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Overview of *Balaenoptera* whales strandings in Southern Brazil from 1993 to 2018

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Abstract

The ecology and distribution of most baleen whales are poorly known in Brazilian waters, despite the history of whaling and the recent increase in the research effort. Although stranding data presents some caveats, it is useful to understand patterns of distribution and occurrence and to detect population trends. In this scenario, data from 25 years of a monitoring marine mammal stranding program were used to evaluate the composition and spatial-temporal patterns of *Balaenoptera* whales in southern Brazil. A stretch of 270 km on the coast of Rio Grande do Sul State (from 29°20'S to 31°21'S) was surveyed year-round between 1993 and 2018. Whales were identified, measured and sex determined whenever possible. Molecular identification through mtDNA analysis was obtained for 22 individuals and confirmed field identification in 17 cases. Forty-eight whales of four species were recorded: common minke whale *B. acutorostrata* n = 27, Antarctic minke whale *B. bonaerensis* n = 1, Bryde's whale *B. brydei* n = 13, fin whale *B. physalus* n = 1. In addition, six whales were not identified at species level due to advanced decomposition. The larger number of strandings of common minke and Bryde's whales may be related to their greater abundance and/or more coastal distribution. Both species were recorded year-round, but strandings of common minke and Bryde's whales occurred mostly during winter/spring (77.77%) and spring/summer (66.66%), respectively. Although Bryde's whales appear to remain in southern Brazilian waters during the entire year, the results suggest the existence of seasonal inshore-offshore movements. Moreover, the greater number of strandings of juveniles of common minke whales compared to adults (ratio 1.86:1) and their occurrence in different seasons suggest that some immature individuals may not leave this region, as previously pointed out by other studies. This long-term survey brings new evidence of the importance of this region in the Southwestern Atlantic Ocean for some *Balaenoptera* species.

Keywords:
baleen whales, habitat use, long-term surveys, molecular identification, population structure, Southwestern Atlantic

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Introduction

Eight species of baleen whales, also referred to as rorquals, compose the genus *Balaenoptera*. All of them have been recorded in Brazilian waters (Zerbini et al., 1997; Siciliano et al., 2011; Cypriano-Souza et al., 2017), except the recently described Rice's whale (*B. ricei*), which seems to be endemic to the northern Gulf of Mexico (Rosel et al., 2021). Conventionally, whales of the genus *Balaenoptera* recorded in Brazilian waters include the common minke whale (*B. acutorostrata*), Antarctic minke whale (*B. bonaerensis*), sei whale (*B. borealis*), Bryde's whale (*B. brydei*), Omura's whale (*B. omurai*), fin whale (*B. physalus*), and blue whale (*B. musculus*) (Zerbini et al., 1997; Milmann et al., 2020).

Several populations of these species have been reduced by whaling activities in the last centuries and some are currently recovering (Clapham et al., 1999; Herr et al., 2022). The conservation status worldwide for whales varies according to the impact of whaling on population size and there are new threats currently affecting their recovery. The species found in Brazil range from Least Concern (LC) for Bryde's whale (Cooke & Brownell, 2018) and common minke whale (Cooke, 2018a) to Endangered (EN) for sei whales (Cooke, 2018b) and blue whales (*B. musculus*) (Cooke, 2018c). Other species are Data Deficient (DD), such as the Omura's whale (Cooke & Brownell, 2019). Nowadays, there are new threats that can affect species recovery, such as reduction in the ice cap of the South Pole (Moore et al., 1999), entanglement in fishing nets (Simões-Lopes & Ximenez, 1993; Secchi et al., 2003; Ott et al., 2009), ship strikes (Van Waerebeek et al., 2007), chemical pollution and noise exposure (Risch et al., 2019; Southall et al., 2019).

Most balaenopterids are known to be migratory and carry out annual movements between the poles and mid-latitude areas (*e.g.*, Corkeron & Connor, 1999). Despite this pattern, there are exceptions, such as individuals of blue whale which are known to remain within a specific zone along years in the northeast Pacific (Busquets-Vass et al., 2017), some individuals of common minke whale in western South Atlantic Ocean, and Bryde's whale (*Balaenoptera brydei*, please see taxonomic discussion below) found in mid-latitude waters across seasons (Zerbini et al., 1997; Secchi et al., 2003; Siciliano et al., 2004; Moura & Siciliano, 2012; Milmann et al., 2018).

Taxonomical nomenclature is still in debate for some balaenopterids. In the case of Bryde's whale, until recently two forms were known to occur in Brazil, a larger one called *B. edeni* and the smaller *B. brydei* (Zerbini et al., 1997). Although the Committee on Taxonomy (2022) still considers the two forms of Bryde's whale as subspecies: *B. e. brydei* Olsen, 1913, and *B. e. edeni* Anderson, 1879, their separation as different species has been fully acknowledged (Wada et al., 2003). Moreover, after molecular identification, the evidence favors the presence only of *B. e. brydei* among the strandings along the Brazilian coast and biopsied individuals (Pastene et al., 2015; Dalpaz et al., 2023). Currently, *B. brydei* is still not officially recognized as a species in the Southwestern Atlantic Ocean, but facing the new evidence should be adopted onwards. Therefore, individuals previously referred to as Bryde's whale are now referred to in the text as *B. brydei*.

