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A review on the distribution, abundance, residency, survival and population structure of coastal bottlenose dolphins in Argentina

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Abstract. Although bottlenose dolphins *Tursiops truncatus* are among the most common delphinid species, global population trends remain poorly understood. To improve the knowledge of the species in the Southwest Atlantic Ocean, this paper reviews all available data related to the distribution and occurrence, abundance, residency and ranging patterns, group size and composition, survival and reproduction and population structure of the coastal bottlenose dolphin in Argentina.

Most information proved to be scattered in time and space. Based on the available data, total abundance of coastal bottlenose dolphins in Argentina appears to be low. Data show sightings decreased notably since the 1990s in the northern province of Buenos Aires and the province of Chubut, with the species having disappeared completely from the former region. Data also indicated that two genetically and morphologically distinct coastal populations occur in Argentinean coastal waters, with a sympatric distribution in the provinces of Río Negro and Chubut. One is an isolated 'Evolutionary Significant Unit' within the larger Southwest Atlantic, whereas the other population appears to be genetically related to the Southwest Atlantic offshore ecotype.

In the absence of more substantial data, the present information is pertinent to our scientific knowledge of the species in the country, collating all published information as well as information from grey literature and previously unpublished data. However, the available information appears to remain insufficient to explain the apparent decline in sightings and to assess the remaining abundance nationwide accurately. Therefore, we strongly recommend increased research efforts for an in-depth assessment of the species' population status in Argentina.

Keywords: Conservation, group size, morphotypes, movements, reproduction, Southwest Atlantic Ocean, *Tursiops truncatus, Tursiops gephyreus*

Introduction

Due to the extensive geographical range of the common bottlenose dolphin (*Tursiops truncatus*) and its complex taxonomy, producing a comprehensive threat assessment for the species remains challenging, even after decades of research and with considerable amount of information available (Reeves and Leatherwood, 1994; Reeves *et al*., 2003). In view of the large-scale habitat degradation and collapse of coastal ecosystems as a result of growing human activities (*e.g.* Jackson *et al.,* 2001), coastal cetaceans, such as the bottlenose dolphin, are particularly susceptible to ensuing anthropogenic pressures (Schwacke *et al*., 2002; Wells *et al*., 2005; Sutherland, 2008). Consequently, in recent years an ever-increasing number of coastal bottlenose dolphin populations are reported to be vulnerable or declining worldwide (*e.g.* Thompson *et al.,* 2000; Bearzi *et al.,* 2004; Currey *et al*., 2007; Fruet *et al*., 2012; Tezanos-Pinto *et al.,* 2013).

Despite being extensively studied in the world, information on the coastal bottlenose dolphins in the larger Southwest Atlantic Ocean is limited. So far, studies have shown that the species lives in relatively small and adjacent communities along the coast of South Brazil, Uruguay and Argentina, with low genetic diversity among them (Fruet *et al*., 2014) and strong genetic distinction from the offshore ecotype (Fruet *et al*., 2017). The same study revealed a high differentiation between the coastal bottlenose dolphins of South Brazil and Uruguay and those from Patagonia, Argentina (Fruet *et al*., 2014). Within south Brazilian waters, the species appears to live in rather stable populations (Fruet *et al*., 2015) whereas sightings in Uruguay and Argentina appear to decrease (Lázaro and Praderi, 2000; Bastida and Rodriguez, 2003). Due to the overall lack of dedicated studies on the species within Argentinean waters until the early 2000s (with the exception of two studies conducted in the early 1970s-1980s), the species is considered officially to be 'not endangered' (Resolution 1030/04) and of 'low concern - conservation dependent' (Ojeda *et al*., 2012). However, more recently Coscarella *et al.* (2012), as well as Vermeulen and Bräger (2015), reported a decline of their study populations in Argentina and raised concerns about the species' nationwide conservation status. Unfortunately, information on the bottlenose dolphin in Argentina is scattered in time and space with most scientific data only available from more recent years, thus making any in-depth assessment of this mobile species challenging. Nonetheless, we attempted to compile all available data on the population structure, distribution, movement patterns, abundance, survival and reproduction of the bottlenose dolphin in Argentina in order to assess the current knowledge on the species in national waters and to prioritize research needs for an improved population and conservation assessment.

Material and Methods

Study area

The Argentinean coastline is nearly 6800km long reaching from the Río de la Plata south to the Canal Beagle. The continental shelf has a surface of approximately 960000km², being 210km wide in the North (38°S) and up to 850km in the South (52°S) (Boltovskoy, 2009). Aside from the province of Buenos Aires (from now on referred to as Buenos Aires), where 40% of the country's urbanization is located, the Argentinean coastline is fairly uninhabited, with population densities of approximately 1.9 inhabitant/km² in Patagonia (Boltovskoy, 2009), which includes the provinces of Río Negro, Chubut, Santa Cruz and Tierra del Fuego (from now on simply referred to by their respective names). Nonetheless, the rapid demographic and industrial growth along the Patagonian coast is resulting in increased pressures on the natural resources (Boltovskoy, 2009; González and Benseny, 2013)[1].

Data collection

Data on bottlenose dolphins in Argentina were compiled from published and unpublished sources including conference proceedings, dissertations, museum records and collections, reports, books, conference abstracts, unpublished data of the authors, newspaper articles and opportunistic photographs (*i.e.* all photographs obtained outside dedicated surveys). Governmental and newspaper agencies were contacted, as well as artisanal fishermen and captains of large fishing vessels of Buenos Aires and the association of whale watching guides in Río Negro and Chubut for additional information. Local inhabitants of various towns along the Argentinean coastline were asked to submit photographs and sighting information of the species. All data received were verified for accuracy

[1]Peralta, C. (1998) *Aspectos sociales de la Patagonia*. Capitula de Patagonia XXI Informe de consultora DHV, Comunicacion Tecnica 173. ISSN 1667-4006. INTA-EEA Bariloche.

and/or reliability independently by at least three researchers, often based on the availability of photographs and/or the trustworthiness of the informant. Any data that could not be substantiated were excluded from this report.

The marine mammal survey effort of the various research groups involved in this review are summarised in Table 1. Their respective databases were consulted for bottlenose dolphin sightings, or to infer the absence of the species.

Data processing

For the purpose of this review, all data were divided into six geographical regions, including the five provinces (Buenos Aires, Río Negro, Chubut, Santa Cruz and Tierra del Fuego).

Table 1. List of research studies by the co-authors of this review with study areas in Argentina (North to South).

