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MARINE MAMMAL OCCURRENCE IN DEEP WATERS OF THE BRAZIL-MALVINAS CONFLUENCE OFF ARGENTINA DURING SUMMER

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ABSTRACT. This article presents the results of a summer survey of marine mammal occurrence at the Brazil-Malvinas Confluence in the Argentine Sea shelf break. A total of 61 marine mammal sightings were recorded. The most frequent species recorded were South American fur seals (*Arctocephalus australis*; 75.4%; 78-4670 m), followed by sperm whales (*Physeter macrocephalus*; 8.2%; 478-2825m), sei whales (*Balaenoptera borealis*; 4.9%; 1513-4674 m) and long-finned pilot whales (*Globicephala melas*; 3.3%; 1119-1534m), with a small number of unidentified cetaceans (4.9%; 87-2248 m). This new information about marine mammal species in the Brazil-Malvinas Confluence updates knowledge of their distribution in this highly productive area.

RESUMO. Ocorrência de mamíferos marinhos no verão austral em águas profundas da Convergência Subtropical no Atlântico Sul Ocidental, Argentina. Este artigo apresenta os resultados de registros de mamíferos marinhos obtidos durante um embarque na região sob influência da zona de Convergência Brasil-Malvinas na quebra da plataforma do Mar Argentino durante o verão austral. Foi obtido um total de 61 avistamentos. As espécies mais comuns foi lobo-marinho-sul-americano (*Arctocephalus australis*, 75.4%; 78-4670 m), cachalote (*Physeter macrocephalus*, 8.2%; 478-2825 m), baleia-sei (*Balaenoptera borealis*; 4.9%; 1513-4674 m) e baleia-piloto (*Globicephala melas*, 3.3%; 1119-1534 m). A presente informação contribui para uma melhor compreensão sobre a ocorrência de mamíferos marinhos em uma área altamente produtiva que é a Convergência Brasil-Malvinas.

Key words: *Arctocephalus australis*. Brazil-Malvinas Confluence. Cetaceans. Pinnipeds. Top predator.

Palavras chave: *Arctocephalus australis*. Cetáceos. Convergência Brasil-Malvinas. Pinípedes. Predadores topo.

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Marine mammals are found in almost all marine environments, and their distribution varies according to the physical, chemical, and biological characteristics of the water masses. The geographical distribution of marine mammals at sea is related to the circulation patterns of ocean currents and its hydrologic characteristics, defined mainly by temperature and salinity, which regulates the presence and abundance of the diverse prey species (Perrin et al., 2009; Bastida and Rodríguez, 2010).

Along the northeastern boundary of the Argentinean Continental Shelf, the warm-salty subtropical waters of the Brazil Current collide with the productive subantarctic waters of the Malvinas Current near 39°S. This area, characterized by intense surface temperature gradients and high mesoscale variability, is referred to as the Brazil-Malvinas Confluence (Gordon, 1989; Saraceno and Provost, 2012). This area is typified by abrupt horizontal and vertical changes in temperature, salinity and nutrient contents (Severov et al., 2012) that, in turn, define conspicuous biological gradients and areas where subtropical and subantarctic species are found (Piola and Gordon, 1989). Furthermore, the shelf-break front is a permanent feature that characterizes the border of the shelf (Acha et al., 2004). Top predators are particularly abundant in some ocean fronts or water mixing zones such as the continental slope and frontal areas (Campagna et al., 2006; Zerbini et al., 2006; Bost et al., 2009; Rodríguez et al., 2013). Nevertheless, the accurate knowledge of marine mammals presence and dynamics at the Brazil-Malvinas Confluence in Argentine Sea shelf break is limited (Moreno et al., 2005; Campagna et al., 2006; Jefferson et al., 2009).

The objective of this study was to report the marine mammal occurrence at the Brazil-Malvinas Confluence in the Argentine Sea shelf break during a summer survey.

Observations were made on the seismic vessel Geco Triton during a cruise carried out by Yacimientos Petrolíferos Fiscales (YPF) on the continental shelf break that overlapped the Brazil-Malvinas Confluence, from 1 December 2006 to 7 March 2007. Due to the operation of the seismic array, the vessel sailed continuously throughout the study period (**Fig. 1**).