Another taxonomical issue is related to the common minke whale (*B. acutorostrata*), which is a different species of the Antarctic minke whale (*B. bonaerensis*) (Pastene et al., 2007). *Balaenoptera acutorostrata* from the Southern Hemisphere has been further regarded as an unnamed subspecies, considering striking molecular divergence in the Southern Hemisphere when compared to other populations and subspecies across the world (Pastene et al., 2007; 2009). Individuals from this subspecies can be found in mid-latitude waters across seasons (Zerbini et al., 1997; Secchi et al., 2003; Siciliano et al., 2004; Moura & Siciliano, 2012; Milmann et al., 2018), and are further structured in the Southern Hemisphere (Glover et al., 2013; Milmann et al., 2021). Despite the evidence, the status of the unnamed subspecies of *B. acutorostrata* is still not officially recognized by the Committee of Taxonomy (2022), and therefore we refer to it as *B. acutorostrata* in agreement with the current classification and for practical matters. It is worth noticing that the data sustaining the existence of *B. brydei* as a species is more robust and well accepted than the unnamed subspecies of common minke whale from the Southern Hemisphere and that is why we used Society for Marine Mammalogy recommendations for common minke whales but not for Bryde's whales.

The knowledge about balaenopterids is still incipient in Brazilian waters, as only a few estimates of the relative abundance of some species in specific areas exist (*e.g.*, Andriolo et al., 2010). Their preferential areas are still a matter of research (*e.g.*, Zerbini et al., 1997; Siciliano et al., 2011; Di Tullio et al., 2016; Tardin et al., 2017). Most of our knowledge about their distribution and occurrence in Brazilian waters comes from oceanographic cruises (Zerbini et al., 2004; Andriolo et al., 2010; Di Tullio et al., 2016), whaling data, incidental catches (Lucena, 2006), and strandings (Zerbini et al., 1997; Siciliano et al., 2004, 2011; Cypriano-Souza et al., 2017; Milmann et al., 2020). Acoustic research has also provided new insights into the occurrence and distribution of species such as Omura's and Antarctic minke whales in Brazilian waters (*e.g.*, Moreira et al., 2020, Rossi-Santos et al., 2022).

Of the seven *Balaenoptera* species presumably occurring along the Rio Grande do Sul state coast, four are considered Data Deficient at the national level or did not have a conservation status locally evaluated (Rocha-Campos & Câmara, 2011). Moreover, there are some particularities from different species of the genus which make them hard to evaluate, such as morphological similarities between the common and the Antarctic minke whales, hampering correct species identification in sympatric areas. A smaller form of Bryde's whale was described as a distinct species named *B. omurai* (Wada et al., 2003), whose first stranding in South America was recorded in northeastern Brazil in 2016 (Cypriano-Souza et al., 2017). The similarity between species highlighted the need for molecular identification of stranded specimens for species confirmation. In the Brazilian National Plan for the Conservation of Large Aquatic Mammals, the investigation of rorquals' distribution patterns is considered a priority to evaluate the conservation status of Data Deficient species to minimize possible threats and define priority areas for conservation (Rocha-Campos & Câmara, 2011).

Studies on stranded carcasses have caveats such as health stress, frequent failure to determine the cause of death, and biases due to feeding and physiological changes prior to stranding (e.g., Hobson et al., 1993; Roman et al., 2021). Moreover, the region where stranding likely occurred does not represent the animal's current distribution, because the carcasses could be carried by ocean currents, and the final disposal may also be influenced by the continental shelf configuration (Prado et al., 2013). This drift may not be as significative for baleen whales as most species have slender bodies and may have negative buoyance, therefore not drifting very long distances but usually sinking just after death (Moore et al., 2020). Humpack whales (*Megaptera novaeangliae*) and right whales (Family Balaenidae) could be exceptions as they have thicker blubber layer. Despite that, the relatively low cost of tissue sampling and the potential information obtained from the carcass (*e.g.*, diet, age class, sex, species id) make long-term surveys a recommended methodology for the study of marine mammals and other marine taxa (*e.g.*, Caretta et al., 2016; Prado et al., 2016; Lenz et al., 2017).

In this study, we conduct systematic beach surveys in southern Brazil as part of a long-term marine mammal monitoring project to fill gaps related to seasonal patterns of the genus *Balaenoptera.* We provide information on habitat use for rorqual species, as well as age class patterns that could help improve conservation measures in the Southwestern Atlantic Ocean. This may also be relevant for providing information for the possible expansion of the South Atlantic Ocean Whale Sanctuary (IWC, 2018), new marine protected areas that may be created accordingly to Brazil's marine biodiversity law (Gerhardinger et al., 2011), and defining the conservation status for data deficient species (Rocha-Campos & Câmara, 2011).

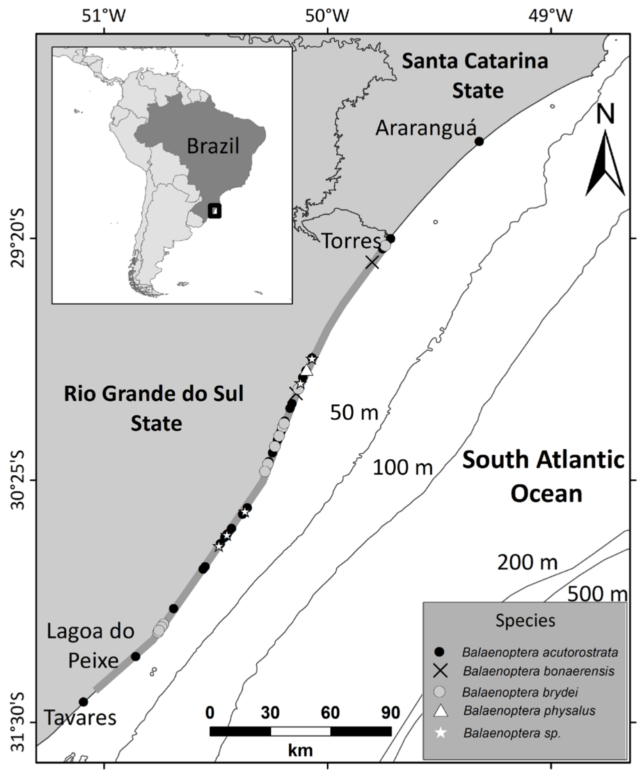

Figure 1. Map of *Balaenoptera* strandings (n=47*) in the states of Rio Grande do Sul and Santa Catarina, southern Brazilian coast. Torres (north) and Tavares (south) are the limits of the monitored study area. *One individual stranded in the survey area is not on the map due to lack of spatial reference.

