department) tourist model and the growing potential for large-scale industrial investments (Menafra *et al.*, 2009). Under this scenario, potential threats currently exist for this species on the Uruguayan coast such as the construction of a deep-water port in the area of El Palenque (34°32’S, 54°03’W; 34°30’S, 54°01’W) or La Angostura (34°06’S, 53°37’W), both areas located near Cabo Polonio and between Cabo Polonio and Cerro Verde, respectively, the first two marine protected areas established in the country.

Considering the small population size and very low genetic variation (Fruet *et al.*, 2014), the ignorance about its historical abundance, decline in sighting frequency in the Uruguayan estuarine coast, overfishing of some of its prey (Norbis *et al.*, 2006) and the expansion of industrial activities and infrastructures along the Uruguayan coast, precaution (*sensu* Gray and Bewers, 1996) is advised in order to protect bottlenose dolphins inhabiting the Uruguayan Atlantic coast. It must be demanded that a robust assessment of the potential effects on the viability of bottlenose dolphins and other components of the marine ecosystem is undertaken before decision makers allow for the establishment of additional human impacting activities. Marine top predators can be effectively used as indicators of underlying prey distribution and ecosystem processes (Hooker and Gerber, 2004). Due to the recent implementation of Marine Protected Areas in Uruguay it is fundamental to understand many ecological aspects of the bottlenose dolphin population to guide the establishment of adequate management plans of Cerro Verde and Cabo Polonio protected areas. Under these circumstances, the bottlenose dolphin, the franciscana (*Pontoporia blainvillei*), and the southern right whale (*Eubalaena australis*) were selected as Priority Conservation Species under the National System of Protected Areas (Soutullo *et al.*, 2013). Moreover, the bottlenose dolphin was selected as focal species for conservation in Cerro Verde and La Coronilla Islands Protected Area. This implies that monitoring of abundance and movement pattern as well as measures to reduce threats should be implemented. The bottlenose dolphin is the only small cetacean that can be observed from shore in Uruguay, therefore, is the most popular dolphin known by local coastal communities and tourists. Considered as a charismatic and flagship species, the designation of marine protected areas and the elaboration of conservation plans can help to effectively protect not only cetacean species but also other species of the marine ecosystem (Hoyt, 2005).

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