Cetaceans using the marine protected area of "Parque Estadual Marinho da Laje de Santos", Southeastern Brazil*

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Abstract

The aim of this study was to evaluate the presence of cetaceans in the waters surrounding the Marine Protected Area (MPA) known as "Parque Estadual Marinho da Laje de Santos (PEMLS)", placed in coastal waters at the southeastern coast of Brazil. Boat-based surveys were conducted once a month from June 2013 to June 2015. A specific transect was followed to cover the area of the quoted MPA, as well as its borders. A total of 24 boat-surveys rendered 18 sightings of cetacean groups of the following species: Atlantic spotted dolphin (*Stenella frontalis*) (12), rough-toothed dolphin (*Steno bredanensis*) (2), common dolphin (*Delphinus delphis*) (1), Bryde's whale (*Balaenoptera edeni*) (2) and common minke whale (*Balaenoptera acutorostrata*) (1). Sightings of *S. frontalis*, the commonest sighted species, was positively correlated with water depth (Mantel test; $r = 0.8072$; $p < 0.05$). Photoidentified individuals moved back and forth to inner and outer areas of the MPA, remaining in the area throughout the 2-year survey. "Paisley" cutaneous marks of unknown origin were reported in two common dolphins for the first time in local waters. As the PEMLS has been used as an important spot for SCUBA divers, it is recommended that cetacean sightings could still be gathered in a future partnership, as well as using the acoustics tool to detect their presence when researchers are not in the field.

Descriptors: Cetaceans, Parque Estadual Marinho da Laje de Santos, *Stenella frontalis*, Paisley Cutaneous Marks.

Resumo

O objetivo deste estudo foi avaliar a presença de cetáceos em águas costeiras nas proximidades da Unidade de Conservação (UC) marinha do Parque Estadual Marinho da Laje de Santos (PEMLS), localizado no sudeste do Brasil. Cruzeiros oceanográficos foram conduzidos entre junho de 2013 e junho de 2015 seguindo um transecto pré-definido para cobrir toda a UC, assim como suas bordas. Um total de 24 embarques foi realizado, rendendo 18 avistagens de cetáceos das seguintes espécies: golfinho-pintado-do-Atlântico (*Stenella frontalis*) (12), golfinho-de-dentes-rugosos (*Steno bredanensis*) (2), golfinho-comum (*Delphinus delphis*) (1), baleia-de-Bryde (*Balaenoptera edeni*) (2) e baleia-minke-comum (*Balaenoptera acutorostrata*) (1). As avistagens de *S. frontalis* estiveram positivamente correlacionadas com a profundidade da água (Teste Mantel; $r = 0.8072$; $p < 0.05$). Indivíduos fotoidentificados moveram-se para dentro e para fora da UC, permanecendo pela região de estudo nos dois anos de investigação. Marcas cutâneas de origem desconhecida e denominadas em literatura como marcas cutâneas de "Paisley" foram observadas em *D. delphis*. Considerando que o PEMLS tem sido utilizado como um importante ponto para mergulhadores em lazer, é recomendável que as avistagens de cetáceos continuem sendo obtidas em futura parceria com as operadoras de mergulho, assim como que se utilize a acústica passiva para detectar a presença de cetáceos na região quando observadores não estiverem ali.

Descritores: Parque Estadual Marinho da Laje de Santos, *Stenella frontalis*, Marcas Cutâneas de Paisley.

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INTRODUCTION

From a total of 90 living cetacean species worldwide (COMMITTEE ON TAXONOMY, 2015), 47 have been recorded in Brazilian waters (SANTOS et al., 2010; SOUZA Et al., 2016). Cetaceans are known to play important roles in their environment, including ecological interactions with other populations as predators, preys and host of parasites, vertical and horizon transportation of nutrients in all ocean basins and in at least four freshwater basins, and sources of habitat and energy in the deep seas after death (ESTES et al., 2006; LAVERY Et al., 2010; 2014; ROMAN Et al., 2014). Based on their relevance to the aquatic environments, cetaceans have received special attention in conservation and management plans worldwide, including in the establishment of marine protected areas (MPAs). As a consequence, efforts have been made to identify and protect cetacean critical habitats.