Two experienced observers monitored the occurrence of marine mammals in an unobstructed 180° view ahead of the vessel. Eye level was approximately 17 m above sea level, and sightings were performed by both naked eye and 7 x 50 binoculars. Observations were conducted mostly in calm seas (Beaufort Sea state 0-5), with 83.6% of the days with low swell (< 2 m). The total observation time (703.2 h) consisted of 55 uninterrupted observation bouts (12.7 ± 1.33 h) performed during all daylight hours (7:00 to 20:00). For all records, date, hour, species identification, georeferenced position and group size, were recorded. The vessel navigated continuously through all the study period at speeds of 5-6 knots. To prevent the potential effect of the seismic activity on the marine mammal behavior, the days with

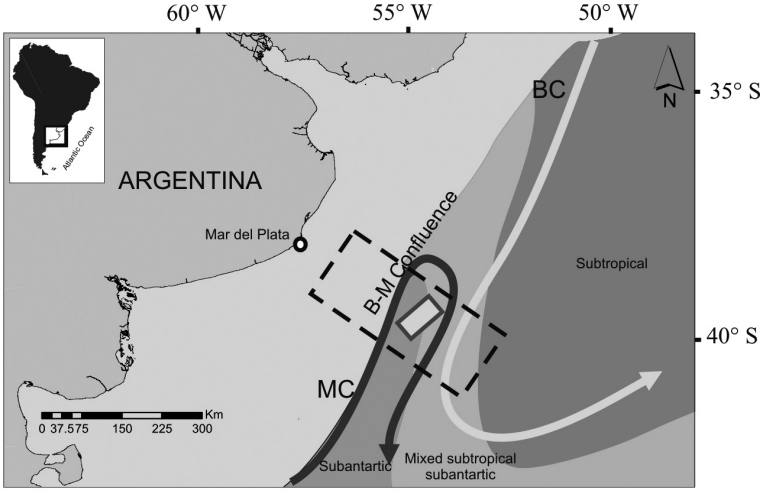

Fig. 1. Location of the study area and major oceanographic features (Campagna et al., 2006). BC: Brazilian Current (white line); MC: Malvinas Current (dark line). Subdivision of survey area: Area 1 (continuous line box) and Area 2 (broken line box).

seismic activity (n = 42) were excluded from the present study, and only sightings during "silent" operation days without seismic activity were included.

According to the ship cruise design, the study region was divided into two main geographic areas (**Fig. 1**):

Area 1 (3450 km²): Includes the research area, where seismic data were actually acquired plus 50 kilometers around the Seismic Area, which encompassed the area where the vessel made the majority of its turns at the end of seismic lines. A total of 300.1 hours of observation were performed, with a daily mean effort of 13.05 ± 1.09 hours (range 10.0-15.0 h) during 23 days.

Area 2 (44,590 km²): Where the ship was sailing out of the prospection zone. This region includes areas where the ship sailed to avoid bad meteorological conditions or to repair equipment. A total of 403.1 hours of observation were performed, with a daily mean effort of 12.60 ± 1.46 hours (range 9.1-14.5 h) during 32 days. No significant differences were found in the mean daily effort between areas (Mann Whitney U = 325; Zadj = 0.734; df = 32, 23; p = 0.462).

Marine mammals were detected in 52.7% of the days of observation (n = 55), with the most frequent records being one (29.1%) or two sightings per day (12.7%). A total of 61 marine mammal sightings were recorded, with one pinniped and three cetacean species identified (**Table 1**; **Fig. 2**). Failure to identify species was usually due to the long distance between the specimens and the observer or the short surfacing time of specimens. Sei whales where identified only when the combination of a single rostral ridge, symmetrical jaw pigmentation, darkish grey dorsal coloration and falcate dorsal fin with rounded tips was present; this combination ruled out Eden (Bryde's) or Fin whales. If these characteristics were not identified or seen, the whale was classified as a non-identified (NI) rorqual.

Sightings were clearly dominated by South American fur seals (*Arctocephalus australis*) (75.4%), followed by sperm whales (*Physeter macrocephalus*) (8.2%), with small number of rorquals and dolphins recorded. Fur seals were found in both continental shelf and shelf-break, whereas the cetaceans were found in both the shelf-break and deep waters (**Fig. 2**).