Material and Methods

Study area

The southern Brazilian coast is in the Subtropical Convergence Zone of the Atlantic Ocean, which is under the influence of the Malvinas and Brazil currents (Silveira, 2000). It extends from Santa Marta Grande Cape, in southern Brazil, to Uruguay, comprising nearly 100,000 km^2 from the shoreline to the slope regions of the continental shelf (Seeliger & Odebrecht, 1998). Moreover, the discharge of the Patos-Mirim Lagoon system in the region and the interaction between the two marine currents make it a very productive and significant area, rich in biodiversity of marine organisms (Castello et al. ,1998; Seeliger and Odebrecht, 1998; Crespo, 2009).

Data collection

Whale carcasses (Fig. 2) were examined, sampled, and in some cases recovered, during surveys on sandy beaches along the northern coast of Rio Grande do Sul State, southern Brazil, between the localities of Torres (~29°19'48" S, 49°43'48" W) and Lagoa do Peixe National Park (~31°18´00"S, 51°02'24" W), extending 270 km (Fig. 1). This stretch of the coast was systematically monitored between January 1993 and December 2014 when 285 expeditions were carried out, accounting for 27,194 km of monitoring effort. After this period, surveys covered the same perimeter but were not systematic until 2018, and total of kilometers monitored is not available. Besides the patrolling surveys, stranded baleen whales in the surveyed area were also notified by the local community. For that reason, one of the strandings was recorded at Araranguá beach, 60 km northward of the end of the northern limit of the transects in Torres in the Santa Catarina State, due to locals call (28°54'00"S, 49°19'12" W). For each specimen, the geographic location (*i.e.*, latitude/longitude) was recorded and whenever possible the total length and the sex determined accordingly to the protocol established by Norris (1961). The spatial distribution of the strandings with respect to the latitudes was verified by visual observation of stranding points plotted on a map, which was elaborated using ArcGIS 10.3 software. Marks that could indicate any type of interaction with human activities were also investigated. The carcass decomposition state was classified according to the Geraci condition index (Geraci & Lounsbury, 2005). Skull, stomach, and other tissue samples were also collected whenever possible as voucher materials and for future analyses, and all collected samples were deposited in the scientific collection of the Grupo de Estudos de Mamíferos Aquáticos do Rio Grande do Sul (GEMARS), in Brazil.

Identification of specimens and age classes

Individuals were firstly identified to species level based on coloration, external and/or skull morphology and the total length, as referred in the literature (*e.g.*, Carwardine, 1995; Zerbini et al., 1996; Jefferson et al., 2008). Age class was attributed based on the total length. For common minke whales, males were considered adults over 6 m and females when over 6.2 m, and juveniles when values were between 3.8 m and 6 m for males and 6.2 m for females with calves smaller than 3.8 m (Zerbini et al., 1996). For Bryde's whales, individuals over 11.2 m were considered adults while between 8 m and 11.2 m were considered

Figure 2. A) Bryde's whale (GEMARS1718) stranded in Torres, Rio Grande do Sul State (Photo: Paulo Ott). B) Research team collecting information of a stranded *Balaenoptera* sp. (GEMARS1335) in an advanced state of decomposition at Rio Grande do Sul State (Photo: GEMARS). C) Fresh specimen of common minke whale (GEMARS1309) stranded at Rio Grande do Sul State (Photo: Rodrigo Machado).

juveniles and under 8 m were considered calves (Jefferson et al., 2008). Finally, fin whales were considered adults when over 18 m, juveniles between 18 and 6.5 m and calves when smaller than 6.5 m (Carwardine, 1995).

Molecular analyses were carried out to confirm or correct species identification. In this context, genomic DNA was extracted for most of the soft and hard tissue samples using Invitrogen™ PureLink™ Genomic DNA Mini Kit or using phenol chloroform protocol (Sambrook et al., 1989). The concentrations of genomic DNA were estimated by Nanodrop UV spectrophotometry (Thermo Scientific Wilmington, DE). The DNA samples were diluted in deionized water until reaching a concentration of approximately 100 ng/μL when necessary. A fragment of the mitochondrial DNA control region (~500 bp) was amplified using primers MT4 (5'-CCTCCCTAAGACTCAAGGAAG-3') (Árnason et al., 1993) and Dlp5R (5'CCATCGAGATGTCTTATTTAAGGGGAAC-3'), following the PCR conditions used by Árnason et al. (1993). DNA extraction and PCR amplification were carried out in the Laboratory of Molecular Biology of Universidade do Vale do Rio dos Sinos (UNISINOS). Sequencing was carried at the Institute of Cetacean Research at Tokyo, Japan (permits SISGEN R607D49 and SISCITES 18BR030112/DF).

The consensus sequences were automatically aligned (with minor manual correction) in ClustalW implemented in MEGA 7 with a later edition in BioEdit 5.0.9 (Hall, 1999). After the alignment, we compared the control region sequences with those available in GenBank (www.ncbi.nlm.nih.gov) using the Basic Local Alignment Search Tool (BLAST) (blast.ncbi.nlm.nih.gov). The molecular identification by GenBank was based on the percentage of similarity among sequences.

Data analysis

The spatial distribution of the strandings in relation to the latitude was verified by visual observation of stranding points plotted on a map elaborated using ArcGIS 10.3 software. Finally, to show the local topography and improve the discussion of results, the bathymetric values from southern Brazil were shown using data from ETOPO 1 (Amante and Eakins, 2009).

