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Report of the Working Group on Interactions between Humans and *Tursiops truncatus* in the Southwest Atlantic Ocean

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Introduction

Interactions between humans and common bottlenose dolphins (*Tursiops truncatus*) - hereafter referred to as bottlenose dolphin - described and compiled for the Southwest Atlantic Ocean (SWAO) include the following issues: direct takes, incidental captures in fisheries, positive interactions with fisheries, interactions of dolphins with tourism and boat traffic, habitat modification or degradation, and environmental pollution. For this review we accessed the contents of several peer-reviewed original scientific articles, technical reports, book chapters and 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,* held in Rio Grande, Rio Grande do Sul (RS), Brazil, between May 21-23, 2010. The content of some reports presented during scientific meetings and personal communications complemented the information. When possible, data were examined according to geographical sub-divisions established in the workshop: a) northern Brazil; b) northeast Brazil; c) southeast Brazil; d) south Brazil-Uruguay; and e) Argentina (see more details of division criteria in Fruet *et al.*, 2016 Introduction, this volume).

Direct takes

Regardless of the purpose (scientific, public display, education or food), the removal of a small fraction of slow-growing individuals reduces the reproductive potential and can seriously affect the viability of their populations (*e.g.* Gilpin and Soulé, 1986; Burkhart and Slooten, 2003). There are no reports of commercial hunting of bottlenose dolphins in the SWAO, but there are a few records of direct captures and intentional killing in the reviewed literature (*e.g.* Lahille, 1908; Simões-Lopes and Ximenez, 1993).

Simões-Lopes and Ximenez (1993) reported cases of intentional killing of bottlenose dolphins by firearms and hand-thrown harpoons in Santa Catarina (SC) State, southern Brazil. However, the purposes, area of killing and biological information on these killed dolphins is not available. Intentional killing of bottlenose dolphins for human consumption is unlikely, as there is no traditional consumption of dolphin meat along the SWAO. However, fishermen occasionally can use carcasses from incidental captures to feed their own families or to use as shark bait (Meirelles *et al.*, 2009; Zappes *et al.*, 2011*a*, *b*; 2014).

Santos *et al.* (2010) reported on the capture of a male bottlenose dolphin for public display at a small facility in São Vicente, São Paulo (SP) State, Brazil. The dolphin was captured in SC (27°S) in 1983 and released into the wild in 1993 at the same spot in which it was captured (Santos *et al.*, 2010). After released, the dolphin was sighted in the southern waters of the SP coast, Cananéia Estuary (25°S) and Santos (24°S), and it was last seen in Paraná (PR) State coastal waters (26°S) in October 1994.

Dolphins in south and southeast Brazil are not seen as usual competitors for resources or rivals to humans, as are sea lions that depredate fishing nets and are victims of intentional killing by fishermen (Kalikoski, 2002; Zappes *et al.*, 2011*a*, *b*; 2014). Instead, artisanal fishermen using hand cast nets have a feeling of respect and gratitude to bottlenose dolphins (*e.g.* Simões-Lopes *et al.*, 1998; Peterson *et al.*, 2008; Zappes *et al.*, 2011*a*). However, in Arraial do Cabo, Rio de Janeiro (RJ) State, Brazil, fishermen considered bottlenose and other coastal dwelling species of dolphins as potential competitors for fish. In this area, bottlenose dolphins were once common in the shoals[1] (*baixio de dentro*) but no longer use the area. It is suggested that harassment by fishermen could have displaced the dolphins from there[2].

In Argentina two dolphins were captured for scientific purposes early in the last century: a female in 1904 in Quilmes and a male in 1907 in Punta Lara, both in La Plata River (Lahille, 1908). Although it is plausible that wild dolphins have been captured in the past in Argentinean waters to be kept in captivity in the two delphinariums located in Argentina - Mundo Marino (MM) (since 1978) and Mar del Plata Aquarium (MPA) (since 1993) - this is in contradiction with the information that 10 of the 13 dolphins currently displayed at MM were born in captivity (Mundo Marino, unpub. data). According to MM directors, the three wild dolphins in MM were found stranded alive or entangled in fishing nets twenty years ago and translocated to MM. The first bottlenose dolphin born at Mundo Marino was in 1982, a female that is still at the park and has had a second-generation calf. Five of the animals at MM are second-generation individuals (Mundo Marino, unpub. data). For MPA, all dolphins were reportedly imported from Cuba. Published data from the international trade of bottlenose dolphins exported from that country between 1986 and 2004 corroborate the above information since Argentina is reported as the destination of six dolphins (three in 1996, two in 1998 and one in 2001) (Van Waerebeek *et al.*, 2006).

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

[2]S. Siciliano, pers. comm., 21 May 2010

Incidental captures

Among many human activities known to threat the survival of cetaceans worldwide, incidental captures in fishing nets are likely the most significant (Reeves *et al.*, 2003; Read *et al.*, 2006). Substantial bycatch rates have been recorded since the early 1970s and they are still a critical global conservation issue deserving special attention (Reeves *et al.*, 2013). Entanglements of cetaceans and other marine mammals have been reported for many species and regions along the SWAO. Gillnet fisheries seem to have the highest records of dolphin entanglements (*e.g.* Siciliano, 1994; Netto and Barbosa, 2003; Secchi, 2010). This type of fishery, used for both industrial and artisanal purposes, has increased in effort (increase in both net size and time in the water) in the last decades in the SWAO as a response to decreasing yield of fish stocks (*e.g.* Haimovici *et al.*, 1997; Kalikoski *et al.*, 2002; Delfino *et al.*, 2003; Pin *et al.*, 2003). The franciscana dolphin (*Pontoporia blainvillei*) is potentially the most impacted small coastal cetacean in the SWAO by the gillnet fishery (Secchi, 2010; 2014). Data from strandings and monitoring programs of fishing fleets suggest relatively lower levels of incidental mortality for bottlenose dolphins (see below; Tables 1 and 2).

Northeast Brazil

Information obtained from strandings indicate overall low mortality and bycatch rates of bottlenose dolphins in northeastern Brazil (Siciliano, 1994; Meirelles *et al.*, 2016 this volume). From 72 strandings recorded between 1992 and 2010 along approximately 2437km of the coast (between Ceará and Bahia states, excluding the coast of Sergipe), six dolphins (8.3%) presented evidence of fishery interactions (Table 1).

Southeast Brazil

Bycatch data collected from several sources, which include systematic fishery fleet monitoring, beach surveys and occasional strandings, suggest low numbers of bottlenose dolphin entanglements (n = 18) along the coast of Espírito Santo (ES), RJ and SP states (Tables 1 and 2). A total of eight records of bycatch of bottlenose dolphins were found in the surveyed literature for systematic fisheries fleet monitoring programs conducted in southeast Brazil. Despite sporadic bycatch in pelagic driftnets, the majority (n = 7; 88.8%) of the entanglements were assigned to gillnet fisheries in coastal areas, which routinely reported a series of incidental captures for other cetacean species (Table 2). No data on the sex and age of the bycaught bottlenose dolphins were available.

Interviews with artisanal fishermen operating in Cagarras Archipelago and adjacent waters in RJ, where a population of bottlenose dolphins has been studied since 2004 (Lodi *et al.*, 2009), revealed the occurrence of incidental catches (Zappes *et al.*, 2011*b*). Five (33.3%) fishermen said that one bottlenose dolphin is caught in gillnets every year and by caught carcasses are discarded in the sea, used for bait in the long-line fishery, or occasionally for food consumption by their own families.

Table 1. Summary of historical information on the bycatch of bottlenose dolphins (*Tursiops truncatus*) recorded from external examination of stranded individuals along the Southwest Atlantic Ocean. NA = information not available.