Critical habitats are defined as "*those parts of a cetacean's range that are essential for day-to-day well-being and survival, as well as for maintaining a healthy population growth rate. Areas that are regularly used for feeding (including hunting), breeding (including all aspects of courtship), calving (including nursing), socializing, resting, as well as, sometimes, migrating*" (HOYT, 2011). This definition includes the values on species interactions in time and space, which have been driving the establishment of ecosystems with high biodiversity, as well as oceanographic processes and topography (habitat heterogeneity). Although when thinking about ocean conservation the establishment of a MPA may seem as the best practice to restrict anthropogenic impacts, its setting has been a challenge. There are critiques regarding the cost, conflicts with human beings (*e.g*. indigenous people who claim the rights to use the land and sea), and discussions concerning climate change and invasive species on aquatic systems (see a review in MORA; SALE, 2011). Besides, a minimum of baseline information is needed to enable impact assessment and decision-making and it is recommended that this compilation follows the ecosystem approach (SECRETARIAT OF THE CONVENTION ON BIOLOGICAL DIVERSITY, 2005).

As of October 2010, *ca*. 6,800 MPAs had been established, covering 1.2% of the global ocean area (TOROPOVA et al., 2010). This is far below the projected goals of 20% to 30% (HALPERN, 2003) and the recent proposed projections by the Target 11 of the Nagoya protocol signed at the 10th Convention on Biological Diversity in 2010 which suggested that "*10 per cent of coastal and marine areas, especially areas of particular importance for biodiversity and ecosystem services, are conserved through effectively and equitably managed, ecologically representative and well-connected systems of protected areas and other effective area-based conservation measures, and integrated into the wider landscape and seascape*."

Along the 8,500km long coast of Brazil, about 1.5% of different categories of MPAs are inserted in the exclusive economic zone (ZEE) (PRATES et al., 2012). Although the documents published by the government show a clear intention to follow the recommendations established by the Nagoya protocol, the proposals to amplify these areas have not been listed as one of the priorities of the federal government in the past six years. New MPAs had not been set up during the quoted period. Besides, some of those MPAs have no management plans which means that they only exist on paper. On the other hand, in 2008 the state of São Paulo established three new MPAs along most of the coastline (State Decrees 53,535; 53,526 and 53,527 - 8 October 2008), representing 0.2% of the total area of MPAs in Brazilian waters. They were established in to regulate human activities in an overpopulated area. The largest port of Latin America, the port of Santos, has been operating almost in the center of the state coastline since 1892 (CODESP, 1992), making the biodiversity conservation efforts a huge challenge.

To address the influence of the port activities on the marine biota, in 1993 the first MPA was established along the coast of São Paulo through the State Decree 37,537: the "Parque Estadual Marinho da Laje de Santos" (PEMLS). Formed by rocky formations that host a unique biodiversity of invertebrates and fish, the PEMLS has been mainly used by scuba diving operators (TEBECHERANI et al., 2009). The original document which established this MPA included a paragraph quoting "the relevance of the presence of marine mammals, whales and dolphins on its surrounding areas". As a consequence, studies on the use of local waters by cetaceans were deemed necessary to evaluate the importance of that MPA to these mammals. As of April 2016, a total of 30 cetacean species had been recorded along the coast of São Paulo state (SANTOS et al., 2010; SANTOS; FIGUEIREDO, 2016), which represents 33% of the global species diversity. Opportunistic non-standardized surveys were conducted in the past 20 years and showed that at least seven cetacean species occurred in the waters of, and closer to, the PEMLS: humpback

whale (*Megaptera novaeangliae*), right whale (*Eubalaena australis*), Bryde's whale (*Balaenoptera edeni*), minke whale (*Balaenoptera* sp. - no reference on which species), common (*Delphinus delphis*), bottlenose (*Tursiops truncatus*) and Atlantic spotted (*Stenella frontalis*) dolphins (GONÇALVES, 2009; GONÇALVES et al., 2015).