Results

A total of 48 specimens of four species of balaenopterids were found between 1993 and 2018 (Table 1). During the study period, the number of stranded specimens per year ranged from 1 to 5 (mean = ~2, standard deviation = 1.15), and there were no records in three years (1996, 1999, 2004). Six whales (12.5%) were not identified at the species level (Table 1). The total length and the age group of the stranded individual were determined in 35 cases (72.9%) and the sex in 27 cases (55.1%). Common minke whale had the highest number of strandings (n = 27, 56.2%) followed by Bryde's whale (n = 13, 27.1%). The other two species (Antactic minke and fin whales) had only one (2%) record each (Table 1).

Field identification was confirmed by molecular analysis in 17 cases and corrected in one case (Table 1). Molecular analysis of hard and soft tissue was conducted for 33 out of the 48 whales

Table 1. Data on *Balaenoptera* strandings (n = 48) on the coast of the states of Rio Grande do Sul and Santa Catarina, southern Brazil, from 1993 to 2018. Information related to mtDNA analysis is also shown, where “f ” means that the individual could not be sequenced, “c” means that the field identification was confirmed, “i” means that the individual lacked identification prior to molecular analysis and “cr” means that the species identification was corrected in relation to field id.

Id	GEMARS	Species	mtDNA	Date	Sex	Age Class	TL (m)	Publication
1	G0108	*B. acutorostrata*	f	26 Sep 1993	M	A	6.65	Present study
2	G0130	*B. acutorostrata*	-	14 Dec 1993	-	A	7.00	Zerbini et al., 1997
3	G0272	*B. acutorostrata*	-	19 Aug 1995	-	J	4.23	Zerbini et al., 1997
4	G0287	*B. acutorostrata*	-	28 Oct 1995	-	C	2.63	Zerbini et al., 1997
5	G0331	*B. acutorostrata*	-	17 Dec 1995	F	C	3.2	Zerbini et al., 1997
6	G0394	*B. acutorostrata*	c	24 Jan 1997	F	J	4.1	Present study
7	G0469	*B. acutorostrata*	f	11 Nov 1997	F	C	3.05*	Present study
8	G0527	*B. acutorostrata*	c	11 Jul 1998	-	A	7.06	Milmann et al., 2021
9	G0741	*B. acutorostrata*	c	27 Aug 2000	M	C	2.51	Milmann et al., 2021
10	G0746	*B. acutorostrata*	c	11 Nov 2000	M	-	-	Milmann et al., 2021
11	G0800	*B. acutorostrata*	f	19 May 2001	-	-	-	Present study
12	G0971	*B. acutorostrata*	i	27 Jun 2003	-	A	8.00	Milmann et al., 2021
13	G1042	*B. acutorostrata*	c	29 Aug 2003	F	C	2.26	Milmann et al., 2021
14	G1093	*B. acutorostrata*	f	28 Oct 2003	-	C	3.25	Present study
15	G1257	*B. acutorostrata*	c	3 Nov 2005	F	C	2.51	Present study
16	G1237	*B. acutorostrata*	i	7 Oct 2005	-	J	<5	Milmann et al., 2021
17	G1295	*B. acutorostrata*	c	23 Oct 2007	F	J	4.40	Present study
18	G1302	*B. acutorostrata*	f	4 Jul 2007	-	-	-	Sholl et al., 2013
19	G1309	*B. acutorostrata*	f	25 Sep 2008	M	J	4.53	Ott et al., 2013; Milmann et al., 2018
20	G1420	*B. acutorostrata*	c	27 Nov 2010	F	-	-	Milmann et al., 2021
21	G1445	*B. acutorostrata*	-	30 May 2011	-	A	12.6	Present study
22	G1468	*B. acutorostrata*	c	29 Sep 2011	M	A	6.85	Milmann et al., 2021
23	G1618	*B. acutorostrata*	c	21 Nov 2012	F	-	-	Milmann et al., 2021
24	G1636	*B. acutorostrata*	-	21 Jun 2013	M	C	2.63	Milmann et al., 2021
25	G1689	*B. acutorostrata*	i	11 Dec 2015	M	-	-	Milmann et al., 2021
26	G1696	*B. acutorostrata*	c	11 May 2016	-	-	-	Present study
27	G1712	*B. acutorostrata*	c	5 Feb 2018	M	A	8	Milmann et al., 2021
28	G0810	*B. bonaerensis*	cr	13 Aug 2001	M	C	2.90	Present study
29	G0510	*B. brydei*		4 Apr 1998	-	-	10.0**	Present study
30	G0248	*B. brydei*	i	22 Dec 1994	M	J	10.75	Zerbini et al., 1997; Lima 2020
31	G0426	*B. brydei*	-	30 Jul 1997	F	C	4.13	Present study
32	G1154	*B. brydei*	-	16 Dec 2003	-	-	-	Present study
33	G1224	*B. brydei*	c	20 Jan 2005	F	A	14	Pastene et al., 2015; Lima 2020
34	G1224	*B. brydei*	-	21 Jan 2005	-	-	-	Pastene et al., 2015; Lima 2020
35	G1266	*B. brydei*	c	17 Dec 2005	M	A	12.65	Present study
36	G1425	*B. brydei*	c	7 Dec 2010	-	A	11.43	Present study
37	G1406	*B. brydei*	-	27 May 2010	-	-	-	Present study
38	G1714	*B. brydei*	c	2016 - 2017	F	-	-	Present study
39	G1705	*B. brydei*	c	18 Jan 2017	M	A	13.00	Present study
40	G1694	*B. brydei*	-	6 Apr 2016	-	-	-	Present study
41	G1718	*B. brydei*	-	8 Dec 2018	F	J	10.13	Present study
42	G0826	*B. physalus*	-	13 Jun 2002	M	J	13.60	Ott et al., 2013
43	G1269	*Balaenoptera* sp.	f	6 Jan 2006	F	-	7.50	Present study
44	G1335	*Balaenoptera* sp.	f	23 Oct 2009	-	-	-	Present study
45	G1338	*Balaenoptera* sp.	-	23 Oct 2009	-	-	8.10	Present study
46	G1628	*Balaenoptera* sp.	f	20 Dec 2012	M	-	7.01	Present study
47	G1679	*Balaenoptera* sp.	f	16 Nov 2014	-	-	13.00	Present study
48	G1680	*Balaenoptera* sp.	f	19 Feb 2015	-	-	-	Present study

TL = Total length in meters, M = male, F = female, C = calf, J = juvenile, A = adult. *Without the tail, **without the skull.