Region	Study area	Organization	Respective co-author	Focus species	Study period
Northern Buenos Aires	Bahía Samborombón, Cabo San Antonio, Pinamar and Villa Gesell	Fundación Aqua Marina	Pablo Bordino, Leonardo G. Berninsone	Franciscana dolphin (*Pontoporia blainvillei*)	1998-ongoing
	San Clemente - Necochea	Universidad Nacional de Mar del Plata	Ricardo Bastida	Bottlenose dolphin	1973-1985
	Mar del Plata	Universidad Nacional de Mar del Plata	Ricardo Bastida	Marine mammals	1977-ongoing
Southern Buenos Aires	Bahía Blanca, Bahía San Blas	Fundación Aqua Marina	Pablo Bordino, Leonardo G. Berninsone	Franciscana dolphin	1998-ongoing
	Bahía Blanca	GEKKO- Universidad Nacional del Sur	Pablo Petracci	Bottlenose dolphin, franciscana dolphin	1999-ongoing
	Bahía Anegada, Bahía San Blas	Fundación Cethus	Miguel Iñíguez	Cetaceans	1993-1994
Río Negro	Estuario Río Negro	Fundación Cethus	Mauricio Failla	Bottlenose dolphin	2001-ongoing (between March and July)
	Bahía San Antonio	Whalefish (previously Fundación Marybio)	Els Vermeulen	Bottlenose dolphin	2006-2012
Chubut	Golfo San José	Wildlife Conservation Society Wildlife Conservation Society	Guillermo Harris Guillermo Harris	Bottlenose dolphin Marine mammals	1981-1990 1991-ongoing
	Península Valdés	Instituto Nacional de Investigación y Desarrollo Pesquero (INIDEP)	Ricardo Bastida	Southern right whale (*Eubalaena australis*)	1981-1990
		Fundación Cethus	Miguel Iñíguez	Killer whale (*Orcinus orca*)	1985-2000 (between January and June)
		Instituto de Conservación de Ballenas	Mariano Sironi	Southern right whale	1995-ongoing (between July and October)
	Golfo San Jorge	Universidad Nacional de la Patagonia	Laura Reyes	Cetaceans	2003-2007 (between October and March)
Santa Cruz	Caleta Olivia, Cabo Blanco, Río Deseado, Bahía San Julián, Río Santa Cruz, Río Gallegos and Cabo Vírgenes	Fundación Cethus	Miguel Iñíguez	Cetaceans	1986-ongoing
Tierra del Fuego	Bahía San Sebastián, Puerto Harberton	Museo Acatushún de Aves y Mamíferos Marinos Australes	María C. Marchesi	Marine mammals	1975-ongoing

In turn, the province of Buenos Aires was subdivided into a northern and southern section in order to clearly represent the variety of information for these two subregions (Fig. 1).

Subsequently, all data were subdivided into subsections related to distribution and occurrence, abundance, residency and ranging patters, group size and composition, and survival and reproduction. The relevant subsection was omitted if no data were available on one of these topics in a particular region.

We considered dedicated effort all (land- and boat-based) survey effort focused only to bottlenose dolphins (whether or not year-round) whereas all survey effort targeting other marine mammal species, or not exclusively bottlenose dolphins, was considered opportunistic. For the visual representation of the available information, maps were created in QGIS (QGIS Development Team, 2016). Tables were created to summarise the information, and presented after all the relevant sections.

Results

Northern Buenos Aires

Distribution and Occurrence

Before 1970 (Fig. 2A): The oldest record found for the presence of bottlenose dolphins in Argentina dates from 1904, when Lahille (1908) caught a male and a female in Río de la Plata, near Quilmes. Subsequently, various authors reported on the sighting or stranding of the species along the coast of Buenos Aires, including in the Río de la Plata (Lahille, 1908), up the Río Uruguay near Gualeguaychú (33°07'S, 58°21'W; Castello *et al.*, 1983), in the area of Mar del Plata and Necochea (R. Bastida, pers. obs.) as well as in Punta Blanca (Marelli, 1953). However, especially in Mar

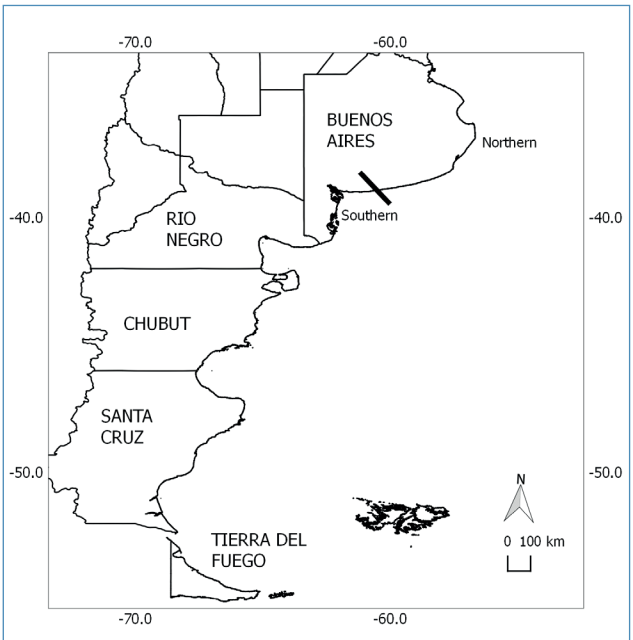


Figure 1. Map of Argentina indicating the coastline of all provinces, as well as the division between northern and southern Buenos Aires.