The aim of the present study is to evaluate the use of inner and closer areas of the MPA of the PEMLS by cetaceans.

MATERIAL AND METHODS

Cetacean sightings were gathered after boat-based surveys that covered the entire area of the PEMLS from June 2013 to June 2015. The transects were designed to cover the widest possible area surrounding the PEMLS considering a 5 km sighting limit based on BUCKLAND et al. (2001) and SUTHERLAND (2006). The surveys were conducted using a 15m long high-speed boat traveling at 10 knots. One researcher took notes of the time, location and sea state (Beaufort) every 30 minutes of navigation or when a cetacean was sighted. Two other researchers acted as observers and photographers covering a 90º area from the bow, each with half of the front view of the boat. Researchers switched positions each 30 minutes. For each sighting, the boat would approach the group to identify the species to estimate the group size and composition, and to photograph the individuals. Nomination of species followed the COMMITTEE ON TAXONOMY (2015). Although recent genetic data has been used to categorize the Bryde's whale of the Western South Atlantic as *Balaenoptera brydei* (PASTENE et al., 2015), the authors used *B. edeni* as suggested by the COMMITTEE ON TAXONOMY (2015). Data on location, depth, sea surface temperature and salinity were recorded. The sighting rate of cetaceans was estimated as the number of groups observed per navigated nautical mile.

The photo-identification technique was conducted to follow individuals in time and space based on the marks found on the cetaceans' dorsal fin (see WÜRSIG; WÜRSIG, 1977; HAMMOND et al., 1990).

A Mantel Test was used to determine if there was a correlation between the presence of a given species and the environmental variables collected at each sighting location (depth, temperature and salinity). The analysis was conducted using the R version 3.2.4 (R CORE TEAM, 2016) with the *mante.rtest* available in the *ade4* package. In this case, the Mantel Test evaluate the null hypothesis that the presence of the investigated species and the variable are unrelated (with p-value > 0.05). It also reveals if this relation is positive or negative, according to the r value.

RESULTS

Twenty-four surveys were conducted, resulting in a total of 1,606.2 nautical miles navigated, 18 cetacean sightings (Figure 1, Table 1) and a rate of 0.011 sightings per nautical mile. The five observed species (number of sightings in parenthesis) were: Atlantic spotted dolphin (*Stenella frontalis*) (12), rough-toothed dolphin (*Steno bredanensis*) (2), common dolphin (*Delphinus delphis*) (1), Bryde's whale (*Balaenoptera edeni*) (2) and common minke whale (*Balaenoptera acutorostrata*) (1).