Country	Region	Study area	Study period	Approach	Strandings (n)	Bycatch (n)	Source (s)
Brazil	Northeast	Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas and Bahia States	1992-2010	Non-systematic	72	6	Siciliano (1994); Meirelles *et al.* (2016 this volume)
	Southeast	Atlantic coast of Espírito Santo State	1984-2001	Non-systematic	NA	1	Barros (1991); Siciliano (1994); Netto and Barbosa (2003)
	Southeast	Between São Francisco de Itabapoana and Saquarema, RJ	1999-2009	Beach surveys	49	9	Moura *et al.* (2016 this volume)
	Southeast	Between Saquarema and Paraty, RJ	1995-2015	Non-systematic	25	NA	Lab. de Mamíferos Aquáticos e Bioindicadores - unpub. data
	South	Between Matinhos and Superagüi, PR	1997-1999 2007-2009	Non-systematic (1997-1999); Systematic (2007-2009)	18	1	Domit *et al.*[3]
	South	Florianópolis, SC	2009	Opportunistic	1	1	Flores *et al.*[4]
	South	Along the coast of SC	1940-1991	Opportunistic	11	3	Simões-Lopes and Ximenez (1993)
	South	Between Lagoa do Peixe and Barra do Chuí, RS	1969-2006	Non-systematic (1969-1982); Systematic (1983-2006)	188	36	Fruet *et al.* (2012)
Uruguay	La Plata River	Punta Gorda	1959	Non-systematic	NA	1	National Museum of Natural History of Uruguay
	Atlantic Ocean	La Coronilla	1971	Non-systematic	0	1	Pilleri and Gihr (1972)
Argentina	North	Mar del Plata, Province of Buenos Aires	1984-1988	Non-systematic	1	0	Bastida *et al.*[5]
	South	Beaches of Tierra del Fuego, Patagonia	1975-2010	Non-systematic	8	NA	Goodall *et al.* (1989; 2011)

[3]Domit, C., Weber Rosas, F.C., Rosso-Londoño, M.C., Ougo, G., Bracarense, A.P.F.R., Domiciano, I.G., Beloto, N. and Monteiro-Filho, E.L.A. (2010) Ocorrência de *Tursiops truncatus* (Montagu, 1821) no litoral do estado do Paraná, no período de 1997/1999 e 2007/2009. Working Paper 15 presented during the *First Workshop on the Research and Conservation of* Tursiops truncatus*: Integrating knowledge about the species in the Southwest Atlantic Ocean*, 21-23 May 2010, Rio Grande, RS, Brazil.
[4]Flores, P.A.C., Pretto, D.J. and Rocha, H.J.F. (2010) A note on a stranded bottlenose dolphin with intensive fishing gear. Working Paper 63 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, RS, Brazil.
[5]Bastida, R., Rodríguez, D., Moreno, V., Pérez, A., Marcovecchio, J. and Gerpe, M. (1992) Varamientos de pequeños cetaceos durante el periodo 1984-1988 en el area de Mar del Plata (Provincia de Buenos Aires, Argentina). Pages 1-12 *in* Anales, *3ª Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur*, 25-30 July 1988, Montevideo, Uruguay.

Table 2. Compiled information on fisheries and bycatch of bottlenose dolphins (*Tursiops truncatus*) collected during monitoring programs of fisheries along the Southwest Atlantic Ocean. Records of bycatch of other marine mammal species are also shown. SY= Systematic; NS= Non-systematic; NA= information not available; SC = Santa Catarina State; ES= Espírito Santo State; RJ = Rio de Janeiro State; SP= São Paulo State; PR=Paraná State; RS= Rio Grande do Sul State; UY = Uruguay; AR = Argentina; RD = Rocha Departament; PBA = Provincia de Buenos Aires.

Country	Region	Location	Sampling scheme	Study period	Fleet	Main target species	*Tursiops* bycatch (n)	Other bycaught marine mammals (n)	Source
Brazil	South	South RS	SY	1999-2003	Industrial gillnetting	*Micropogonias furnieri*	0	*P. blainvillei* (214)	Prado (2016)
				2006-2009		*Cynoscion guatucupa*	0	*P. blainvillei* (89)	
	South	Barra Velha, SC	SY	2000-2005	Artisanal coastal gillnetting	NA	3	*P. blainvillei* (18), *S. guianensis* (1), Undetermined (1)	Barreto *et al.*[6]
	South	SC	NS	1995	Pelagic driftnetting	*Sphyrna lewini*, *S. zygaena*	0	*S. longirostris* (1)	Zerbini and Kotas (1998)
	Southeast	ES	SY	2002-2003	Coastal/oceanic gillnetting, longlining, bottom trawling, beach seining	NA	0	*E. australis*, *M. novaeangliae*, *P. blainvillei*, *S. guianensis*	Netto and Di Beneditto (2008)
	Southeast	Northern RJ	SY	1989-1996	Coastal gillnetting	*Xyphopenaeus kroyeri*, *M. furnieri*, *Carcharhinus plumbeus*, *C. acronotus*, *Rhizoprionodon porosus*	5	*P. blainvillei* (127), *P. crassidens* (1), *S. fluviatilis* (78), *S. frontalis* (1), *S. bredanensis* (2), Undetermined (139)	Di Beneditto *et al.* (1998)
	Southeast	Northern RJ	SY	2001-2002	Coastal gillnetting	NA	0	*P. blainvillei* (22), *S. guianensis* (20), *S. frontalis* (2), Undetermined (1)	Di Beneditto (2003)
	Southeast	Ubatuba, SP	NS	1997	Pelagic driftneting	*S. lewini*, *S. zygaena*	1	*S. frontalis* (3)	Zerbini and Kotas (1998)
	Southeast	Ubatuba, SP	NS	2005-2006	Pelagic driftneting	NA	0	*F. attenuatta* (1), *P. electra* (2), *S. frontalis* (3), *S. longirostris* (1)	Marigo and Giffoni (2010)
Uruguay	Southeast	SP and PR	SY	2004-2007	Coastal gillnetting	NA	2	*P. blainvillei* (22), *S. guianensis* (99), *S. coeruleoalba* (1), *S. frontalis* (11), Undetermined (2)	Sidou (2008)
	-	UY and AR EEZ	NS	1975-1982	Research fishing vessel (*FAO69*)	NA	1	NA	Records of National Museum of Natural History of Uruguay
	- -	UY EEZ and AR Common Fishing Zone	SY	1996-2007	Pelagic longlining	Tuna, swordifsh, pelagic sharks	0	Cetaceans (16), Pinnipeds (31)	Passadore *et al.* (2015)
		UY EEZ and AR Common Fishing Zone	SY	2002-2005	Coastal bottom trawling	Sciaenidae and other teleost fishes	0	*P. blainvillei* (31)	Abud *et al.*[7]
				2009-2010			0	*P. blainvillei* (18), Pinnipeds (16)	Szephegyi *et al.*[8]
	Atlantic Ocean	La Coronilla, RD	NS	NA	Artisanal coastal gillnetting	Carcharhinidae, Sciaenidae	1	NA	Pilleri and Gihr (1972)
		RD	SY	1974-1994	Artisanal coastal gillnetting	Carcharhinidae, Sciaenidae	4	*P. blainvillei* (3683)	Praderi[9]
		RD	SY	2006	Artisanal coastal gillnetting	Carcharhinidae, Sciaenidae	1	*P. blainvillei* (80)	Proyecto Franciscana unpub. data; Franco-Trecu *et al.* (2009)
	La Plata River	San José, Canelones and Maldonado Departments	SY	2006	Artisanal coastal gillnetting	Sciaenidae and other teleost fishes	0	*P. blainvillei* (10)	Proyecto Franciscana unpub. data; Franco-Trecu *et al.* (2009)