(Table 1). Sequences for species identification were obtained in 22 cases. Two whales were molecularly identified from bone samples and 20 from skin samples. The molecular analysis made it possible to identify four whales without previous species morphological identification.

Most strandings (26 out of 47, 55.3%) occurred between 30°00′00″ S and 30°36′00″ S, which corresponds to only about 1/4 of the total surveyed area. The total number of strandings were 48 but one of them did not have stranding coordinates. Although clear marks of human interaction from fisheries artifacts were not found in most cases, one specimen of common minke whale with the tail severed was found (G0469, Table 1).

Strandings were recorded in all seasons with a variable number of occurrences by species (Figure 2). Winter was the unique season with the presence of the four identified species (n = 10, 20.8%) while summer was the season with the highest number of stranding records (n = 16, 33.3%). Two species (*B. brydei* and *B. acutorostrata*) were recorded throughout the year and have a

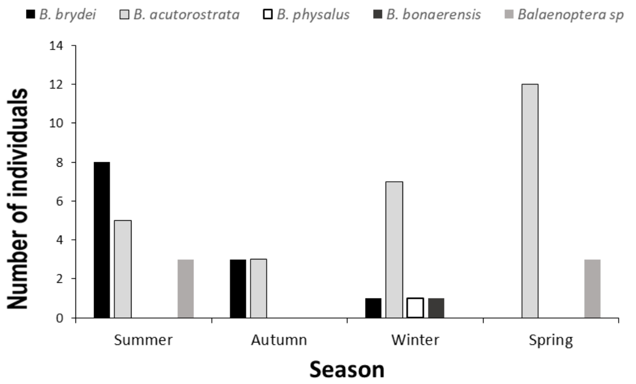

Figure 3. Stranding distribution of individuals from four *Balaenoptera* species and non-identified specimens in relation to the different seasons of the year on the coast of Rio Grande do Sul state, southern Brazil, between 1993 and 2018.

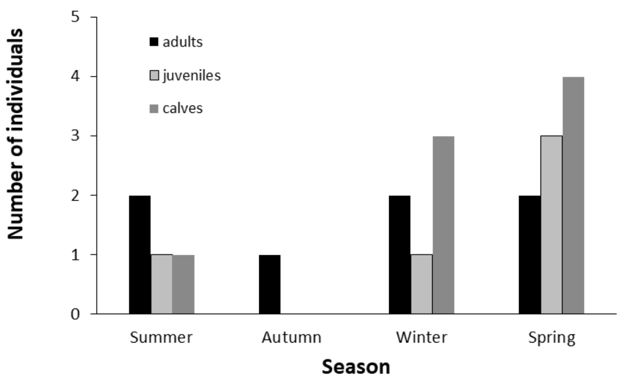

Figure 4. Comparison between the number of adults (n = 7), juveniles (n = 5) and calves (n = 8) of common minke whale *Balaenoptera acutorostrata* stranded between 1993 and 2018 during different seasons in southern Brazil. The age class was defined based on the individual's total length following the values presented by Zerbini et al. (1996) for the Southern Hemisphere subspecies.

large majority number of strandings (Table 1, Fig. 3), with the highest occurrence of Bryde's whale during the summer and common minke whales during the winter and the spring. However, the occurrence of common minke whale in the summer and fall (warm seasons in the Southern Hemisphere) represents only 29.6% (n = 8) of the total number of the species.

Regarding the proportion of individuals of different age classes of common minke whale within seasons, adults occur in the area during all seasons in similar amount (Fig. 4). There is a predominance of juveniles during the spring (n = 3, 60%) and calves during winter (n = 3, 37.5%) and spring (n = 4, 50%), although both age classes were also recorded during the summer. There was a total predominance of juveniles (n = 5) and calves (n = 8) in relation to adults (n = 7). That was expected because populations tend to have a greater number of juveniles when compared to adults, as observed for humpback whale (Clapham & Mayo, 1990). Considering only the total of individuals sexed (n = 16, 59.2%), eight individuals were female and eight were males. The total length of individuals varied from 2.26 m to 12.6 m (n = 20, mean = 4.98 m, sd = 2.68 m).

Discussion

Monitoring strandings through beach surveys has advantages, is economical and provides information of species with unknown aspects of their natural history, as demonstrated in the present study. Moreover, the presence of balaenopterids in the area over the year and the predominance of common minke whale compared to other species is relevant information for conservation, as this species is still Data Deficient in the area (Rocha-Campos & Câmara, 2011). Besides, the predominance of juveniles and neonates of common minke whale in stranding records, especially during winter and spring, confirms that southern Brazil is an important area for immature and newborn individuals of the species (Baldas & Castello, 1986; Zerbini et al., 1997; Secchi et al., 2003; Milmann et al., 2018).