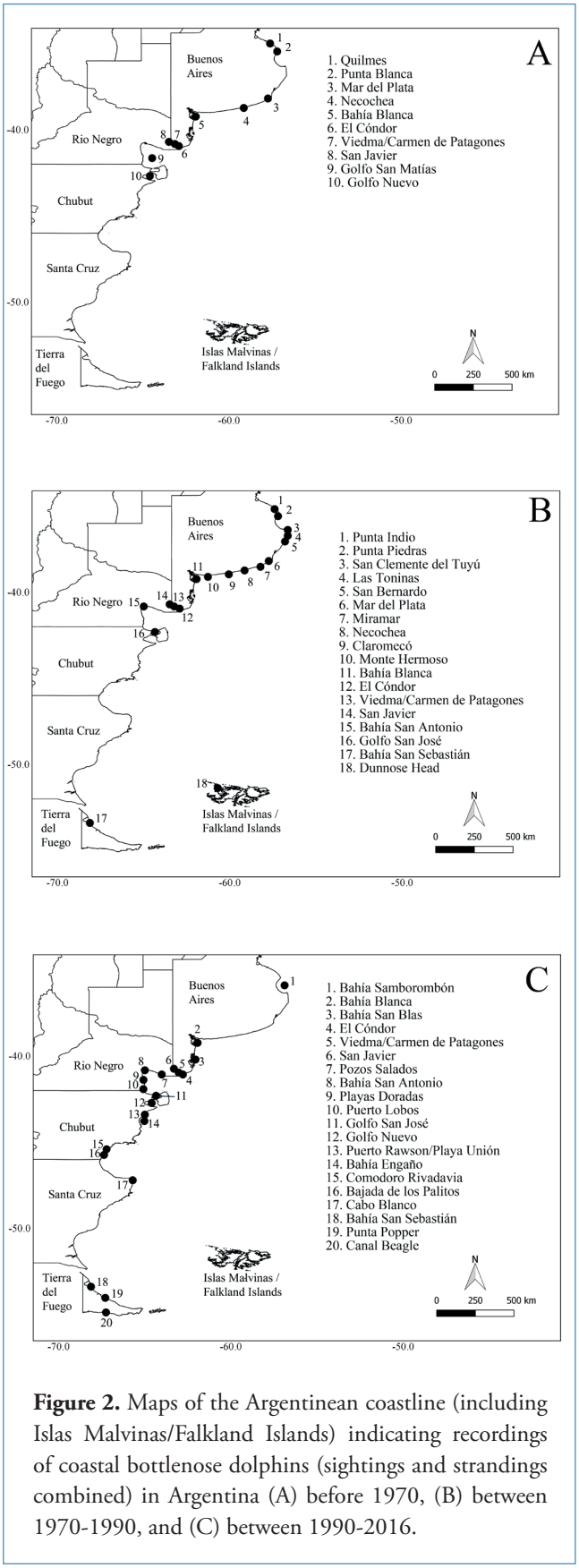


Figure 2. Maps of the Argentinean coastline (including Islas Malvinas/Falkland Islands) indicating recordings of coastal bottlenose dolphins (sightings and strandings combined) in Argentina (A) before 1970, (B) between 1970-1990, and (C) between 1990-2016.

del Plata, the bottlenose dolphin was considered a common species by local inhabitants and tourists, and could be seen at least once a week (R. Bastida, pers. obs.).

1970-1990 (Fig. 2B): In his review, Castello *et al.* (1983) indicated a continuous distribution of bottlenose dolphins along the entire coasts of Buenos Aires, Río Negro and Chubut. Specifically, Mermoz (1977) reported the presence of the species in Punta Indio, and Bastida and Rodríguez (2003) reported on a coastal population residing between Punta Piedras and Necochea. Due to the frequent presence of bottlenose dolphins in this area, a newly founded town was called 'Las Toninas' after the bottlenose dolphin's common name in Argentina. Strandings were recorded at Chapadmalal Beach (38º12'S, 57º41'W; Bastida *et al.*, 1992) and Miramar (38º16'S, 57º50'W; M. Iñiguez, pers. obs.). Additionally, several manuscripts mentioned the bycatch of bottlenose dolphins in coastal fisheries near the port of Mar del Plata in January 1982 and in the port of Necochea and Claromecó between 1988 and 1990 (Moreno *et al.*, 1984; Bastida and Lichtschein, 1986). Nonetheless, bycatch mortality appears to have been low (Crespo *et al.*, 1994).

1990-2016 (Fig. 2C): In this period, only three live sightings of a single bottlenose dolphin could be confirmed in northern Buenos Aires (Punta Mogotes, 1992; Bahía Samborombón, 19 May 2007; Necochea, 2011) as well as one stranding[2] (a possible case of bycatch; 14 Dec. 2004; Fundación Aqua Marina, unpubl. data; Bastida, unpubl. data).

Abundance (see also Table 2)

In the late-1970s to mid-1980s, based on mark-recapture analyses, approximately 100 coastal bottlenose dolphins were estimated to occur between San Clemente del Tuyú and Miramar (Bastida and Rodríguez, 2003). A decrease in sightings was noted in this area in the late 1980s, after which sightings dropped dramatically in the 1990s despite continued opportunistic survey effort in the region (Table 1; Bastida, 2003; 2015; Bastida and Rodríguez, 2003; Fundación Aqua Marina, unpubl. data). These data indicate an extremely low abundance of the species in northern Buenos Aires during the last decades, and confirm the most frequent records occurred some 40 years ago (Lodi *et al.*, 2016).

Residency and ranging patterns

In the late 1970s to mid-1980s, 30 identified bottlenose dolphins were recorded to move over a coastal stretch of 250km between Miramar and San Clemente del Tuyú, with maximum ranging distance measured of nearly 400km between Bahía Samborombón and Necochea (Bastida and Rodríguez, 2003). Most of these identified individuals were resighted on multiple occasions, two of which over a time span of 10 years, indicating a long-term site-fidelity (Bastida and Rodríguez, 2003; R. Bastida pers. comm.).

Group size and composition (see also Table 2)

In Bahía Samborombón, groups of 10 to 100 individuals could be observed in the early 1980s, with one extreme sighting of several hundred individuals in one group (summer 1985)[3]. In the 1970s and 1980s, bottlenose dolphins between San Clemente del Tuyú and Miramar were most often seen in groups of 4-6 individuals, with the maximum recorded group size ≤30 individuals (Bastida, unpubl. data). Calves were observed in approximately 15% of the groups, but never more than one calf per group (Bastida, unpubl. data).

Southern Buenos Aires

Distribution and Occurrence

Before 1970 (Fig. 2A): Along the coast of Monte Hermoso, R. Bastida (pers. obs.) observed the presence of a single bottlenose dolphin interacting with bathers (incl. physical contact) in February 1968.

1970-1990 (Fig. 2B): Castello *et al.* (1983) indicated a continuous distribution of bottlenose dolphins along the entire coast of Buenos Aires, including the southern part of the province. Balbiano and Suárez (2000) commented on the recurrent presence of a single bottlenose dolphin interacting with swimmers along the beach of Monte Hermoso during the summer of 1974.

1990-2016 (Fig. 2C): Records indicate the continued presence of bottlenose dolphins in Bahía Blanca, mainly in the interior channels of the estuary of Ría Bahía Blanca, as well as in Bahía San Blas (Fidalgo, 2004; Vermeulen *et al.*, 2016; Fundación Aqua Marina, unpubl. data; Petracci, unpubl. data).

Abundance (see also Table 2)

Although no precise information is available on the local abundance of the species in Bahía Blanca, based on mark-recapture data numbers are believed to be low, not exceeding 50 individuals (Petracci, unpubl. data).

Residency and ranging patterns

In Bahía Blanca, 21 individuals were identified from opportunistic photographs between 2008 and 2016, of which various were re-sighted on multiple occasions suggesting some degree of site-fidelity to the region (Vermeulen *et al.*, 2016). Vermeulen *et al.* (2016) also identified five individuals in Bahía San Blas and described the ranging distance of one individual traveling at least 180km (one way) between Bahía Blanca and Bahía San Blas.

Group size and composition (see also Table 2)

For the area of Bahía Blanca, observations between 1999 and 2016 recorded a median group size of four individuals in the area (max = 20 inds; Fidalgo, 2004; Fundación Aqua Marina, unpubl. data; Petracci, unpubl. data). The presence of calves in these groups was observed regularly, although data were not recorded systematically (Petracci, unpubl. data).