Country	Region	Location	Sampling scheme	Study period	Fleet	Main target species	*Tursiops* bycatch (n)	Other bycaught marine mammals (n)	Source
Argentina		Plata, PBA			gillnetting			*P. blainvillei*	Lichtschein[10]
		Nechochea and Claromecó fishing villages, PBA	SY	1988-1990	Artisanal coastal gillnetting	Sharks (*Galeorhinus galeus, Mustelus* spp., *Eugomphodus taurus, Squatina argentina*)	0	*D. delphis* (1), *L. obscurus* (2), *P. spinipinnis* (6), *P. blainvillei* (47)	Corcuera *et al.* (1994)
			NS	1989	Purse-seining	Anchovies (*Engraulis anchoita*), mackerel (*Scomber japonicus*)	0	*D. delphis* (32), *L. obscurus* (64)	
		Cabo San Antonio, PBA	SY	1999 -2000	Artisanal coastal gillnetting	Sciaenidae and other teleost fishes, small sharks	0	*P. spinipinnis* (6), *P. blainvillei* (52)	Bordino *et al.* (2002)
	North	Bahía Samborombón to Mar del Plata, PBA	SY	1988-1990	Artisanal coastal gillnetting and bottom trawling	Sciaenidae and other teleost fishes, Argentine hake (*Merluccius hubbsi*), Argentine red shrimp (*Pleoticus muelleri*)	NA	*D. delphis, L. obscurus*	Crespo *et al.* (1994)
	Central/ South	From Rio Negro to Tierra del Fuego Provinces, Patagonia			Purse-seining	Anchovies, mackerel (*Scomber japonicus*)	0	*C. commersonii, D. delphis, G. melas, L. australis, O. flavescens, P. dioptrica; P. blainvillei*	
	Central/ South	Along the coast of Patagonia	SY	1992-1994	Mid-water trawling	Argentine hake, shortfin squid (*Illex argentinus*), Argentine red shrimp	0	97 marine mammals: *C. commersonii, L. obscurus, O. flavescens*	Crespo *et al.* (1997)
					Jiggins	Shortfin squid, black squid (*Martialia hyadesi*)	0	NA	
					Longlining	Patagonian toothfish (*Dissostichus eleginoides*), pink cuskeel (*Genypterus blacodes*), Argentine hake	0	NA	
		Argentine shelf (38°S - 48°S)	SY	1989-1999	Mid-water trawling	Argentine hake, Argentine red shrimp	1	*D. delphis* (100), *L. obscurus* (21), Other delphinids (4)	Dans *et al.* (1997) Crespo *et al.* (2000)
		Chubut Province	NS	NA	Pelagic net	Anchovies	0	NA	Crespo *et al.* (2008)
		Santa Cruz and Tierra del Fuego Provinces, Patagonia	SY	1975-1990	Artisanal coastal gillnetting; crab netting and trapping	Southern red king crab (*Lithodes santolla*), Patagonian blennie (*Eleginops maclovinus*) and hake (*Merluccius* sp.)		*C. commersonii* (313), *L. australis* (20), *L. peronii* (6), *P. dioptrica* (34), *P. spinipinnis* (4), Pinnipeds (12)	Goodall *et al.* (1994)

[6]Barreto, A.S., Henrique-Garcia, J. and Moreira, P.P. (2005) Histórico de 5 anos do *Programa Pescador Amigo do Golfinho* nas Comunidades de Barra-Velha, Penha e Balneário Camboriú, SC. Page 50 *in* Abstracts, *IV Encontro sobre Conservação e Pesquisa de Mamíferos Aquáticos*, 12-15 November, Itajaí, Brazil.
[7]Abud, C., Costa, P., Dimitriadis, C., Franco-Trecu, V., Laporta, P. and Piedra, M. (2006) Pesca de arrastre: un nuevo problema para la Franciscana *Pontoporia blainvillei* en Uruguay. Page 65 *in* Abstracts, *XII Reunión de Trabajo de Especialistas en Mamíferos Acuáticos del América del Sur* y *Primera reunión Internacional sobre el estudio de mamíferos acuáticos SOMEMMA–SOLAMAC*, 5-9 November, Merida, Mexico.
[8]Szephegyi, M.N., Franco-Trecu, V., Doño, F., Reyes, F., Forselledo, R. and Crespo, E.A. (2010) Primer relevamiento sistemático de captura incidental de mamíferos marinos en la flota de arrastre de fondo costero de Uruguay. Pages 148-151 *in* Anales, *VII Workshop for Research Coordination and Conservation of* Pontoporia blainvillei *(Gervais & d'Orbigny, 1844)*, 24-28 October, Florianópolis, Brazil.
[9]Praderi, R. (2000) Estado actual de la mortalidad de franciscana en las pesquerías artesanales de Uruguay. Pages 12–16 *in* Report of the *3rd Workshop for Research Coordination and Conservation of the Franciscana Dolphin in the Southwestern Atlantic.* UNEP/CMS, Bonn.
[10]Bastida, R. and Lichtschein, V. (1986) Capturas incidentales de pequeños cetáceos en el área de Mar del Plata (Prov. de Bs. As., Arg.). Pages 14-22 *in* Actas, *1a Reunión de Trabajo de Especialistas en Mamíferos Acuáticos de América del Sur*, 25-29 June, Buenos Aires, Argentina.

South Brazil and Uruguay

The artisanal fishing fleet off Barra Velha and surrounding areas (SC) were systematically monitored during five years and a total of three bottlenose dolphins were reported to being caught in fishing nets[6]. With the exception of the previously mentioned study, data on the mortality of bottlenose dolphins in south Brazil originated from the external examination of stranded carcasses[3] (Simões-Lopes and Ximenez, 1993; Fruet *et al*., 2012). From a total of 218 records of stranded individuals along the coast of south Brazil (about 1250km of coast), 41 (18.8%) had clear evidence of being caught in fishing nets. Bycatch rates were relatively high in SC (33.3%) and RS (19.1%) states, and low in PR (5.5%) (Table 1). These bycatch rates should be viewed with caution because the advanced state of decomposition of several carcasses makes the external examination for bycatch signs difficult. For example, when mortality data was restricted to freshly stranded carcasses, bycatch rates in RS increased to 43% (Fruet *et al*., 2012). It is important to notice that within the coast of RS numbers compiled came from data collected over its south coast (*ca* 355km), where systematic beach monitoring for marine mammals has been conducted for more than three decades (Pinedo and Polacheck, 1999; Fruet *et al*., 2012; Prado *et al*., 2013). Analysis of this long-term series of stranding data revealed a substantial increase in incidental mortality in areas close to the Patos Lagoon Estuary (PLE), raising concerns about the conservation status of the small resident population inhabiting the PLE (Fruet *et al*., 2012).

Bycatch of bottlenose dolphins in south Rio Grande do Sul, Brazil

Although bottlenose dolphins and fisheries potentially co-exist in the estuarine waters of the Patos Lagoon since the beginning of European colonization in the region (18th century), bycatch was first documented in 1975 for an individual captured in a net used to catch mullet (*Mugil* sp.) (Laboratório de Ecologia e Conservação da Megafauna Marinha - Ecomega, unpub. data). This coincides with the introduction of monofilament line and the intensification of gillnet fisheries in south Brazil (Kalikoski, 2002). However, unlike the franciscana dolphin, which has been intensely captured in gillnets since 1980 (Secchi, 2010), for decades the mortality of bottlenose dolphins due to interactions with fishing activities was sporadic (Fruet *et al*., 2012). A comprehensive analysis of stranding data over several decades revealed low bycatch rates of bottlenose dolphins during a period of 30 years (1969-1999), followed by a marked increase after 2001 (Fruet *et al*., 2012). During 2002-2006, the minimum number of bycaught dolphins per year in coastal areas close to the PLE varied from two to nine, and bycatch was responsible for at least 43% of the overall recorded mortality (Fruet *et al.,* 2012). During this time, incidental captures were skewed toward males (3.5M:1F), which were predominantly (57.1%) composed of immature animals (Fruet *et al*., 2012). Catches were strongly seasonal, occurring mostly during summer months (Fruet *et al*., 2012), when the gillnet fishery efforts are intensified in the estuarine and adjacent marine system (Di Tullio *et al*., 2015).

Changes in fishery areas and effort are suspected to be the most likely causes of increased bycatch in coastal areas close to the estuary (Di Tullio *et al*., 2015). The size of gillnets used by artisanal fisheries in the PLE and the time in the water have increased over time in response to the decreasing yield (Kalikoski, 2002). Today, nets could be 2000m long, while initially they were about 50 to 300m (Von Ihering, 1885). The artisanal fishery inside the Patos Lagoon has experienced a collapse in production due to overfishing and to non-selective fishing gear (Reis, 1992), resulting in loss of biodiversity, poverty and loss of cultural identity of fisheries communities, and therefore the fishery is going through a tragedy of the commons (Kalikoski *et al*., 2002). This made artisanal fishermen to start placing their nets in other areas inside the Lagoon and in adjacent coastal areas (Kalikoski *et al*., 2002), where bottlenose dolphins concentrate (Di Tullio *et al*., 2015).