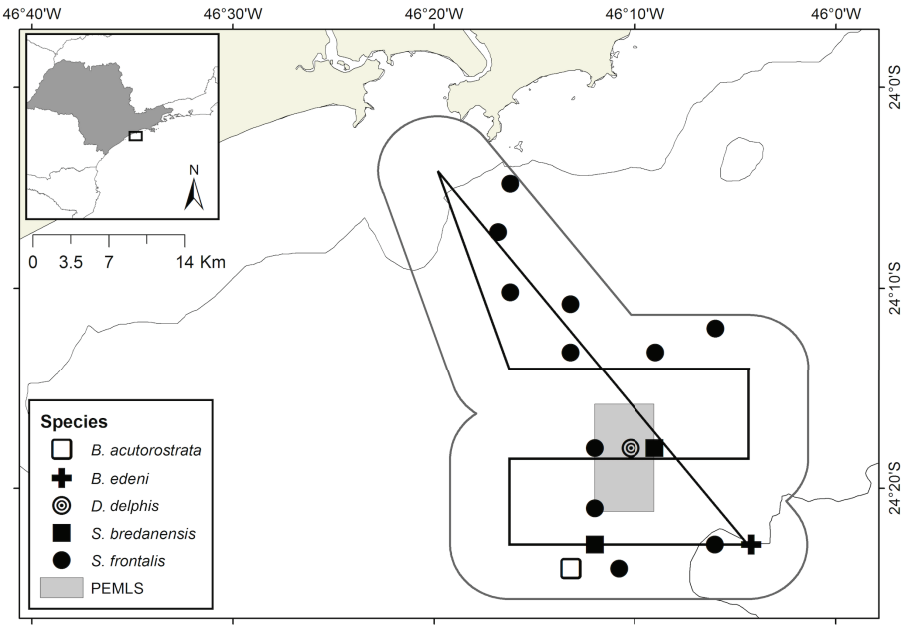

Figure 1. Map of the study area in inner and outer waters of the "Parque Estadual Marinho da Laje de Santos", showing the transects (black lines) starting and finishing in shallow waters at 24º03'S and 46º20'W. The gray line shows the sampled area which includes a 5 km distance from the transects. Sightings of each cetacean species are shown. The black cross indicates two sightings of Bryde's whale made on the same location on consecutive days.

Table 1. Cetacean sightings made in inner and outer waters of the "Parque Estadual Marinho da Laje de Santos" between June 2013 and June 2015. Date, position, group size and identification of each species are given. Sf = *Stenella frontalis*, Sb = *Steno bredanensis*, Dd = *Delphinus delphis*, Be = *Balaenoptera edeni* and Ba = *Balaenoptera acutorostrata*.

Sighting	Species	Date	Latitude	Longitude	Group Size
1	Sf	31 Jul 2013	24°10'S	46°16'W	60
2	Sf	27 Nov 2013	24°18'S	46°12'W	40
3	Be	27 Nov 2013	24°23'S	46°04'W	2
4	Be	28 Nov 2013	24°23'S	46°04'W	2
5	Sf	5 Feb 2014	24°21'S	46°12'W	30
6	Sf	1 Apr 2014	24°07'S	46°17'W	30
7	Sf	1 Apr 2014	24°23'S	46°06'W	250
8	Sf	1 Apr 2014	24°12'S	46°06'W	250
9	Sf	1 Apr 2014	24°13'S	46°13'W	8
10	Sf	24 Jun 2014	24°24'S	46°11'W	70
11	Ba	25 Jun 2014	24°24'S	44°13'W	2
12	Sf	15 Jan 2015	24°05'S	46°16'W	12
13	Sb	26 Feb 2015	24°18'S	46°09'W	15
14	Sb	19 May 2015	24°23'S	46°12'W	50
15	Dd	20 May 2015	24°18'S	46°10'W	7
16	Sf	26 May 2015	24°11'S	46°13'W	50
17	Sf	8 Jun 2015	24°13'S	46°09'W	20
18	Sf	8 Jun 2015	24°13'S	46°13'W	120

The Atlantic spotted dolphin was the species most commonly observed (67% of all sightings). Groups were always composed by all age classes, spatially distributed in social units composed by female-calf pairs first, then juveniles, and far beyond the bow of the boat, the large adults. Group size ranged from 8 to 250 individuals (mean+ sd = 80.9 ± 80.1 individuals; n = 12). Table 2 shows the environmental data acquired on each sighting of S. frontalis. Sightings were made in depths ranging from 20 to 43 meters, sea surface temperatures ranging from 19°C to 29ºC, and salinity values ranging from 32 to 40. According to the Mantel Test (Table 3) depth was the only variable that correlated positively with the sightings of *S. frontalis* ($r = 0.8072$; $p < 0.05$).

Table 2. Sightings of Atlantic spotted dolphins (*Stenella frontalis*) in inner and outer waters of the "Parque Estadual Marinho da Laje de Santos" between June 2013 and June 2015, including the date, water depth, temperature and salinity at the surface, group size, number of pictures taken (# of pictures) and the number of identified individuals (# of IDs). Missing data (-) are related to malfunctioning of the used gear.