[2]Julián Bastida, pers. comm., April 2011. INIDEP, Paseo Victoria Ocampo Nº 1, Escollera Norte, Mar del Plata 7600, Argentina

[3]Mario Beade, pers. comm., May 2016. Intendente Parque Nacional "Campos del Tuyú", Bme. Mitre 160, 7103 General Lavalle, Buenos Aires, Argentina

Table 2. An overview of available information on group size, presence of calves in groups and abundance of bottlenose dolphins in Buenos Aires, Río Negro and Chubut between 1974 and 2016. Santa Cruz and Tierra del Fuego are not included due to the existence of few occasional sightings of bottlenose dolphins only in these provinces. NA = not available.

	Time period	Individuals identified	Group size	Presence of calves in group	Local abundance (and method used)	Reference
Northern Buenos Aires						
Bahía Samborombón	1983-1986	0	Between 10-100	NA	NA	M. Beade, pers. comm.
	1998-2016	0	NA	NA	Near 0	Fundación Aqua Marina, unpubl. data
San Clemente del Tuyú Miramar	1974-1992	30	Most frequently between 4-6; max.=30	15% of groups; 1 calf per group	Approx. 100 (rough estimate; mark-recapture)	Bastida and Rodríguez, 2003; Bastida, 2015; Bastida, unpubl. data)
	1993-present	0	NA	NA	Near 0	Bastida, unpubl. data
Southern Buenos Aires						
Bahía Blanca	2003-2016	17	Median=4; max.=20	NA	NA (believed to be < 50 based on mark-recapture)	Vermeulen *et al.*, 2016; Fundación Aqua Marina, unpubl. data; Petracci, unpubl. data
Bahía San Blas	2008-2016	5	Ranging between 1 to >10 (anecdotal)	NA	NA	Vermeulen *et al.*, 2016; Fundación Aqua Marina, unpubl. data
Rio Negro						
Estuario del Río Negro	2008-2015	21	Most frequently between 1-5; max.=20	31% of groups; 1 calf per group	Included in estimate below	Failla *et al.*, 2017
Bahía San Antonio	2006-2012	67	Median=4; max.=50	75% of groups; 1-8 calves per group	83 (95%CI = 45.8 - 151.8) (mark-recapture)	Vermeulen and Cammareri, 2009*b*; Vermeulen *et al.*, 2015, 2016; Vermeulen and Bräger, 2015
Chubut						
Golfo San José	1974-1976	53	Mean=14.9; max.=22	10% of groups; 1.5 calf per group	> 53 (mark-recapture)	Würsig and Würsig, 1977
	1981-1988	0	Between 5-8	NA	NA	Würsig and Harris,1990; G. Harris, pers. obs.
	1999-2007	NA	One group of 2 inds observed	0	34 (95%CI = 22-51) (aerial survey)	Coscarella *et al.*, 2012
Golfo Nuevo	2001-2007	NA	Mean=2.8; max.=10 (decrease from 5 to 2 over years)	0	Included in estimate above	Coscarella *et al.*, 2012
Bahía Engaño	1999-2002	NA	Mean=2.3; max.=12	0	Included in estimate above	Coscarella *et al.*, 2012

Río Negro

Distribution and Occurrence

Before 1970 (Fig. 2A): Anecdotal records indicate the presence of coastal bottlenose dolphins in Golfo San Matías (Cabrera and Yepes, 1940) as well as 60km upstream in the Río Negro (near the cities of Viedma/Carmen de Patagones and San Javier; Failla, unpubl. data).

1970-1990 (Fig 1B): Continuous records were made also for this period of the frequent occurrence of bottlenose dolphins in Río Negro (Castello *et al.*, 1983), including up to 60km upstream the river near Viedma/Carmen de Patagones and San Javier (Failla, unpubl. data). Two strandings as a result of bycatch were reported in El Cóndor in the autumn of 1976 and summer of 1983 (Failla, unpubl. data).

1990-2016 (Fig. 2C): Despite the general presence of coastal bottlenose dolphins in the area for the past decades, dedicated studies only commenced in 2006, documenting the presence of a resident community ranging from Bahía San Antonio to El Cóndor (Vermeulen and Cammareri, 2009*b*; Vermeulen *et al.*, 2016; Failla *et al.*, 2016). In this area, 13 strandings were recorded between 2001 and 2015 (E. Vermeulen and M. Failla, pers. obs.). Four of these were

related to bycatch in gillnets, whereas another individual was observed in the freezer of an artisanal fisherman who intended to consume it (E. Vermeulen, pers. obs. 2012). It remains unclear whether the latter animal was bycaught or intentionally killed. Additional sightings of the species were made along the coast of Pozos Salados and Playas Doradas (E. Vermeulen, pers. obs.) as well as further south in Puerto Lobos (Vermeulen and Cammareri, 2009*a*).

Abundance (see also Table 2)

Based on mark-recapture studies, Vermeulen and Bräger (2015) reported a total annual abundance of 83 (95% CI = 46-152) individuals. The proportion of marked individuals in the population averaged 0.65 (± 0.05 SD) between 2009 and 2011, and appeared to increase over the years (reported to be only 0.53 in 2008; Vermeulen and Cammareri, 2009*b*).

Residency and ranging patterns

In Río Negro, a community of coastal bottlenose dolphins was reported to reside in Bahía San Antonio (Vermeulen and Cammareri, 2009*b*; Vermeulen *et al.*, 2016). A total of 67 bottlenose dolphins could be photo-identified between 2006 and 2011, and resighted up to 44 times on separate days in the area. These data resulted in a median Residency Index value of 0.24, with a maximum of 0.56 (for an individual that was re-sighted in 25 of the 45 study months; Vermeulen *et al.*, 2016). In Bahía San Antonio, residency appeared to increase in winter and was positively correlated to a between-year site-fidelity (Vermeulen *et al.*, 2016). Twenty of the 67 identified individuals were reported to range northeast to the Estuario del Río Negro (El Cóndor; 200km one way), with a minimum interval of eight days between sightings in both areas (equivalent to a mean travel speed of 25km/day; Vermeulen *et al.*, 2016). Two individuals were reported to range even further towards the area of Bahía San Blas (Buenos Aires; 290km one way; Vermeulen *et al.*, 2016). Additionally, Vermeulen and Cammareri (2009*a*) mentioned a ranging distance of 150km one way for four identified bottlenose dolphins between Bahía San Antonio and Puerto Lobos.

Group size and composition (see also Table 2)

In El Cóndor, Failla *et al.* (2016) found that most groups observed contained 1-5 individuals (37%), although occasional aggregations of up to 20 dolphins (2% of groups) were recorded. The authors further reported that 31% of the observed groups contained calves, but never more than one calf per group. In Bahía San Antonio, Vermeulen *et al.* (2015) recorded a median group size of four individuals, ranging from one to 50. Only 8% of the sighted dolphin groups contained >20 individuals. The group sizes varied significantly across seasons and behavioural patterns, with the largest groups found in winter and during surface feeding bouts (Vermeulen *et al.*, 2015). One to eight calves were present in 75% of the dolphin groups encountered (Vermeulen *et al.*, 2015).