Specific data from fisheries (*e.g.* target species, net mesh size, depth and location of fisheries) harming bottlenose dolphins in the PLE and adjacent coastal areas are still scarce. One isolated event of five dolphins supposedly killed in a net set for sharks in 1983 was reported, but no further information was provided[11]. Records of free-swimming dolphins with pieces of net entangled on their back[12] and carcasses washed ashore entangled in set nets (Figure 1) suggest that fisheries targeting demersal fishes, such as Atlantic white croaker (*Micropogonias furnieri*) and southern king croaker (*Menticirrhus* sp.) are the main sources of incidental dolphin mortality. The main types of fishing gears used by artisanal fishermen inside the PLE are gillnets, stow nets, bag nets and otter trawls (Kalikoski *et al*., 2002). Bottom gillnet fisheries for white croaker inside the lagoon generally occur in deeper waters (between 10-18m) than in coastal areas. Coastal zones are also subject to a type of fishery known as *pesca de cabo* (fishing cable). Fishermen use trammel gillnets, locally known as *feiticeiras*, which are composed of three overlapping rectangular panels constructed of nylon monofilament, with mesh size varying (between 3-12cm) according to the target fish species (Klippel *et al*., 2005). Nets are generally between 30-400m in length and 1.5 to 2.2m tall. The net is attached at one end by a cable, which is attached to a stake on the beach, while the other end is fixed to the sea bottom, staying in a perpendicular position in relation to the shore. It operates

[11]Pinedo, M.C. (1986) Mortalidade de *Pontoporia blainvillei*, *Tursiops gephyreus*, *Otaria flavescens* e *Arctocephalus australis* na costa do Rio Grande do Sul, Brasil, 1976-1983. Pages 187-199 *in* Actas, *1ª Reunión de Trabajo de Expertos en Mamíferos Acuáticos de América del Sur*, 24-29 June, Buenos Aires, Argentina.

[12]Fruet, P.F., Hassel, L.B. and Di Tullio, J.C. (2004) Registro do boto, *Tursiops truncatus*, emalhado vivo em rede de pesca no Estuário da Lagoa dos Patos, RS, Brasil. Page 234 *in* Abstracts, *XIV Congresso Brasileiro de Oceanografia*, 10-15 October, Itajaí, SC, Brazil.

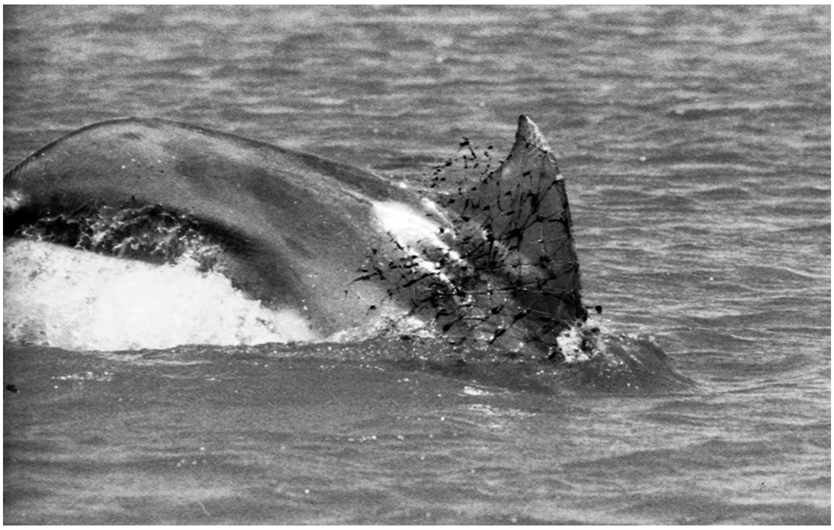
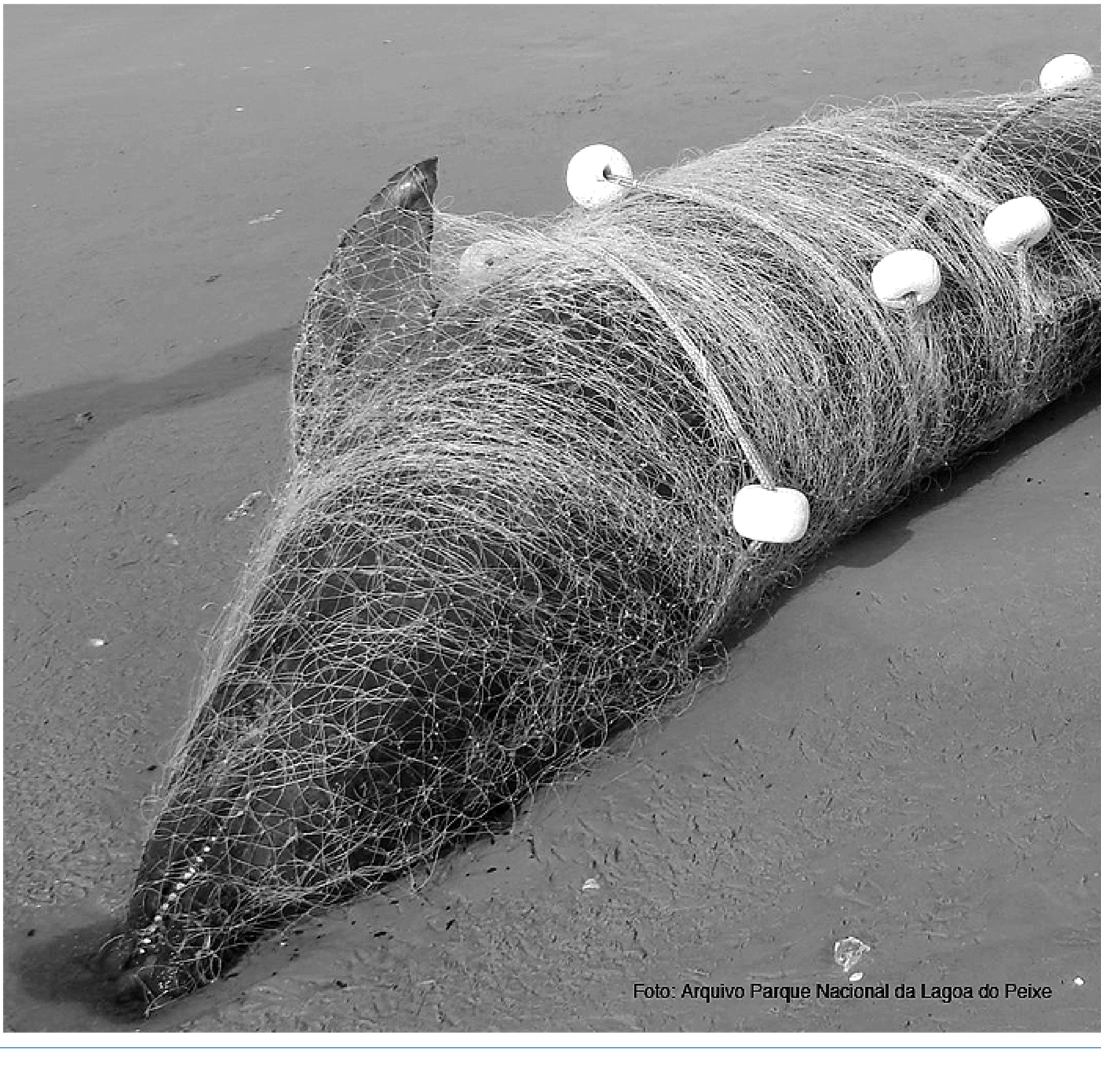


Figure 1. Examples of bottlenose dolphins entangled in fishing nets in southern Brazil. Left = resident dolphin swimming in the Patos Lagoon Estuary with a piece of net used for catching *Micropogonias furnieri* entangled around its body; Below = a stranded bottlenose dolphin completelly entangled in a net used by artisanal fishermen to catch *Menticirrhus* spp. in the first 400m from the coastline.



in very shallow waters (maximum depth of 8m) and can be placed up to 1km away from the beach, greatly overlapping with the coastal distribution of bottlenose dolphins in this region (Di Tullio *et al.*, 2015).