Date	Depth (m)	Temperature (ºC)	Salinity	# of pictures	# of IDs
31 Jul 13	30	19	38	613	10
27 Nov 13	30	-	37	462	0
5 Feb 14	42	26	40	540	0
1 Apr 14	20	28	40	447	3
1 Apr 14	43	28	40	545	13
1 Apr 14	38	28	40	421	4
1 Apr 14	30	-	-	0	0
24 Jun 14	30	23	-	1,244	5
15 Jan 15	25	29	40	183	2
26 May 15	33	24	36	262	5
8 Jun 15	38	24	32	478	10
8 Jun 15	33	24	32	926	32
Average/Total	32.7	25.3	37.5	6,121	84

Table 3. Results of the Mantel Test applied to evaluate data of the Atlantic spotted dolphins (*Stenella frontalis*) sightings in inner and outer waters of the "Parque Estadual Marinho da Laje de Santos" between June 2013 and June 2015. Positive values of r indicate the variable is positively related to the species presence, and negative values indicate that the association is negatively correlated. The null hypothesis that the presence of the species and the variable are unrelated is rejected when the p-value is smaller than 0.05, indicating that the variable is related to the presence *S. frontalis*.

Mantel Test	
Variables	*Results*
Depth	r = 0.8072
	p-value < 0.05
Salinity	r = -0.0047
	p-value > 0.05
Temperature	r = -0.2324
	p-value > 0.05

The photo-id study identified ten Atlantic spotted dolphin individuals in two different occasions in the study area (Table 4). The interval between sightings of the same individual ranged from 13 to 677 days. Figure 2 shows the location of each sighting and the number of individuals identified between two consecutive sightings.

Table 4. Sightings of individually marked Atlantic spotted dolphins (*Stenella frontalis*) in inner and outer waters of the "Parque Estadual Marinho da Laje de Santos" between June 2013 and June 2015. The table shows the individual ID number (ID), date and geographic coordinates where the first and the second sightings were made. ID numbers are higher than 10 as the main catalog includes a broader area of investigation not reported here.

ID	1st Sighting			2nd Sighting		
	Date	Latitude	Longitude	Date	Latitude	Longitude
13	31 Jul 13	24°10'S	46°16'W	1 Apr 14	24°23'S	46°06'W
14	31 Jul 13	24°10'S	46°16'W	1 Apr 14	24°23'S	46°06'W
17	31 Jul 13	24°10'S	46°16'W	1 Apr 14	24°23'S	46°06'W
22	31 Jul 13	24°10'S	46°16'W	15 Jan 15	24°05'S	48°16'W
25	31 Jul 13	24°10'S	46°16'W	8 Jun15 (II)	24°13'S	46°13'W
36	1 Apr 14	24°23'S	46°06'W	26 May 15	24°11'S	46°13'W
41	1 Apr 14	24°23'S	46°06'W	26 May 15	24°11'S	46°13'W
62	1 Apr 14	24°23'S	46°06'W	8 Jun15 (II)	24°13'S	46°13'W
136	1 Apr 14	24°23'S	46°06'W	8 Jun15 (I)	24°13'S	46°09'W
127	26 May 15	24°11'S	46°13'W	8 Jun15 (II)	24°13'S	46°13'W