The results show that the northern coast of Rio Grande do Sul State is regularly inhabited by species of the genus *Balaenoptera*, as reported in adjacent areas (Prado et al., 2016) and in offshore waters of the continental slope (Di Tullio et al., 2016). In this context, environmental characteristics that result in high local productivity (Castello et al., 1998; Crespo, 2009) and the geographical position between areas of higher and lower latitudes used by these species at different stages of life (Lucena, 2006; Andriolo et al., 2010) may favor their occurrence in the study area. The low frequency of strandings of Antarctic minke and fin whales could be related to the species' offshore habitat (Di Tullio et al., 2016), which reduces the probability of their carcasses reaching the coast. It should be noted that the continental shelf of the study area is approximately 100 km wide (Fig. 1). On the other hand, the large number of strandings of common minke and Bryde's whales could indicate that both species are more abundant in the area and use more coastal habitats than the other balaenopterids (Siciliano et al., 2004; Di Tullio et al., 2016; Tardin et al., 2017). Because of the lack of abundance estimates for these species in the area, the impact of the mortality reported here at the population level is unknown.

Evidence of interactions between anthropogenic activities and *Balaenoptera* whales found stranded during this study were not directly observed prior the stranding or verified during necropsy due to the advanced decay conditions of some carcasses. Although the tail of a common minke whale (GEMARS 0469) reported here was likely severed by humans during fishery interactions, it is not possible to determine the specific type of fishery involved. It should be noted that previous notifications of interactions between baleen whales and fisheries were scarcely recorded in the literature in Brazil. Pinheiro et al. (2015) reported one case of severe mutilation of the entire fluke of a minke whale during longline operations that probably led to its death, and three others were previously caught in gillnets in southern Brazil (Simões-Lopes & Ximenez, 1993; Secchi et al., 2003). Further evaluation of the causes of death of stranded baleen whales are ultimately needed as entanglement was also observed for the recovering stock of humpback whales in the Southwestern Atlantic Ocean (Ott et al., 2009).

The molecular analyses were useful to identify whales that were in an advanced stage of decomposition or when only part of the carcass was available, confirming that this tool is useful in stranding monitoring studies (Sholl et al., 2013; Cypriano-Souza et al., 2017). DNA could not be successfully amplified in all samples probably due to different factors such as greater difficulties in DNA extraction from bone samples, long time lapse from tissue sampling to analysis (Kilpatrick, 2002), and tissue deterioration. In all cases, the information obtained from this method refined our results increasing the number of identified whales. For example, the mtDNA analysis aided the identification of a species that would otherwise not be reported, as was the case of the *B. bonaerensis* previously identified in the field as *B. acutorostrata.*

Our data confirmed that this region of southern Brazil is widely used by migratory whales as reported before (Banister, 2002; Andriolo et al., 2010). It is worth noting that information on the spatial pattern of stranded whales with oceanic distribution should be interpreted with caution since some carcasses drift for a long time before reaching the beach (Prado et al., 2013), although rorquals may sink after death as reported by whalers (Moore et al., 2020). Therefore, it is expected that the number of strandings represents only a fraction of the mortality of these species in the continental shelf and the continental slope (Secchi et al., 2003; Di Tullio et al., 2016; Moore et al., 2020).

The strandings were correlated to the seasons. This is expected, since the majority of the species studied here displayed typical annually migratory behavior between low and high latitudes (Laws, 1977). In general, it is assumed that whale species migrate to waters close to the South Pole searching for food in the warmer months, when the ice cap decreases resulting in greater food availability (Laws, 1977). Unlike the rest of the species, Bryde's whale remains in Brazilian waters and is not found in higher latitudes (Siciliano et al., 2004; Moura & Siciliano, 2012; Pastene et al., 2015). The south of Brazil presents ocean fronts which serve as nursery grounds for several bony fish that are an important resource for local fisheries (Haimovici et al., 1996). Therefore, the area may have favorable conditions for maintaining biodiversity and maybe also for feeding piscivorous species such as *B. brydei* (Best, 2001). Thus, the present results indicate that southern Brazil may be an area frequently occupied by some individuals of Bryde's whale, although there was seasonal variation on the number of strandings. In this context, cetacean sighting survey cruises on the continental slope of Rio Grande do Sul also indicated that the species substitution in the area is more influenced by temporal than spatial scale (Di Tullio et al., 2016).

Besides stranding records of *B. acutorostrata* throughout the year, more juveniles and calves occur during the winter and spring in southern Brazil, as reported in a previous review of strandings on the east coast of South America (Milmann et al., 2020) and in Uruguay alone (Juri et al., 2020). The regional peak for neonates and immature individuals in northern Argentina is from March to July and Baldas & Castello (1986) suggested that this region is a nursery and birthing area. The number of juveniles and calves in southern Brazil during winter/ spring and the proximity between these areas (approximately 1,000 km) also indicated that the birth area of this subspecies of common minke whale probably encompasses southern Brazil, Uruguay and Argentina (Zerbini et al., 1997; Milmann et al., 2020). The common minke whale subspecies occurrence in the study area is probably influenced by resources availability (Haimovici et al., 1996), use of the area for displacements between feeding and breeding areas, and for the birth and parental care (Baldas & Castello, 1986; Zerbini et al., 1997). Juveniles were found in all seasons except in autumn, probably because they may feed in the area during their first years of life (Secchi et al., 2003). Moreover, a stranded juvenile, reported in the present study (GEMARS 1309), had large quantities of prey of oceanic distribution squid (*Illex argentinus*), probably consumed in the Rio Grande do Sul slope (Table 1) (Milmann et al., 2018). Although adults normally have lower mortality rates when compared to young and old individuals in different mammal species (Caughley, 1966), the proportion of juveniles found here and the fact that it is a birth area may indicate the segregation of mature males and females without offspring. Segregation related to age class has been previously suggested for common minke whale in Brazilian waters based on information from strandings and accidentally caught individuals (Zerbini et al., 1997; Secchi et al., 2003), and for Antarctic minke whale based on catch data (Lucena, 2006). The amount of data presented here reinforces this hypothesis of age class segregation, although juveniles and calves of common minke whale are also found in other places in Brazil (*e.g.*, Geise & Borobia, 1988; Siciliano et al. 2008; Santos et al., 2010). In any circumstances, the importance of southern Brazil for this species should be regarded and further investigated, as the area is already under the impacts of anthropic activities such as overfishing (Haimovici & Cardoso, 2016) and ship traffic.