Overall, group encounter rate (GER; groups per hour of sighting effort) was 0.088 ± 0.138, failing to reject the null hypothesis of equality between Areas 1 and 2 (test t = 1.365; df = 53; p = 0.178). Overall GER was significantly dif-

Table 1

Number of sightings (SI), animals (n=), group encounter rate (GER; sightings per effort hour -1), group size (GS) and depth range (DR; m) of the marine mammal species found off Argentina. Values are expressed as mean ± SD. All the statistical differences (Dif.) between areas were non-significant: (1) t = 1.321; df = 53; p = 0.192 (Pooled value: 0.069 ± 0.131). (2) t = 1.118; df = 46; p = 0.270 (Pooled value: 3.29 ± 4.99). (3) t = -0.840; df = 53; p = 0.405 (Pooled value: 0.007 ± 0.021). (4) t = 1.365; df = 53; p = 0.178 (Pooled value: 0.088 ± 0.138).

Species	SI (n=)			GER			GS			DR
	Area 1	Area 2	Total	Area 1	Area 2	Dif.	Area 1	Area 2	Dif.	
A. australis	11 (20)	37 (138)	46 (158)	0.04 ± 0.11	0.08 ± 0.16	(1)	1.82 ± 1.25	3.73 ± 5.59	(2)	78-4670
P. macrocephalus	3 (5)	2 (2)	5 (7)	0.010 ± 0.025	0.005 ± 0.018	(3)	1.67 ± 0.58	1.0		478-2825
B. borealis	---	3 (10)	3 (10)	---	0.013 ± 0.016			3.33 ± 1.15		1513-4674
G. melas	--	2 (47)	2 (47)	---	0.005 ± 0.021		---	23.5 ± 2.12		1119-1534
Balaenopteriidae NI	1 (1)	1 (1)	2 (2)	0.003 ± 0.017	0.003 ± 0.016		1.0	1.0		1246-2248
Delphinidae NI	--	1 (4)	1 (4)	---	0.002 ± 0.012		---	4.0		87
Total	15 (26)	46 (202)	61 (228)	0.06 ± 0.11	0.11 ± 0.15	(4)				78-4674

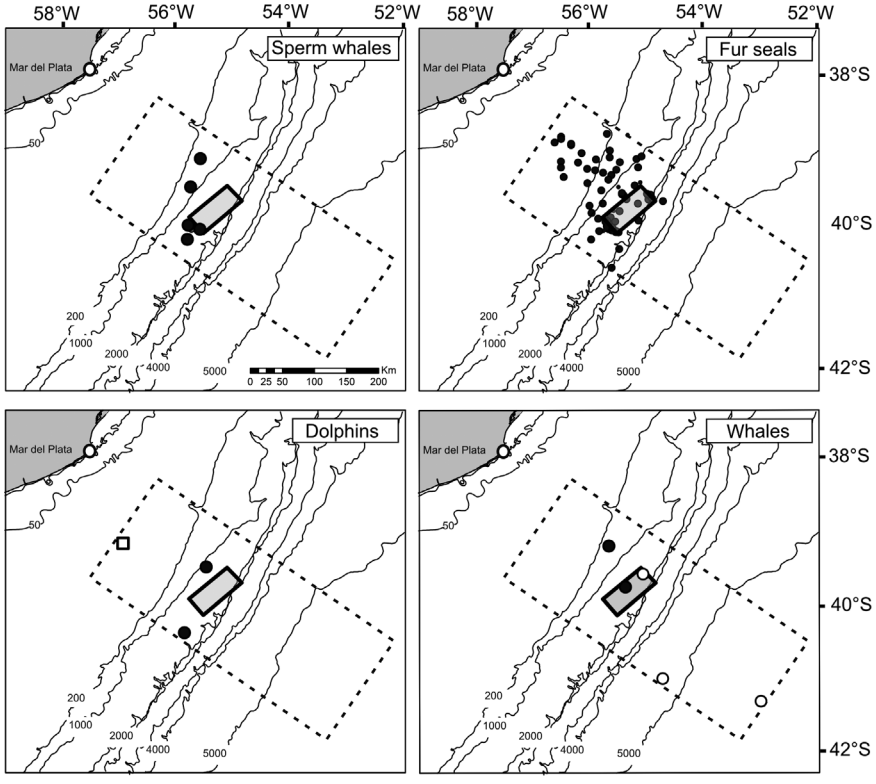

Fig. 2. Location of marine mammal sightings during the survey period. Dolphins: black circles, *Globicephala melas*; white boxes, unidentified Delphinidae. Whales: white circles, *Balaenoptera borealis*; black circles, unidentified Balaenopteriidae. Subdivisions of the survey area follow references in **Fig. 1**.

ferent between species (Kruskal Wallis ANOVA H = 23.725; df = 2, 165; p< 0.001) (**Table 1**).