Uruguay

Incidental captures of bottlenose dolphins in Uruguayan fisheries seem to be occasional. Ricardo Praderi made the earliest record of a bottlenose dolphin incidentally captured in October 1959, concerning one individual captured in a fishing net in Punta Gorda, Montevideo (records in the National Museum of Natural History). After that only a few studies have reported the mortality of bottlenose dolphins in fishery activities, even in the face of systematic studies. For example, in a study about incidental captures of franciscana dolphins in the Atlantic Uruguayan coast, four specimens of bottlenose dolphins captured in artisanal fishing nets were reported over a period of 25 years (Praderi, 1985). In a similar study conducted between 2004 and 2006 along the estuarine and Atlantic Uruguayan coasts (Franco-Trecu *et al.*, 2009), two bottlenose dolphins were reported by fishermen (Proyecto Franciscana, unpub. data). Past and present studies have surveyed the fleet of several fisheries in Uruguay, which include the pelagic longline (Passadore *et al.*, 2015), coastal bottom trawl[7,8] (Domingo *et al.*, 2006; Laporta *et al.*, 2006) and artisanal gillnet fishery[9] (*e.g.* Franco-Trecu *et al.*, 2009), but bycatch of bottlenose dolphins was recorded exclusively in coastal gillnets (Table 2).

The low number of bottlenose dolphins captured in Uruguayan waters could be explained by the differential spatial use between the species and the fisheries. The artisanal fishery of Uruguay operates between 0.3 and 28km from the coast, depending on vessel length and capacity, but the greatest fishing effort occurs between 11 and 18km from the coast[13] (Franco-Trecu *et al.*, 2009; Zappes *et al.*, 2014). This generates little overlap between coastal bottlenose dolphins and preferred fishing grounds, as dolphin sightings mainly occur within 0.5km from the coast[14] (Laporta, 2009; Zappes *et al.*, 2014).

Argentina

According to the available literature, bottlenose dolphins do not interact regularly with fisheries in Argentinean waters. There is one past record of a male captured in the coastal fleet in Mar del Plata[10] and one in the trawl fishery (Goodall *et al.,* 1988). More recently, the bycatch of one bottlenose dolphin was recorded for the pelagic anchovy fishery along the Patagonian coast. This event occurred in the *Anchovy Experimental Fishing Plan* in the Province of Chubut (Crespo *et al.,* 2008).

Since the mid 1980s several studies have monitored the fishing fleet operating around Argentinean waters in relation to marine mammal interactions (*e.g.* Pérez Macri and Crespo, 1989; Corcuera *et al.*, 1994; Goodall *et al.*, 1994; Crespo *et al.*, 2000). These include fishing activities in the province of Buenos Aires (bottom trawling, purse-seining and gillnetting with bottom set nylon monofilament), Atlantic Patagonian coast (high sea fisheries: trawling, jiggins and longline), and Argentine shelf (mid-water trawl fishery). No catch of bottlenose dolphins was recorded during all these studies, although several other coastal and oceanic cetacean species were incidentally captured (Corcuera *et al.,* 1994; Crespo *et al.*, 1997; Crespo *et al.,* 2000; Bordino *et al.*, 2002) (Table 2).

Caveats

The findings reported here should be viewed with caution because the lack of systematic sampling in some regions (*i.e.* consistent beach or fishing fleet monitoring) make unclear if bycatch is low or if it is a result of poor sampling. This could lead to the initial conclusion that incidental captures are not a source of conservation concern for bottlenose dolphins along the SWAO. The incidental captures listed here are those known to have occurred, and an unknown, higher level of incidental captures is likely. Stranding carcasses were generally sampled in an advanced state of decomposition[3] (Fruet *et al.*, 2012) making it difficult to verify if a fishery interaction had occurred and this certainly underestimates bycatch rates. The low bycatch number reported should not be used as justification for neglecting the impacts of bycatch on bottlenose dolphins, as even a small number of incidental captures can pose a serious conservation threat for the small populations of coastal bottlenose dolphins in south Brazil, Uruguay and Argentina (Fruet *et al.*, 2014; 2016 this volume).

Bioaccumulation of pollutants

Some micropollutants (*e.g.* heavy metals, polychlorinated biphenyls and chlorinated pesticides) biomagnify through food chains, reaching high concentration in top-order predators, such as marine mammals (Gray, 2002; Lailson-Brito *et al.*, 2010; 2012; Bisi *et al.*, 2011). Limited information has been published on contamination levels for the genus *Tursiops* in the SWAO. Currently, there is information on micropollutant contamination in bottlenose dolphins only for southeast and south Brazil and for the Argentinean coast (*e.g.* Marcovecchio *et al.*, 1994; Dorneles *et al.*, 2010; Lailson-Brito *et al.*, 2012).

1. Heavy metals

Southeast Brazil

Renal cadmium concentrations were assessed in two bottlenose dolphins stranded on the coast of RJ (Dorneles *et al.*, 2007; Table 3). Concentrations were low when compared with oceanic cetacean species but of similar magnitude to other coastal dolphins (Dorneles *et al.*, 2007). The authors

[13]Praderi, R. (1997) Análisis comparativo de estadísticas de captura y mortalidad incidental de *Pontoporia blainvillei* en Uruguay durante 20 años. Pages 42-53 *in* Pinedo, M.C. and Barreto, A.S. (Eds) Anais, *2º Encontro sobre Coordenação de Pesquisa e Manejo da Franciscana*, 22-23 October, Florianópolis, Brazil.

[14]Laporta, P., Di Tullio, J.C. and Secchi, E.R. (2010) Uso do habitat do boto *Tursiops truncatus* na costa atlântica uruguaia. Working Paper 65 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, RS, Brazil.

Table 3. Metal concentrations (µg/g wet weight) in tissues of bottlenose dolphins (*Tursiops truncatus*) from the Southwest Atlantic Ocean. Mean ± standard deviation; range of concentrations (minimum-maximum); n = number of samples; blank cells = not analyzed; DL = detection limit; Cd = cadmium; Sn = tin; THg = total mercury; Zn = zinc; Cu = copper.

Locality	n	Tissue	Cd	Sn	THg	Zn	Cu	Source
Rio de Janeiro, Brazil	2	liver	1.10±0.9 (0.15-2.04)					Dorneles *et al.* (2007)
Rio de Janeiro, Brazil	3	liver		2.58±0.5 (<DL-2.92)				Dorneles *et al.* (2008)
Mar del Plata, Argentina	1	liver			54.0			Moreno *et al.* (1984)
		muscle			3.2			
		kidney			8.3			
		blubber			0.4			
		melon			0.6			
		lung			1.6			
		heart			2.0			
		brain			0.7			
Mar del Plata, Argentina	2	liver	0.8±0.2		86.0±7.3	196±34.1	77.7±3.8	Marcovecchio *et al.* (1990)
		muscle			5.50±0.8	93.3±13.1	6.3±1.1	
		kidney	28.4±4.3		13.4±2.5	93.6±5.9	29.5±3.9	
		blubber				4.7±0.8	4.0±0.6	
		melon				3.2±0.6	2.7±0.4	
		stomach content					1.2±0.2	

discussed that the cadmium concentrations observed may be related to predation on particular cephalopod species. As described for other regions, it was expected that oceanic dolphins in southeast Brazil prey on oceanic ommastrephid squids, which are well known for their high cadmium concentrations (Bustamante *et al.*, 1998; Dorneles *et al.*, 2007). On the other hand, inshore bottlenose dolphins probably feed on coastal loliginid cephalopods in which cadmium concentration is lower (Bustamante *et al.*, 1998; Dorneles *et al.*, 2007). Therefore, the cadmium trophic transfer to bottlenose dolphins is likely to be reduced in the latter (Dorneles *et al.*, 2007).