Survival and reproduction

A dedicated study of survival rate and reproduction was conducted in Bahía San Antonio between 2006 and 2012 (Vermeulen and Bräger, 2015). Of an estimated population of approximately 83 individuals in this area, the authors modelled an annual adult survival rate between 0.97-0.99. During the same study, a total of 25 different calves were registered from 14 reproductive females, resulting in an estimated annual calf mortality of 22% or 0.7 calf/year (Vermeulen and Bräger, 2015). The majority (83%) of the calves was born in late spring/early summer, and reproductive females had an average calving interval of 3.5 years (ranging from two to five years). The same study estimated 3.5 births/year for the whole population, resulting in a minimum annual birth rate of 4.2%/year.

Chubut

Distribution and Occurrence

Before 1970 (Fig. 2A): Bastida and Rodriguez (2009) indicated that the first interaction between divers and bottlenose dolphins in Península Valdés dates from the late 1950s. Further anecdotal records confirmed the presence of bottlenose dolphins in Golfo Nuevo from 1958 onward (R. Bastida, pers. obs.).

1970-1990 (Fig. 2B): The first dedicated study of coastal bottlenose dolphins was conducted during 21 months in 1974-1976 (Würsig and Würsig, 1977). This study recorded the year-round presence of coastal bottlenose dolphins in Golfo San José (Würsig and Würsig, 1977; 1979; Würsig, 1978). A few years later, based on dedicated survey effort in the region between 1981 and 1988, Würsig and Harris (1990) reported a notable decrease in sightings in this area. It was suggested to be related to a shift in range, although no clear evidence for this hypothesis was provided.

1990-2016 (Fig. 2C): No dedicated research has been conducted on bottlenose dolphins in Chubut since the early 1990s[4]. Coscarella *et al.* (2012) reported on the presence of coastal bottlenose dolphins along the outer coastline of Península Valdés and inside Golfo San José and Golfo Nuevo since 1999, albeit in relatively low numbers. They occurred year-round in Golfo Nuevo, and seasonally in adjacent areas (in winter and spring). Romero *et al.* (2014) reported on the stranding of six bottlenose dolphins between 1997 and 2012 in northern Patagonia (40°30'S to 43°30'S, 64°W to 65°W), one of which took place in Playa Unión (Sánchez *et al.*, 2002). Observations made by Coscarella and Crespo (2009) indicated bottlenose dolphins might use the area of Playa Unión for feeding, and reported on their interaction with Commerson's dolphins (*Cephalorhynchus commersonii*). In a first annotated checklist of cetaceans for the central Patagonian coast, including opportunistic sources as well systematic boat surveys for marine mammals in the northern coast of Golfo San Jorge, Reyes (2006) did not report strandings or sightings

[4]Mariano Coscarella, pers. comm., May 2017. Laboratorio de Mamíferos Marinos, CENPAT, CONICET, Boulevard Brown 2915, Puerto Madryn (U9120ACD), Chubut, Argentina

of bottlenose dolphins, even if other 13 cetaceans species were reported. However, aerial surveys of Crespo *et al*. (2008) indicated the presence of bottlenose dolphins just north of Comodoro Rivadavia. Additionally, two bottlenose dolphins stranded alive in Bajada de los Palitos on 15 February 2011 (Anonymous, 2011), and four individuals were recorded during maritime operations in July 2016, just in front of Comodoro Rivadavia[5].

Abundance (see also Table 2)

Würsig and Würsig (1977) photo-identified 53 individuals in Golfo San José. Although no abundance estimates are available, this number was regarded to be a minimum as bottlenose dolphins were also sighted at the same time outside the study area. Dolphins were sighted in the study area on 44% of their survey days (Würsig and Würsig, 1977). A decade later, this number had decreased to 5% for the same area (Würsig and Harris, 1990), with sightings consisting mostly of the same five individuals (G. Harris, pers. obs.). A few decades later, Coscarella *et al*. (2012) reported a total abundance estimate of 34 (95% CI = 22-51) bottlenose dolphins for the entire coastline of Chubut, with no sightings inside Golfo San José.

Annual aerial surveys conducted between 1981 and 1990 along the coast of Península Valdés (Table 1), resulted in the sighting of only three bottlenose dolphin groups in three different years (R. Bastida pers. obs.). Similarly, despite intensive shore-based observations between July and October, and aerial photo-identification surveys each September since 1995 in Golfo San José and Golfo Nuevo (Table1), only two sightings of solitary bottlenose dolphins were recorded in Golfo Nuevo (in 2001 and 2005) and none in Golfo San José for the period 1995-2015 (M. Sironi, pers. obs.). Considering >300 opportunistic records of dusky dolphins (*Lagenorhynchus obscurus*) during these surveys, this confirms the extremely low abundance of bottlenose dolphins in this area since 1995, at least during winter and early spring (July-October).

Residency and ranging patterns

Würsig and Würsig (1977) described the ranging patterns of identified coastal bottlenose dolphins over 300km (one way). The authors further recorded the residency of at least five individuals in Golfo San José during their entire 21-month study in 1974-1976. Six other individuals were present in the first study year, with four of them being re-sighted in the area 30 months after commencement of the study (Würsig and Harris, 1990).

Group size and composition (see also Table 2)

Würsig (1978) reported a mean group size of 14.9 individuals, ranging from eight to 22. The author further indicated that on average 10% of a dolphin group was composed of calves, with a mean of 1.5 calf per group. A few decades later, Coscarella *et al*. (2012) indicated a mean group size of 2.5 individuals (median = 2, max. = 9; n = 17) based on aerial surveys from Península Valdés to Bahía Engaño (2001-2007). During boat-based surveys, the authors recorded a median group size of 3.5 individuals inside Golfo Nuevo (mean = 2.8; max. = 10; n = 85), with a decrease from five to two individuals between 2001 and 2007 (Coscarella *et al*., 2012). Based on land-based surveys, the median group size observed in Bahía Engaño was three individuals (mean = 2.3, max. = 12; n = 91; Coscarella *et al*., 2012).

Survival and reproduction

Calves appeared to be born in all seasons except in winter during a 21-month study in 1970s in Golfo San José (Würsig, 1978). Coscarella *et al*. (2012) reported that no calves had been observed in Chubut between 1999 and 2007.

Santa Cruz

Distribution and Occurrence

1990-2016 (Fig. 2C): Bastida and Rodríguez (2006; 2009) mentioned the sighting of one bottlenose dolphin in Santa Cruz. This individual was sighted within a group of three Peale's dolphins (*Lagenorhynchus australis*) in Cabo Blanco on 15 February 2001 (R. Bastida, pers. obs.). One other sighting was made of a single individual a few days later, on 27 February 2001, near Río Gallegos[6]. It remains unclear if these sightings concern the same individual. No other bottlenose dolphin sightings or strandings were recorded in this province, despite the intensive cetacean research effort in Caleta Olivia, Ría Deseado, Bahía San Julián, Ría Santa Cruz, Río Gallegos and Cabo Vírgenes since 1986 (Table 1; Fundación Cethus, unpubl. data).