Conclusions

Although the number of strandings of balaenopterids remained stable across years, there was seasonal variation in the composition of the species observed, with a preference by Bryde's whale for warmer seasons and by common minke whale for colder seasons. Results also evidenced the use of southern Brazilian waters as a calving and nursery area by common minke whales, as juveniles and calves were predominantly found. Moreover, the occurrence of juveniles of the species across the seasons suggests that some immature individuals may not leave this region.

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References

Amante, C. & Eakins, B. W. (2009). *ETOPO1 1 Arc-Minute Global Relief Model: Procedures, Data Sources and Analysis* (NOAA Technical Memorandum NESDIS NGDC-24). National Oceanic and Atmospheric Administration. https://www.ngdc.noaa.gov/mgg/global/relief/ETOPO1/docs/ETOPO1.pdf

Andriolo, A., Rocha, J. M., Zerbini, A. N., Simões-Lopes, P. C., Moreno, I. B., Lucena, A., Danilewicz, D., & Bassoi, M. (2010). Distribution and relative abundance of large whales in a former ground off eastern South America. *Zoologia, 27*(5), 741-750. https://doi.org/10.1590/S1984-46702010000500011

Árnason, U., Gullberg, A., & Widegren, B. (1993). Cetacean mitochondrial DNA control region: sequences of all extant baleen whales and two sperm whale species. *Molecular Biology and Evolution, 10*(5), 960-970. https://doi.org/10.1093/oxfordjournals.molbev.a040061

Baldas, M. I., & Castello, H. P. (1986). *Sobre el hallazgo de ejemplares juveniles de ballena minke,* Balaenoptera acutorostrata, *en el estuário del Rio de la Plata y sur de Brasil* [Conference Proceedings]. 1ª Reunion de Trabajo de Expertos en Mamiferos Acuaticos de America del Sur, Buenos Aires, Argentina.

Banister, J. L. (2002). Baleen Whales (Mysticetes). In W. F. Perrin, B. Würsig, & J. G. M. Thewissen (Eds.), *Encyclopedia of Marine Mammals* (2nd ed., pp. 80-89). Academic Press.

Best, P. B. (2001). Distribution and population separation of Bryde's whale *Balaenoptera edeni* off southern Africa. *Marine Ecology Progress Series, 220*, 277-289. https://www.jstor.org/stable/24864863

Busquets-Vass, G., Newsome, S. D., Calambokidis, J., Serra-Valente, G., Jacobsen, J. L., Aguíñiga-García, S., & Gendron, D. (2017). Estimating blue whale skin isotopic incorporation rates and baleen growth rates: implications for assessing diet and movement patterns in mysticetes. *PLoS ONE, 12*(5), e0177880. https://doi.org/10.1371/journal.pone.0177880

Caretta, J. V., Danil, K., Chivers, S. J., & Weller, D. W. (2016). Recovering rates of bottlenose dolphin (*Tursiops truncatus*) carcasses estimated from stranding and survival data rates. *Marine Mammal Science, 32*(1), 349-362. https://doi.org/10.1111/mms.12264

Carwardine, M. (1995). *Whales, dolphins, and porpoises* (1st American ed.). Dorling Kindersley.

Caughley G. (1966). Mortality patterns in mammals. *Ecology, 47*(6), 906-918. https://doi.org/10.2307/1935638

Castello, J. P., Haimovici, M., Odebrecht, C. & Vooren, C. M. (1998). A plataforma e o talude continental. In U. Seeliger, C. Odebrecht, & J. P. Castello (Eds.), *O ecossistema costeiro e marinho do extremo sul do Brasil* (pp. 189-197). Ecoscientia.

Clapham, P. J., & Mayo, C. A. (1990). *Reproduction of humpback whales* (Megaptera novaeangliae) *observed in the Gulf of Maine* (Special Issue 12). International Whaling Commission.

Clapham, P. J., Young, S. B. & Brownell Jr, R. L. (1999). Baleen whales: conservation issues and the status of the most endangered populations. *Mammal Review, 29*(1), 37-62. https://doi.org/10.1046/j.1365-2907.1999.00035.x

Committee on Taxonomy (2022). *List of marine mammal species and subspecies*. Society for Marine Mammalogy. https://marinemammalscience.org/science-and-publications/list-marine-mammal-species-subspecies/

Cooke, J. G. (2018a). *Balaenoptera acutorostrata. The IUCN Red List of Threatened Species 2018*, e.T2474A50348265. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T2474A50348265.en

Cooke, J. G. (2018b). *Balaenoptera borealis. The IUCN Red List of Threatened Species 2018*, e.T2475A130482064. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T2475A130482064.en

Cooke, J. G. (2018c). *Balaenoptera musculus (*errata version published in 2019*). The IUCN Red List of Threatened Species 2018*, e.T2477A156923585. https://doi.org/10.2305/IUCN.UK.2018-2.RLTS.T2477A156923585.en

Cooke, J. G., & Brownell Jr, R. L. (2018). *Balaenoptera edeni. The IUCN Red List of Threatened Species 2018,* e.T2476A50349178. https://doi.org/10.2305/IUCN.UK.2018-1.RLTS.T2476A50349178.en

Cooke, J. G., & Brownell Jr, R. L. (2019). *Balaenoptera omurai (*amended version of 2018 assessment*). The IUCN Red List of Threatened Species 2019*, e.T136623A144790120. https://doi.org/10.2305/IUCN.UK.2019-1.RLTS.T136623A144790120.en

Corkeron, P. J., & Connor, C. C. (1999). Why do baleen whales migrate? *Marine Mammal Science, 15*(4), 1228-1245. https://doi.org/10.1111/j.1748-7692.1999.tb00887.x

Crespo, E. A. (2009). South American aquatic mammals. In W. F. Perrin, B. Würsig, & J. G. M. Thewissen, (Eds.), E*ncyclopedia of Marine Mammals* (2nd ed., pp. 1071-1076). Academic Press.