A high hepatic total tin concentration was found in three bottlenose dolphins off the RJ coast (Dorneles *et al.* 2008*a*), indicating they were exposed to organotin compounds (Table 3). The mean total tin concentration was considered low only when compared to the Guiana dolphin (*Sotalia guianensis*) from Guanabara Bay (RJ), which is a highly polluted environment (Kjerfve *et al.*, 1997; Dorneles *et al.*, 2007; 2008*a, b*; Lailson-Brito *et al.*, 2010). Organotin compounds have been widely used as antifouling agents in boats and they undergo bioaccumulation through food chains, reaching high concentrations in top predators (Tanabe, 1999).

Argentina

Moreno *et al.* (1984) assessed the total mercury concentration in 17 different tissues of one bottlenose dolphin incidentally captured in waters adjacent to the city of Mar del Plata. Concentrations ranged from 0.4 to 54mg/kg (Table 3). High mean total mercury concentrations were found in the liver (54mg/kg) and in the kidney (8.3mg/kg). The levels were considered high and the authors attributed these findings to natural sources of mercury, but also to contributions from atmospheric sources (Moreno *et al.,* 1984).

Marcovecchio *et al.* (1990; 1994) assessed tissue distribution of heavy metal concentration (total mercury, cadmium, zinc and copper) in two specimens of bottlenose dolphins stranded in beaches near Mar del Plata (Table 3). The authors found total mercury concentrations higher than in oceanic cetacean species, but the levels were lower when compared to cetacean species inhabiting highly contaminated areas (Marcovecchio *et al.*, 1990; 1994). The tissue distribution concentration for total mercury, zinc and copper was similar to other studies of marine mammals from the South Atlantic coast, where these metals mostly concentrate in the liver followed by kidney and muscle (Das *et al.*, 2003; Capelli *et al.*, 2008). On the other hand, kidney was the most important accumulator organ for cadmium (Marcovecchio *et al.*, 1990; 1994) due to the presence of metal-binding proteins in this tissue (Das *et al.*, 2003).

2. Organohalogen compounds

Southeast and southern Brazil

Levels of dichloro diphenyl trichloroethane (DDT), polychlorinated biphenyls (PCBs) and hexachloro cyclo hexane (HCH) were assessed in a male bottlenose dolphin stranded on the coast of SP (Yogui *et al.*, 2010) (Table 4). The higher ∑PCB than ∑DDT concentration was attributed to the fact that the specimen was collected in an area under strong influence of pollutant discharge close to the city of Santos (Yogui *et al.*, 2010).

Lailson-Brito *et al.* (2012) investigated organochlorine compound levels (PCBs, DDTs and HCB) in blubber samples of six delphinid species from RJ, including two specimens of bottlenose dolphins (Table 4). The authors found intermediate ∑PCB and ∑DDT levels for the species when compared to other delphinids. Mean ∑PCB concentration was 11.8μg/g. Similar to the other species examined in that study, bottlenose dolphins presented a predominance of heavier PCBs, such as hexa-chlorobiphenyls and heptachlorobiphenyl. The predominant congeners were PCB 153, followed by PCB 138 and PCB 180 (Lailson-Brito *et al.*, 2012). Bottlenose dolphins showed a mean ∑DDT/∑PCB ratio of 0.44, which demonstrates that the species is predominantly exposed to compounds of industrial origin.

A study of organochlorine compounds contamination in the bubbler of bottlenose dolphins stranded in beaches from ES, RJ, PR and SC revealed a higher concentration in the specimen from ES, with the exception of ∑HCH15 (Table 4). PCBs showed the highest concentration in ES, RJ and SC, while in PR the highest concentration was observed for DDT (Table 4). The highest mean value of the ∑DDT/∑PCB ratio was observed in specimens from PR (1.55), while the lowest value occurred in individuals from ES (0.26). Samples from SC and RJ showed a ratio of 0.63 and 0.33, respectively. These findings indicate that the main source of contamination in ES, RJ and SC was industrial. In PR, contributions from agricultural sources were more evident. The lower p,p'-DDE/∑DDTs ratio observed in bottlenose dolphins from PR indicate a recent discharge of DDT in the environment[15] (Aguilar *et al.*, 1999).

Contamination by organochlorine compounds (PCBs and DDTs) was measured in skin and blubber of 18 resident bottlenose dolphins from the PLE (RS) (Lago, 2006; Table 4). The highest mean concentration was found for ∑PCB, but it was lower than values reported for bottlenose dolphins from the Northern Hemisphere (Morris *et al.*, 1989; Corsolini *et al.*, 1995; Hansen *et al.*, 2004). Mean value of p,p'-DDE/∑DDTs ratio was 2.8, indicating that DDT usage in the PLE is not recent (Lago, 2006). The levels of other chlorinated pesticides (*e.g.* chlordane, HCH and dieldrin) varied from below detection limit to 0.11μg/g. Overall, organochlorine compounds levels in bottlenose dolphins from the PLE were lower than those observed in the literature for this species (Lago, 2006). Dorneles *et al.* (2008*b*) evaluated the link between marine mammal exposure to perfluorooctane sulfonate (PFOs) and carbon stable isotope ratios ($\delta^{13}C$) in neritic and oceanic waters off Brazil. Carbon stable isotopes have been successfully used to trace the potential primary sources of food webs, indicating inshore versus offshore, or benthic versus pelagic contributions to food intake (McConnaughy and McRoy, 1979; Michener and Kaufman, 2007). The authors found a mean hepatic PFOs concentrations ranging from 63 to 91ng/g in bottlenose dolphins (mean value = 74ng/g). Besides, a significant positive correlation between PFOs concentrations and $\delta^{13}C$ value was verified (Dorneles *et al.*, 2008*b*). These findings indicated that species, such as the bottlenose dolphin, that inhabit the continental shelf in highly industrialized areas were exposed to high concentrations of PFOs due to their proximity to effluent discharges (Dorneles *et al.*, 2008*b*). The study suggests that organohalogen compounds may be exported to the continental shelf from Guanabara Bay, RJ (Dorneles *et al.*, 2008*b*).

Dorneles *et al.* (2010) assessed hepatic concentration of anthropogenic (PBDEs) and naturally-produced (MeO-PBDEs) organobrominated compounds in cetaceans from RJ, including three specimens of bottlenose dolphin. The mean PBDEs concentration was 957ng/g, and the results varied from 270 to 1353ng/g. The values found for eight congeners of PBDEs analyzed (Dorneles *et al.*, 2010) were similar to that reported for harbour porpoises (*Phocoena phocoena*) from the North Sea (Covaci *et al.*, 2002). However, the concentrations of naturally produced organobrominated compounds obtained for cetaceans from the RJ coast (min-max: 12458-32436ng/g for bottlenose dolphins) were among the highest reported for marine mammals worldwide (Dorneles *et al.*, 2010).

Habitat modification

Human interferences to coastal ecosystems (particularly habitat modification, pollutants, overfishing and the introduction of invasive species) are known to have caused

[15]Vidal, L.G., Pinheiro, L.S., Ferraz, D.R., Cremer, M.J., Barbosa, L.A., Domit, C., Azevedo, A.F. and Lailson-Brito, J. (2010) Compostos organoclorados (DDT, PCB, HCB, HCH e MIREX) em *Tursiops truncatus* da costa sudeste e sul do Brasil. Page 130, abstract 3054 *in* Abstracts, *XIV Reunião de Trabalhos de Especialistas em Mamíferos Aquáticos da América do Sul*, 20-24 October 2010, Florianópolis, Brazil.

Table 4. Organochlorine concentrations (∑PCB, ∑DDT, HCH, Mirex and HCB; µg/g on a lipid basis) in the blubber of bottlenose dolphins (*Tursiops truncatus*) from the Southwest Atlantic Ocean. Mean ± standard deviation; range of concentrations (minimum-maximum); n = number of samples; blank cells = not analyzed; DL = detection limit.