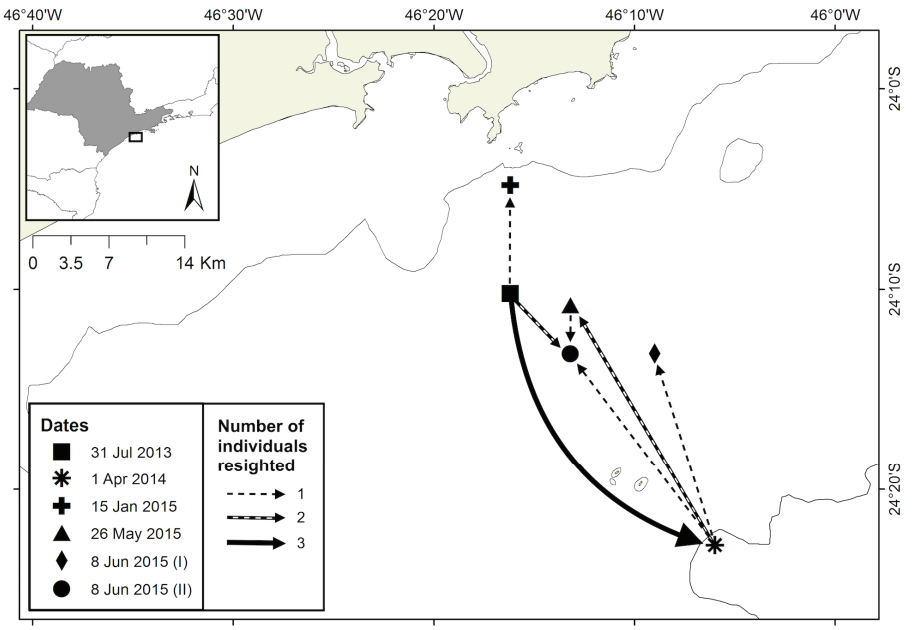

Figure 2. Sightings of individually marked Atlantic spotted dolphins (*Stenella frontalis*) in inner and outer waters of the "Parque Estadual Marinho da Laje de Santos" between June 2013 and June 2015. Symbols show the dates of the sightings and the arrows indicate the number of individuals seen on distinct dates.

The pictures used in the photo-identification study also allowed the identification of two *D. delphis* with large and circumvoluted, light gray skin marks evoking the "Paisley" lesions described by SWEENEY; RIDGWAY (1975). In one individual the marks were extensive and affected most of the visible body (Figure 3A). In the other individual (Figure 3B) the lesions were less numerous and seemed to be concentrated on the anterior part of the visible body.

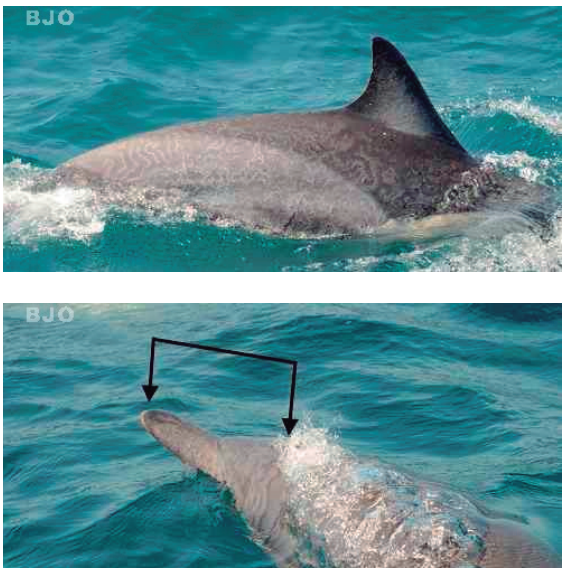

Figure 3. Common dolphins (*Delphinus delphis*) with "Paisley" skin marks on 20 May 2015 in inner waters of the "Parque Estadual Marinho da Laje de Santos". The marks were seen on most of the visible body in one of the individuals (A), but only on the head of another one (B).

DISCUSSION

Until now, data on cetacean sightings in inner and closer areas of the PEMLS had been gathered opportunistically. This is the first time that a multidisciplinary study was conducted in two consecutive years using standardized methods to search for, and report on, cetaceans in the waters of the PEMLS. However, it is important to emphasize that the survey frequency was not adequate to evaluate trends when considering highly mobile long-living species in a complex system. Monthly surveys may not be the best strategy to evaluate the seasonality on the use of local waters by cetaceans. A larger number of boat surveys (*e.g.* once a week) should better address this issue. Even with such a low frequency of survey days in a year, interesting and unknown information could be gathered.