Tierra del Fuego

Distribution and Occurrence

1970-1990 (Fig. 2B): One bottlenose dolphin was found stranded in Tierra del Fuego in 1977 (Goodall, 1989; Goodall *et al*., 2011). Furthermore, two male bottlenose dolphins were reported stranded in Dunnose Head, Isla Gran Malvina/West Falkland Island in May 1984 (Strange, 1992), within a group of approximately 100 pilot whales.

1990-2016 (Fig. 2C): Two single individuals were found stranded in Tierra del Fuego in December 1992 and October 1996 (Otley, 2012). Goodall *et al*. (2011) further mentioned the stranding of at least seven individuals in this province (in Bahía San Sebastián, Punta Popper and Puerto Harberton/ Canal Beagle) between 2003 and 2006. The same authors also confirmed a sighting of at least three bottlenose dolphins in the Canal Beagle (54°55'S, 67°34'W) in 2003. This appears to comprise one of the southernmost records of live bottlenose dolphins worldwide, with species identification verified by Goodall *et al*. (2011).

[5]Gustavo Koszel, pers. comm., September 2016. ServiSub, Av. Las Toninas y Capitán Gómez Roca, Zona Portuaria, 9000 Comodoro Rivadavia, Chubut

[6]Mariano Coscarella, pers. comm., April 2017. Laboratorio de Mamíferos Marinos, CENPAT, CONICET, Boulevard Brown 2915, Puerto Madryn (U9120ACD), Chubut, Argentina

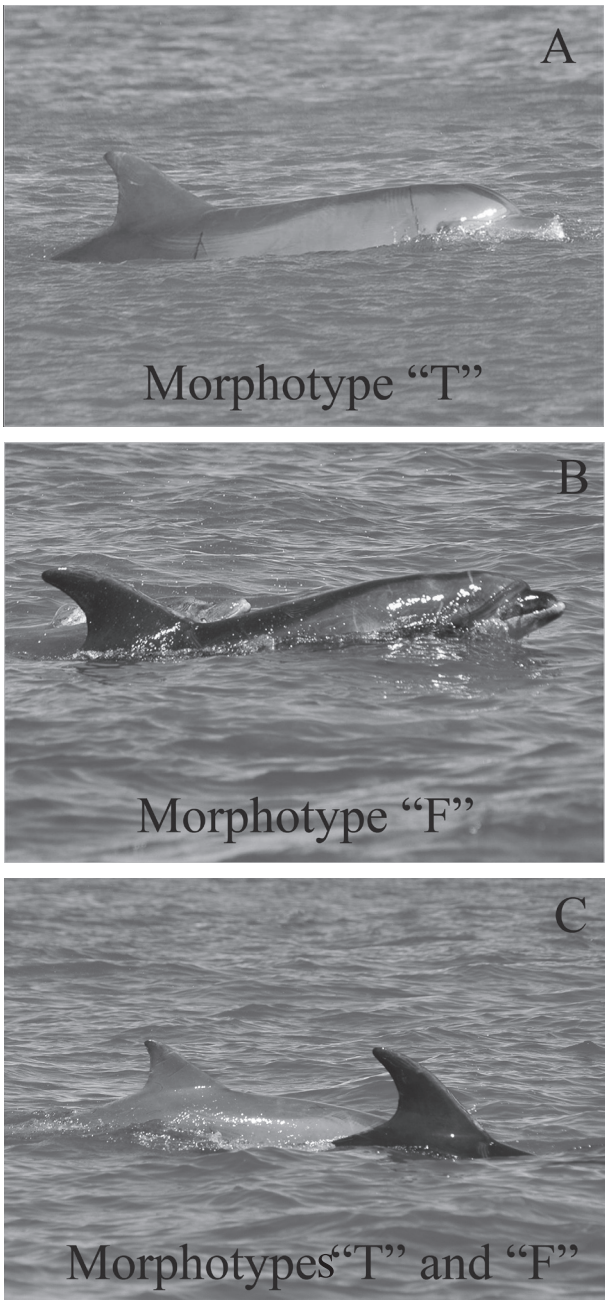


Figure 3 A. adult bottlenose dolphin identified in Bahía San Antonio, Río Negro; morphotype 'T', described by Lahille (1908) as *Tursiops gephyreus.* **B:** adult bottlenose dolphin identified in Bahía San Antonio; morphotype 'F'. **C:** identified adult individuals of both morphotypes 'T' and 'F' interacting in Bahía San Antonio.

Population structure

Based on external morphology, various authors have described two distinct coastal populations in the Southwest Atlantic in the 1980s (Castello *et al.*, 1983; Bastida and Rodríguez, 2003; Bastida *et al.*, 2007). A northern population was reported to range along the coasts of southern Brazil, Uruguay and Buenos Aires (Argentina), with bottlenose dolphins displaying a 'triangular dorsal fin, relatively longer beak and light grey coloration' (Vermeulen and Cammareri, 2009*a;* here referred to as morphotype *'T'*: Fig. 3A). These dolphins were first described by Lahille (1908) as *Tursiops gephyreus*. Although to date this species name has not been recognized and instead is regarded as a junior synonym to *T. truncatus* (*e.g.*, Cabrera and Yepes, 1940; 1960; Hershkovitz, 1963; Marcovecchio *et al.*, 1990; 1994; Bastida and Rodríguez, 2003; 2006), its re-validation has been proposed recently based on skull morphometry (Wickert *et al.,* 2016).

Another coastal population was reported to range in the south, along the coast of Chubut (Würsig and Würsig, 1977; Würsig and Harris, 1990), with bottlenose dolphins displaying a 'falcate dorsal fin, short beak and darker coloration' (Vermeulen and Cammareri, 2009*a;* here referred to as morphotype *'F'*: Fig. 3B).

It appears, however, that the geographical distribution of these two morphotypes *'T'* and *'F'* was not clearly separated from 'north to south'. As such, on one occasion morphotype *'T'* was sighted in Golfo Nuevo (Chubut) in 1958 (R. Bastida, pers. obs.), and on multiple occasions in 1973-1976 inside Caleta Valdés (Chubut)[7]. More recent data show that a sympatric distribution indeed exists in Río Negro and Chubut (Fig. 4). As such, Vermeulen and Cammareri (2009*a*) confirmed the presence of morphotype *'F'* as far north as Bahía San Antonio (Río Negro) where they live in sympatry with – and interact with – a resident community of morphotype *'T'* (Fig. 3C). Other records exist for their presence in the Golfo San Matías (Vermeulen and Cammareri, 2009*a*; Svendsen, 2013). On the other hand, morphotype *'T'* can also be observed in Playa Unión/Puerto Rawson (Chubut; Vermeulen and Failla, unpubl. data).