Region	n	∑PCB	∑DDT	∑HCH	Mirex	HCB	Reference
Espírito Santo, Brazil	2	52.9±51.8	13.5±12.5	0.79±0.51	1.51±1.32	0.004±0.004	Vidal *et al.*[15]
Rio de Janeiro, Brazil	5	20.3±14.7	7.42±5.88	0.32±0.27	0.53±0.42	0.02±0.02	Vidal *et al.*[15]
Rio de Janeiro, Brazil	2	11.8±2.4 (10.1-13.5)	5.0±0.6 (4.55-5.47)			0.05±0.02 (0.04-0.07)	Lailson-Brito *et al.* (2012)
São Paulo, Brazil	1	5.91	2.42	0.01	0.09	0.08	Yogui *et al.* (2010)
Paraná, Brazil	2	6.67±3.13	10.4±11.9	1.09±0.90	0.59±0.65	<DL	Vidal *et al.*[15]
Santa Catarina, Brazil	3	5.72±3.05	3.59±1.72	0.29±0.12	0.24±0.08	0.01±0.01	Vidal *et al.*[15]
Rio Grande do Sul, Brazil	18	26.2±12.6 (7.89-46.2)	2.92±2.24 (0.34-5.81)	0.05±0.19 (<DL-0.75)	<DL		Lago (2006)

irreversible changes to ecological communities (Jackson *et al.,* 2001), also affecting top-chain predators such as marine mammals (*e.g.* the modern extinction of the Yangtze river dolphin, *Lipotes vexillifer*, in China - Turvey *et al.*, 2007). Despite this, few studies in the SWAO have investigated how dolphins respond to human-induced habitat modification in their natural environment. In the Itajaí River (SC), for example, the effects of anthropogenic activities (dredging, coastal engineering to expand the navigation channel and vessel traffic) on the occurrence and behavior of bottlenose dolphins was evaluated[16]. The engineering involved the use of explosives in order to remove submerged bedrock. The study detected changes to the dolphins' activity budgets, with a decrease in foraging and an increase in traveling[16]. A decline in dolphin sightings was also reported during the coastal work. Dredging activities also affected the relative presence and group size of dolphins in Itajaí River[16].

The PLE, which comprises the second largest port in Brazil, has also faced intense human intervention (*e.g.* overfishing, expansion of jetties, dredging of estuarine channel) in the last decades (Kalikoski *et al.*, 2002; Tagliani *et al.*, 2007). The establishment of a major shipyard produced underwater noise and degradation to the estuarine margins. At the same time, work related to the jetty expansion occurred to allow the flow of ships with larger drafts by deepening the navigation channel through dredging and narrowing the channel connecting the Patos Lagoon with the Atlantic Ocean. The jetty expansion took place in a preferred dolphin use area (the mouth of the estuary – see Mattos *et al.*, 2007; Di Tullio *et al.*, 2015) and involved placing rocks on the seabed using a variety of methods, as well as the placement of tetrapods (Figure 2). Opportunistic observations suggested short-term behavioral responses of the dolphins, with prolonged diving and temporary displacement during the activities (P. Fruet, pers. obs.). No long-term responses were observed, with dolphins which were regularly seen feeding at the end of the jetty continued to be seen feeding on the same general area after its expansion (*i.e.* as the piers extended, dolphins moved to their end to feed). The activities of the work do not seem to have had a prolonged negative effect on the dolphins' behavior and population dynamics (Fruet *et al.*, 2015*a*, *b*). However, how dolphins will respond to the expected changes in ecosystem dynamics is still unknown. Narrowing of the single interface channel between the Patos Lagoon and the Atlantic Ocean is expected to increase outflow of river discharge (Fernandes *et al.*, 2005), possibly acting as a barrier to the ingression of marine fish and crustacean larvae into the estuary (Vieira *et al.*, 2008; Möller *et al.*, 2009). As a consequence, a decrease in the abundance of marine fish assemblage in the estuary may occur, raising concerns about the local bottlenose dolphin population as they are known to feed exclusively on marine fish species[17] (Pinedo, 1982; Mehsen *et al.*, 2005).

The perception and understanding of structural changes and transitional processes in coastal marine ecosystems by both human disturbances and natural causes require the integration of research and monitoring of variables on a long-term basis

[16]Britto, M.K. and Barreto, A.S. (2010) Effects of human activities on the behavior of bottlenose dolphins (*Tursiops truncatus*) in the Itajaí river mouth. Working Paper 39 presented during the *First Workshop on the Research and Conservation of* Tursiops truncatus*: Integrating knowledge about the species in the Southwest Atlantic Ocean,* 21-23 May 2010, Rio Grande, RS, Brazil.

[17]Lopez, L.A., Di Tullio, J.C., Fruet, P.F. and Secchi, E.R. (2010). Alimentação do boto *Tursiops truncatus* no litoral sul do Rio Grande do Sul, Brasil. Working Paper 59 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, RS, Brazil.

Figure 2. Activities conducted to expand the jetties in the Patos Lagoon Estuary. (A) Boat used to throw tons of rock to the seabed at the end of the jetties; (B) activity of throwing smaller rocks to the bottom of the sea by land when using trucks; (C) completion of work activities with the placement of tetrapods.

(Seeliger and Costa, 2010). Only with the establishment of a continued monitoring will it be possible to elucidate the changes that may occur over the years and thus enable the provision of recommendations for the ecological sustainability of these and other environments that may receive similar development in coastal-estuarine areas.

Interactions with tourism activities and boat traffic

The potential impacts of boat traffic and tourism on cetaceans have been well documented and debated around the world in the past decade (*e.g.* Constantine, 2001; Lusseau, 2003; Williams *et al.,* 2009; Parsons, 2012). For small cetaceans, vessel disturbance is of particular concern because it has been shown that dolphins can change their behavior as a response to boat approach or even avoid boats (Lusseau, 2003; Stensland and Berggren, 2007). This became a critical issue in areas of intensive dolphin watching or where there is a concentration of uncontrolled recreational boats because the presence of fast boats can easily disrupt natural dolphin activities and put them at risk of collision (*e.g.* Gubbins, 2002; Dwyer *et al.,* 2014). Engine size and consequent underwater noise is also a source of disturbance, given cetaceans' reliance on acoustics for communication, orientation, and predator/prey detection (*e.g.* Richardson *et al.*, 1995; Tyack, 1998; Bejder *et al.*, 2006; Martinez *et al.,* 2012). Despite short-term behavior effects of tourism on bottlenose dolphins have been well documented, little is known about how dolphins respond on the long-term. Some studies have shown a decline in relative abundance within the tourism site during a period of increased exposure to tour vessels (Bejder *et al.*, 2006), and reduced reproductive success of populations by increased calf mortality due to collisions with such vessels (Lusseau *et al.*, 2006).

Few dolphin-watching companies focus on bottlenose dolphins along the SWAO and the exposure to vessel disturbance occurs mainly in estuarine/coastal areas, where small populations co-exist with intense human activities. In the Cagarras Archipelago (RJ), a group of coastal islands in southeast Brazil, dolphins are exposed to impacts of tourism in an unregulated way (presence of fast boats, jet-skis and recreational diving disturb the dolphins' behavior), although no strikes have been recorded to date (Lodi *et al.*, 2013). These activities are intensified in winter and spring, when a larger number of bottlenose dolphin groups, mostly composed of immature individuals, are observed in the area (Lodi, 2009). In Arraial do Cabo (RJ) interactions between dolphins and tourism boats are common along the year and are intensified during summer and weekends. In this area boat tourism is dedicated to cetacean observations, and bottlenose dolphins are one of the main targets due to their relative high abundance in the area[2]. However, no evaluation of the impacts of boat tourism on bottlenose dolphins has been conducted so far in Arraial do Cabo and Cagarras Archipelago.

The effects of boat traffic on a small group of bottlenose dolphins has been investigated in the Itajaí River (SC)[16], the largest and economically most important port of this State. A significant decrease in the sighting frequencies of dolphins in relation to boat traffic was reported. However, no significant changes in dolphin behavior was observed, possibly as the trade off for food supply is still positive in relation to vessel disturbance in favorable conditions of prey abundance[16]. No collisions between boats and bottlenose dolphins were registered, probably because of the sporadic presence of recreational boats in this area.