Motivated by the present survey, boat crews of SCUBA diving operators have been opportunistically observing cetaceans in the same area during the 2-year survey period. Humpback and pilot whales were only seen once using the local waters. The common and rough-toothed dolphins were sighted more frequently by operators than by us. Bryde's whales (from November to May) and Atlantic spotted dolphins (all year round) were the most often sighted species by these operators.

Considering the high costs involved in research cruises, the authors strongly recommend the establishment of a partnership between cetacean researchers and the PEMLS managers, in order to use SCUBA diving operators as "citizen" scientists. A building capacity program should be coordinated by all responsible ones considering these three groups of actors. Besides, the use of acoustic devices should be emphasized to better report on cetaceans using the PEMLS, mainly when researchers can not be there (e.g. night, dawn, bad sea state conditions). This could result in a better cost-benefit relation when balancing research efforts and gathered results.

The Atlantic spotted dolphin was not only the most common cetacean species in the surveyed area (representing 12 of the 18 sightings), but also the most abundant (Tables 1 and 2). Their presence was positively correlated with water depth (ranging from 20 to 43 m) (Table 3). Individuals of this species occupy a strip along the southeastern coast of Brazil that is not close enough to the shoreline. Our observations corroborate recent niche modeling studies showing that in the Southwestern Atlantic Ocean *S. frontalis* can be found in strictly coastal habitats (AMARAL et al., 2015). Three of the 12 sightings were reported close to the 20m isobath, which is the location where sometimes *ca*. 100 merchant ships remain anchored before entering the port of Santos. The hypothesis that these dolphins could be following preys attracted to the ships for food and/or protection from predators should be evaluated. Distinct and spatially distributed social units were observed in all occasions, and the authors recommend further investigations with a larger sample size.

Ten photo-identified individuals could be re-sighted at intervals ranging from 13 to 677 days. This indicates that several individuals used local waters more than once in a two-year period (Table 4, Figure 2). More surveys should be conducted in time and space to address the existence of residency patterns in this stock. Local short-range movements of Atlantic spotted dolphins were also recorded for the first time in closer areas to the PEMLS. As fish and cephalopods are the main food items of *S. frontalis* (see LOPES et al., 2012), it is possible that these dolphins travel in large groups to find patchy food items associated to coastal islands, including the PEMLS. Atlantic spotted dolphins are known to use shallow coastal, as well as deeper offshore waters (see PERRIN, 2001). Stranding, incidental capture and sighting data showed a hiatus on the species distribution along the Brazilian coast, with an isolated stock in southern and southeastern Brazil

(MORENO et al., 2005), closely related to another one found in the Northeastern Atlantic (CABALLERO et al., 2013). Altogether, it is clear that one of the best spots to further study this isolated stock are the surrounding waters of the PEMLS.

Though other mysticetes have been previously reported in this area (ZERBINI Et al., 1997; SICILIANO et al., 2004; GONÇALVES et al., 2015), we only sighted two groups of Bryde's whales in early summer and one group composed by two adult common minke whales of the same size in winter.

Common dolphins can be found in waters up to 200m in southeastern Brazil (TAVARES et al., 2010). In this study we recorded two *D. delphis* with "Paisley" cutaneous marks of unknown origin in inner waters of the PEMLS. Other skin diseases, such as lobomycosis-like disease, were not observed in any species. Large "Paisley" marks have, to our knowledge, not been previously observed in free-ranging dolphins. As it was not possible to collect samples, the etiology of the disease remains unknown.

The PEMLS may serve as the source of organic matter and larvae to other systems placed within short and long-ranges. The occurrence of several species of cetaceans all year round and, occasionally, in great numbers, is an important indicator of the MPA productivity and health, as these mammals have often been used as sentinels of aquatic ecosystems (MOORE, 2008). As previously quoted, the efforts to better understand the use of local waters by cetaceans should be improved, coupling boat-based observations with other tools such as the acoustic detections of cetaceans.

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