Recent data indicate a strong genetic differentiation between both morphotypes. Fruet *et al.* (2017) reported the bottlenose dolphins of morphotype *'F'* to be closely related to the offshore bottlenose dolphins of South and Southeast Brazil in the reconstructed mtDNA haplotype genealogy, with no current genetic exchange with bottlenose dolphins of morphotype *'T'*. Although based on only three samples collected from morphotype *'F'*, this would suggest that morphotype *'F'* individuals are of offshore origin despite their apparent coastal presence and ecology (*e.g.*, Würsig and Würsig, 1977; Vermeulen and Cammareri, 2009*a*). So far, only one record exists of morphotype *'F'* in waters >100m water depth in Argentina albeit close to shore, where they were observed with pilot whales (*Globicephala melas*; Svendsen, 2013). The bottlenose dolphins sighted further south (*e.g.* Goodall *et al.*, 2011) are of unknown morphology or ecotype.

Figure 4 provides an overview of the distribution of the different morphotypes of bottlenose dolphins in Argentina.

[7]Bernd Würsig, pers. comm., July 2016.Texas A&M University at Galveston, P.O. Box 1675, 77553 Galveston, Texas, USA

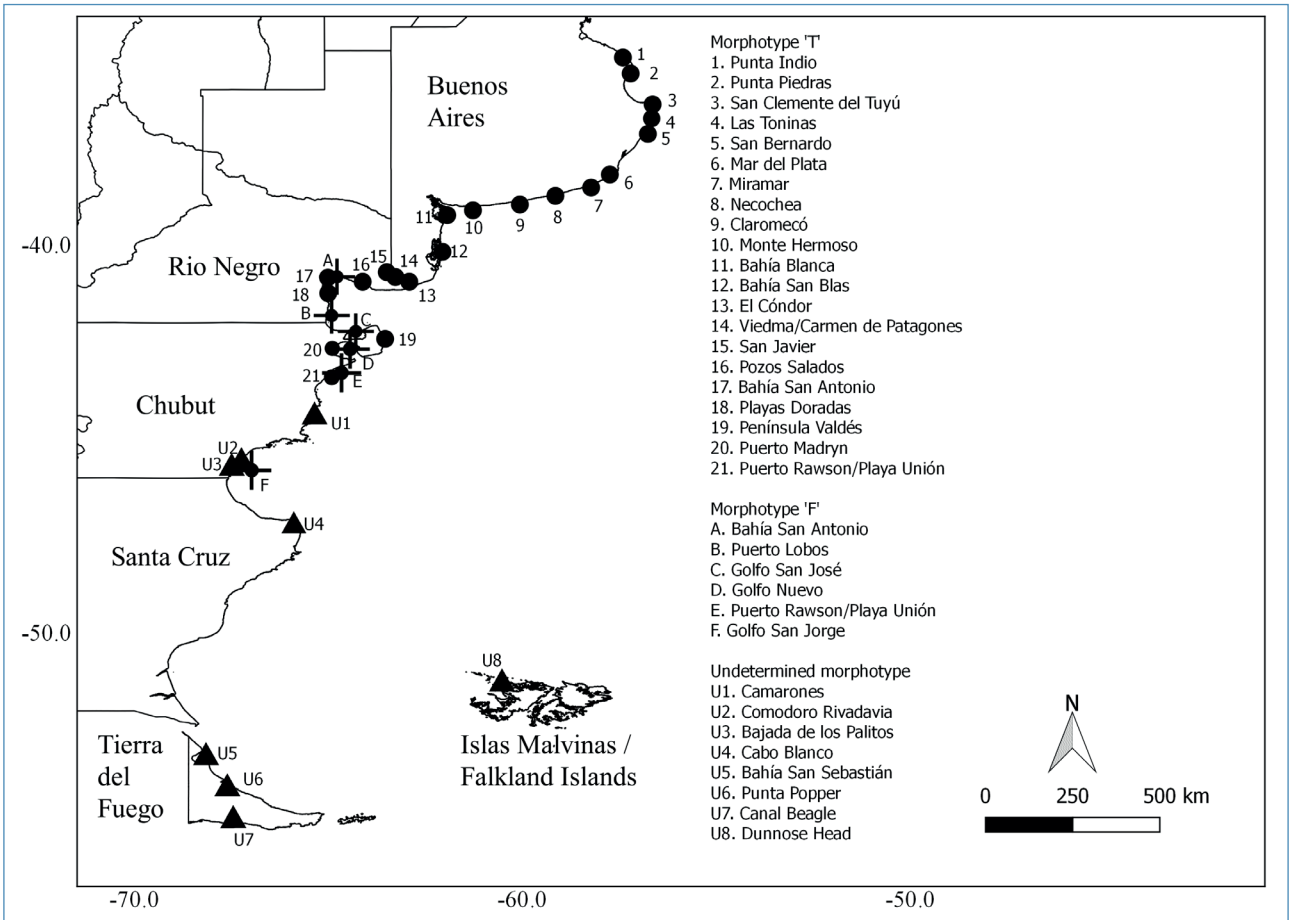


Figure 4. Map of the Argentinean coast (including Islas Malvinas/Falkland Islands) indicating the past and present distribution of bottlenose dolphins, as summarized in this review. Dots indicate the presence of morphotype 'T', described as *Tursiops gephyreus* by Lahille (1908) (cf. Fig. 3A). Dots with plus sign indicate the presence of morphotype 'F' (cf. Fig. 3B). Triangles indicate sightings and strandings of bottlenose dolphins with undetermined morphology.

Within the larger Southwest Atlantic, genetic information revealed that morphotype *'T'* individuals of Bahía San Antonio possess a unique mtDNA haplotype not shared with morphotype *'T'* dolphins from Brazil and Uruguay, and can be viewed as a distinct 'Evolutionary Significant Unit' of morphotype *'T'* (Fruet *et al.*, 2014). Additionally, genetic diversity among morphotype *'T'* dolphins of Bahía San Antonio at both mitochondrial and nuclear DNA was extremely low (Fruet *et al.*, 2014), likely reflecting their overall small population size (Vermeulen and Bräger, 2015).