The most frequent behavior observed in the fur seals was resting (59.6%), with animals passive floating on the surface, in a belly-up position and the flippers in a vertical position extending out of the water; other frequent behaviors observed were surface swimming (21.3%) or porpoising (17.0%). Only in one occasion (2.1%) fur seals were seen eating fish at the surface, and in other occasion it was associated with *Macrocystis pyrifera* kelp rafts.

Sperm whale sightings were mainly of solitary animals, with a few pairs, whereas rorquals were recorded in groups up to four animals and pilot whales in groups of 20-25 animals.

The assemblage of marine mammals in shelf and deep waters influenced by the Brazil-Malvinas Confluence off Argentina was composed by one dominating pinniped (*A. australis*, Frequency of Ocurrence FO: 40%) and a set of odontocetes (FO: 9%): pilot whale (*Globicephala melas* FO: 3.3%) and misticetes (sei whale, *Balaenoptera borealis* FO: 49%).

Our study confirms that the occurrence of fur seals in the Argentine Sea shelf break and nearby deep sea areas is frequent, and the geographical location, high abundance and increasing population trends of the stock that breeds off the coast of Uruguay suggest that this is the most probable origin of the seals (Vaz Ferreira, 1982; Lima and Paez, 1997; Ponce de León and Pin, 2006). Marked fur seals from Uruguay were recorded in northern Argentina (Vaz Ferreira, 1982), and pelagic records in the outer continental shelf are also available (Bastida and Lichtschein, 1984). Furthermore the accessibility to the shelf-break has been

suggested to drive the distribution pattern of rookeries of *Arctocephalus australis* in the South Western Atlantic, with colonies located mostly in coastal islands where the continental shelf is narrow (Túnez et al., 2008). Stable isotope analysis suggests that South American fur seals, especially males, forage offshore (Franco Trecu et al., 2012; Vales et al., 2014). The permanent occurrence of fur seals in coastal waters off Mar del Plata (38º06'S - 57º33'W; Bastida and Rodríguez, 1994; Dassis et al., 2012) and Golfo San Matías (Svendsen et al., 2013) also confirms this potential connection.

Both the sea lions (*Otaria flavescens*) and fur seals off northern Argentina and Uruguay spent ca. 70% of their time at sea foraging (Rodríguez et al., 2013; Mandiola, in progress), and the prevailing occurrence of surface resting behavior is a strong indication of active foraging, as floating periods at-sea were interpreted as an energy conserving strategy that would allow an increase overall foraging efficiency (Dassis et al., 2012). The association of fur seals with kelp rafts off the South Western Atlantic would also contribute to surface resting, as they were frequently reported in the open ocean off Malvinas Islands and South Georgia (Helmuth et al., 1994).

Marine mammals are usually found in waters with high densities of their main prey species (Bowen et al., 2002), and frequently associated with oceanic and neritic frontal areas (Haney, 1986; Guinet et al., 2001; Ainley et al., 2005; Campagna et al., 2006; Rodríguez et al., 2013). The occurrence of marine mammals near the Confluence of the Brazil and Malvinas currents may be an indication of this association, as this area is part of the subtropical front in the South Atlantic Ocean, and constitutes an important biogeographic boundary between organisms of subtropical and subantarctic origin and an area of prey concentration (Carreto et al., 1986; Piola and Gordon, 1989; Bezzi and Dato, 1995; Provost et al., 1995; Romero et al., 2006).

The present study provides updated information of marine mammal distribution in deep waters off Argentina, a highly productive area affected by increasing commercial fisheries. Due to the limited information and the conservation status of the reported species in this area (*Globicephala melas*: Data Deficient; *Physeter macrocephalus*: Vulnerable; *Balaenoptera borealis*: Endangered), the present report should be considered as a preliminary baseline for the conservation and management of this complex zone.

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