Around Florianópolis (SC) a well-established dolphin watching operation for Guiana dolphins has existed since the early 1980s (Pereira *et al.*, 2007) and bottlenose dolphins are also targeted on occasion as they are found by boat operators mainly in summer (P. Flores, unpub. data). Usually, these dolphins do not show changes to their surface behavior (P. Flores, unpub. data), but a proper study assessing the potential effects of long-term disturbance of tourism upon bottlenose dolphins in Baía Norte (north portion of Florianópolis waters) is needed before a conclusion can be made.

In the Tramandaí River mouth (RS), small (8m) to midsize (20m) vessels such as fishing boats and tugboats dominate boat traffic (Hoffmann, 1997; Moreno *et al.*, 2009). A study of impacts of boats on dolphins in this area found no visible negative effects for the majority of vessel types when they were traveling at low speed (Hoffmann, 1997). Although dolphins generally approached motorboats and jet-skis at first contact, the animals tended to leave the river when tourist boats prolonged their presence in the area (Hoffmann, 1997). This is a particular cause of concern because this dolphin population is very small, and individuals perform a rare positive interaction with the artisanal fishermen, who depend, in part, on this interaction to catch fish (Simões-Lopes *et al.*, 1998). For local fishermen this uncontrolled tourism activity, which occurs mainly in January-February and June-July (main holiday periods in Brazil), is a source of concern, as is the intense boat traffic (Zappes *et al.*, 2011*a*).

Cooperative interactions between dolphins and artisanal fishermen

In some areas bottlenose dolphins have developed feeding strategies to take advantage of human activities (Leatherwood and Reeves, 1983). There are different kinds of ecological interactions in which dolphins and fishermen may act as competitors, commensals or generating mutual advantages: cooperative or positive. Pryor *et al.* (1990) and Simões-Lopes (1991) provided preliminary information on cooperative and spontaneous human-dolphin interactions in southern Brazil. Cooperative fishing with artisanal fishermen occurs mainly at the mouth of rivers or estuaries: Araranguá and Laguna (SC), Mampituba and Tramandaí rivers, and in the PLE (RS) (Simões-Lopes, 1991; Zappes *et al.*, 2011*a*; 2014). Cooperative fishing is initiated by the dolphins and is composed of ritualized movements that demand synchronization between both parties (Simões-Lopes *et al.*, 1998). Humans benefit from fish schools corralled by the dolphins, while dolphins catch disoriented and isolated fish. The influence of dolphins during cooperative fishing can be verified by increased capture efficiency and selectivity of larger prey when compared to an independent fishery (Simões-Lopes *et al.*, 1998).

The ritualized behavioral displays of the dolphins, the learning from mother to calf, and the participation of most of the individuals in these communities provide evidence of extra-human cultural transmission (Simões-Lopes *et al.*, 1998), which is reinforced by the high site fidelity of the individuals (Simões-Lopes *et al.*, 1998; Simões-Lopes and Fabian, 1999; Daura-Jorge *et al.*, 2012).

In most cases cooperative fishing takes place during fishing for mullet (*Mugil* spp.), which occurs mainly between autumn and winter in southern Brazil. In Laguna (SC) mullet comprised 92% of the total prey caught by fishermen, and in Tramandaí (RS) it is about 75% (Simões-Lopes *et al.*, 1998). The gear employed by the artisanal fishermen during the cooperative fishing is called *tarrafa de argola* in Portuguese, a cast net of the falling type (for details see Peterson *et al.*, 2008). In Laguna and Tramandaí mullet fishing has become a very important cultural event for the local community. In both locations dolphins were declared *Patrimônio Natural Municipal* (Natural Heritage of the City), emphasizing the positive feelings from the local population, and identifying the animals as friends of the fishermen, which improve family incomes and are also a tourism attraction (Peterson *et al.*, 2008; Zappes *et al.*, 2011*a*).

Despite seen as a positive interaction by the fishermen because they understand that the dolphins are assisting the fishing activities (*e.g.* Pryor *et al.*, 1990; Simões-Lopes *et al.,* 1998; Zappes *et al.,* 2011*a*), dolphins involved in cooperative fishing have increased risk of entanglement and injuries, as fishermen have reported dolphins removing and stealing fish from their cast nets and ripping the mesh if their calves get stuck in the cast net (Zappes *et al.,* 2014). Damages to the nets and events whereby dolphins frighten the school away or deceive the fishermen by not correctly revealing the location of the school (Zappes *et al.*, 2014) result in losses for the artisanal fishermen.

Conclusions

The data compiled in this review demonstrate that coastal bottlenose dolphins are under anthropogenic pressure in the SWAO. There are several potential sources of impact and some populations may be especially vulnerable, such as the resident populations inhabiting the Patos Lagoon Estuary and the coastal waters of Argentina. However, in general, the studies are scarce or preliminary - a great effort is still required to understand the real impact of human activities on bottlenose dolphins in the SWAO. The main conclusions of this report are:

1. Direct take of bottlenose dolphins in the wild does not appear to be an issue of conservation concern;

2. Incidental captures occur throughout the species distribution and seem to be occasional in Uruguayan and Argentinean waters, where there is evidence of a historic decline in dolphin sightings. In Brazil, bycatch is apparently low in the northeast and southeast coasts, but is frequent in certain areas of southern Brazil, especially in areas close to the PLE, where it seems to occur in high rates in relation to the dolphin population size;

3. Specific data from fisheries (*e.g.* target species, net mesh size, depth and location of fisheries) harming bottlenose dolphins in SWAO are still scarce, but there is evidence suggesting coastal artisanal gillnet fisheries, which operate very close to shore and target demersal fishes, are the main type of fisheries impacting upon coastal bottlenose dolphins;

4. The bottlenose dolphins are exposed to bioaccumulation of micropollutants along the SWAO. Populations near or under influence of large urban centers may be especially vulnerable to accumulate higher concentrations. However, the studies are still extremely scarce and sample numbers are low;

5. Coastal works (*e.g.* dredging, coastal engineering to extend jetties), vessel traffic and dolphin-watching tourism disrupt natural behaviour and habitat use of bottlenose dolphins at least in the short-term. Potential long-term impacts of these activities on bottlenose dolphins in the SWAO remain undetected;

6. Dolphin cooperative fishing with artisanal fishermen occurs mainly in south Brazil, especially at the mouth of Laguna, and Mampituba and Tramandaí rivers. Despite cooperative fishing increasing the capture efficiency of fishermen, the effects of this activity on bottlenose dolphins are still unknown.

Recommendations

1. The implementation of an integrated systematic monitoring program of the main artisanal fishing fleets operating in coastal waters of southern Brazil, Uruguay and Argentina is highly recommended since the presence of coastal bottlenose dolphins is common in these waters. This program should focus on obtaining standard information such as: current fleet size, preferred fishing areas, main target species, fishery characteristics (net type, mesh and size), fishery effort, numbers of incidental captures of cetaceans and other marine mammals. This information could be obtained in partnership with stakeholders through local knowledge in addition to studies of the fisheries carried out by researchers;

2. To conduct studies to investigate levels of micropollutants in bottlenose dolphins from the SWAO, taking into account the effects of ontogeny and life history parameters. It is suggested that the use of biopsy sampling from bottlenose dolphins to obtain tissue samples may be more effective. Also, it is recommended to perform studies regarding pollutant-pathology relationships through biomarker analyses;

3. To conduct studies aimed at estimating the rate of

injuries on bottlenose dolphins caused by fishery interaction and boat strikes. This information could be accessed through analysis of the current available photo-identification databases from different regions;

4. To elaborate regulations for tourism activities on bottlenose dolphins along coastal areas in the SWAO. This could be based on the best-documented studies, such as Shark Bay, Australia (Bejder *et al.*, 2006) and Fiordland, New Zealand (Lusseau *et al.*, 2006). This precautionary approach should be sustained until the effects of tourism and recreational boat traffic have been properly measured.

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