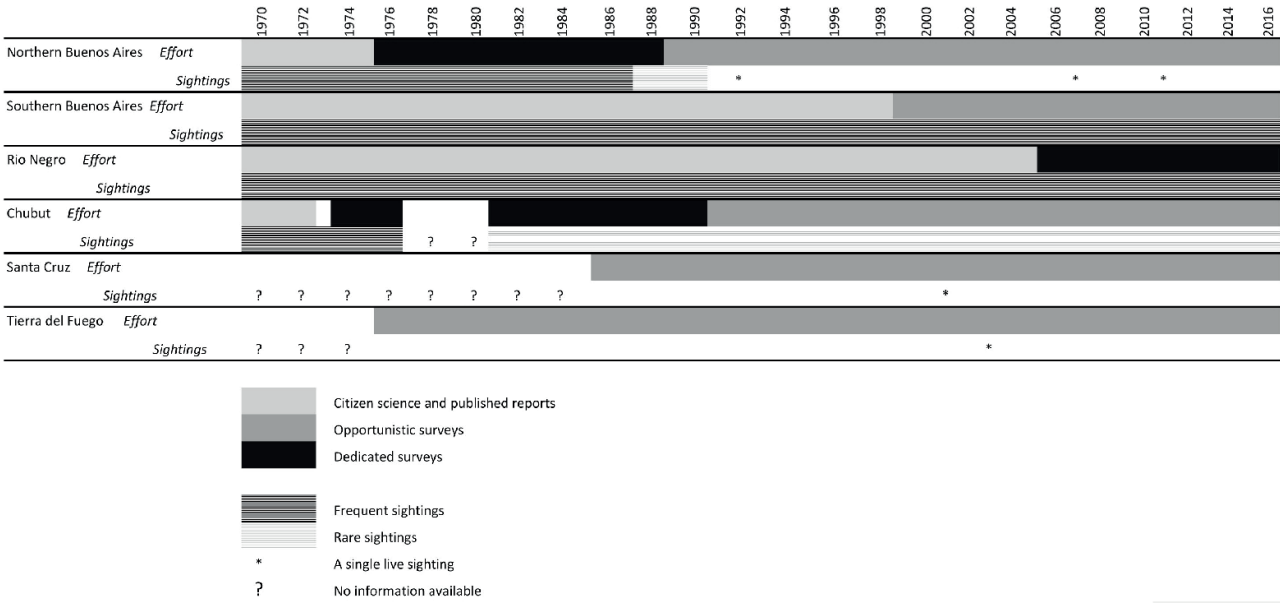
Discussion

All available data of bottlenose dolphins in Argentina suggest that currently two genetically and morphologically distinct populations exist in the nation's coastal waters. One of these populations (morphotype *'T'*) is distributed between Bahía Blanca and Playa Unión/Puerto Rawson. Genetic data further showed they can be regarded as an isolated 'Evolutionary Significant Unit' within the larger Southwestern Atlantic (Fruet *et al.*, 2014). The other population (morphotype *'F'*) appears to be restricted to coastal waters between Bahía San Antonio and just south of Península Valdés. Genetic data further revealed their relatedness to the Southwest Atlantic offshore ecotype (Fruet *et al.*, 2017). Based on the available data, the total abundance of coastal bottlenose dolphins in Argentina appears to be low. Further dedicated surveys are needed to assess this hypothesis and obtain national abundance estimates for the species. These studies need to include a clear distinction among the two morphotypes, especially in areas where they live in sympatry.

Long-term data indicate a decline in sightings of bottlenose dolphins along the coast of northern Buenos Aires and Chubut in past decades (Table 3; as suggested previously by Bastida and Rodríguez, 2003; Coscarella *et al.*, 2012; Vermeulen and Bräger, 2015). This is especially prevalent in the northern province of Buenos Aires, where the species appears to have disappeared completely.

For the area of Chubut, suggestions have been made previously on possible distribution shifts as an underlying cause (*e.g.* Würsig and Harris, 1990). Indeed, considering morphotype *'F'* occurs in Chubut, and its relatedness to the offshore ecotype, an offshore movement of these dolphins cannot be excluded. Nonetheless, a distributional shift is unlikely to explain the drastic decrease in sightings in northern

Table 3. Summary of effort and sightings of bottlenose dolphins in the provinces Buenos Aires, Río Negro, Chubut, Santa Cruz and Tierra del Fuego. If dedicated and opportunistic surveys occurred simultaneously, only dedicated surveys were represented.



Buenos Aires, as these dolphins are of the coastal morphotype *'T'* (and thus genetically distinct from offshore animals) and no other coastal areas were identified where their presence has increased substantially over time. In fact, bottlenose dolphins appear to have always occurred in adjacent coastal areas yet currently in low numbers (too low to explain a relocation of at least 100 individuals) (*e.g.* Coscarella *et al.,* 2012; Vermeulen and Bräger, 2015; Vermeulen *et al.*, 2016), including the coastal waters of Uruguay (Lázaro and Praderi, 2000).

Previously, hypotheses have been formulated about the wide-ranging effects of increasing environmental pressures, for example, of overfishing or contamination, on the marine top predators such as the bottlenose dolphin (Moreno *et al.*, 1984; Bastida and Rodríguez, 2003; Coscarella *et al.*, 2012). However, very little mortality was observed over the past decades. Research has also indicated that there are very low bycatch rates of bottlenose dolphins in Argentinean fisheries despite the relatively high entanglement rates of other marine mammal species (Crespo *et al.* 1994; 1997; 2008; see Fruet *et al.,* 2016). Moreover, the only information on adult survival rates suggests high estimates, despite the apparent declining trend of the study population (Vermeulen and Bräger, 2015), suggesting that adult mortality may not be the most direct and eminent threat to bottlenose dolphin at least in this study region. In fact, Vermeulen and Bräger (2015) found only a small number of reproducing females (and thus a low recruitment rate) in this population and presumed this to be a potential cause for the population decline according to a population viability analysis. Interestingly, Bastida (unpubl. data) noticed an extremely low number of calves observed in Buenos Aires in the 1970s and 1980s, and Coscarella *et al.* (2012) reported a complete absence of calves in Chubut between1999 and 2007, whereas they were still present there in the 1970s (Würsig, 1978).

Although adult survival is frequently assumed to be the determining factor in the dynamics of K-selected species, a recent study showed that reproductive rates may be equally important to the viability of such species (Manlik *et al.*, 2016). However, detecting temporal changes in reproductive rates of a cetacean population and their effects on population dynamics requires years of substantial data and population monitoring.

Unfortunately, despite the first mention of the decrease in bottlenose dolphin sightings in Argentina more than a decade ago (Bastida and Rodríguez, 2003), it has been largely ignored, resulting in a lack of substantial data for empiric assessments of population dynamics. In fact, collecting and structuring all available data relevant to the coastal bottlenose dolphins in Argentina has proven to be a difficult task due to the complexity of their population structure, movement patterns, quality of available data and dedicated studies in the country, and the multitude of data gaps that still exist, including basic population monitoring.

Understanding the limitations of the currently existing data reviewed here, it is difficult to verify any hypothesis regarding the causes that possibly drive the decline in bottlenose dolphin sightings in Argentina. As was shown, dedicated research on the species in the country is limited. Therefore, we recommend an increase in dedicated research efforts in order to obtain an in-depth assessment of the current population abundance and dynamics, and to achieve an accurate assessment of the conservation status of coastal bottlenose dolphins in that country. Collaborative research efforts along the nation's coastline will be essential to gain a comprehensive insight into the species' life history and population status.

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