Cypriano-Souza, A. L., Meirelles, A. C. O., & Carvalho, V. L. (2017). Rare or cryptic? The first report of an Omura's whale (*Balaenoptera omurai*) in the South Atlantic Ocean. *Marine Mammal Science, 33*(1), 80-95. https://doi.org/10.1111/mms.12348

Dalpaz, L., Cypriano-Souza, A. L., Lodi, L., Wedekin, L., & Daura-Jorge, F. G. (2023). Bryde's whales in South Brazil Bight: evidence of low genetic diversity and seasonal habitat use. *Marine Biology, 170*(8), 94. https://doi.org/10.1007/s00227-023-04241-0

Di Tullio, J. C., Gandra, T. B. R., Zerbini, A. N., & Secchi, E. R. (2016). Diversity and distribution patterns of cetaceans in the subtropical Southwestern Atlantic Outer Continental Shelf and Slope. *PLoS ONE, 11*(5), e0155841. https://doi.org/10.1371/journal.pone.0155841

Geise, L., & Borobia, M. (1988). Sobre a ocorrência de cetáceos no litoral do estado do Rio de Janeiro entre 1968 e 1984. *Revista Brasileira de Zoologia, 4*(4), 341-346.

Geraci, J. R., & Lounsbury, V. J. (2005). *Marine Mammals Ashore: A Field Guide for Strandings* (2nd ed.). National Aquarium in Baltimore, Maryland.

Gerhardinger, L. C., Godoy, E. A. S., Jones, P. J. S., Sales, G., & Ferreira, B. P. (2011). Marine protected dramas: the flaws of the Brazilian National System of Marine Protected Areas. *Environmental Management, 47*(4), 630-643. https://doi.org/10.1007/s00267-010-9554-7

Glover, K. A., Kanda, N., Haug, T., Pastene, L. A., Øien, N., Seliussen, D. B., Sørvik, A. G. E., & Skaug, H. J. (2013). Hybrids between common and Antarctic minke whales are fertile and can back-cross. *BMC Genomic Data, 14*, 25. https://doi.org/10.1186/1471-2156-14-25

Haimovici, M., Martins, A. S., & Vieira, P. C. (1996). Distribuição e abundância de peixes teleósteos demersais sobre a plataforma continental do sul do Brasil. *Revista Brasileira de Biologia, 56*(1), 27-50.

Haimovici, M. & Cardoso, L. G. (2016). Long-term changes in the fisheries in the Patos Lagoon estuary and adjacent coastal waters in Southern Brazil. *Marine Biology Research, 13*(1), 135-150. https://doi.org/10.1080/17451000.2016.1228978

Hall, T. (1999). BioEdit: a user friendly biological sequence alignment editor and analysis program for Windows 95/98/NT. *Nucleic Acids Symposium Series, 41*, 95-98.

Herr, H., Viquerat, S., Devas, F. et al. (2022). Return of large fin whale feeding aggregations to historical whaling grounds in the Southern Ocean. *Scientific Reports, 12*, 9458. https://doi.org/10.1038/s41598-022-13798-7

Hobson, K., Alisauskas, R., & Clark, R. (1993). Stable-Nitrogen Isotope enrichment in avian tissues due to fasting and nutritional stress: Implications for isotopic analyses of diet. *The Condor, 95*(2), 388-394. https://doi.org/10.2307/1369361

IWC (2018). *The South Atlantic: a sanctuary for whales* (Publication No. IWC/67/10/Rev.1). International Whaling Commission.

Jefferson, T., Webber, M., & Pitman, R. (2008). *Marine mammals of the world. A comprehensive guide to their identification.* Academic Press.

Juri, E., Valdivia, M., Simões-Lopes, P. C. & Le Bas, A. (2020). A note on minke whales (Cetacea: Balaenopteridae) in Uruguay: strandings review. *Journal of Cetacean Research and Management, 21*, 135-140.

Kilpatrick, C. W. (2002). Noncryogenic preservation of mammalian tissues for DNA extraction: an assessment of storage methods. *Biochemical Genetics, 40*(1-2), 53-62. https://doi.org/10.1023/A:1014541222816

Laws, R. M. (1977). Seals and whales of the Southern Ocean. *Philosophical Transactions of the Royal Society of London Series B, 279*(963), 81-96. https://www.jstor.org/stable/2417753

Lenz, A. J., Avens, L., & Martins, M. B. (2017). Age and growth of juvenile green turtles *Chelonia mydas* in South Atlantic Ocean. *Marine Ecology Progress Series, 568*, 191-201. https://doi.org/10.3354/meps12056

Lima, E. C. C. (2020). A note on strandings of Bryde's whales (*Balaenoptera edeni*) in the southwestern Atlantic. *Journal of Cetacean Research and Management, 21*, 9-15.

Lucena, A. (2006). Estrutura populacional da *Balaenoptera bonaerensis* (Burmeister) (Cetacea, Balaenopteridae) nas áreas de reprodução do Oceano Atlântico Sul. *Revista Brasileira de Zoologia, 23*(1), 176-185.

Milmann, L., Machado, R., Sucunza, F., Oliveira, L. R., Santos, R. A., Di Beneditto, A. P. M., Rezende, C. R., Baumgarten, J., & Ott, P. H. (2018). New trophic link and potential feeding area of dwarf minke whale (*Balaenoptera acutorostrata* subsp.) in mid latitude waters of the southwestern Atlantic Ocean. *Mammalia, 83*(1), 49-52. https://doi.org/10.1515/mammalia-2017-0127

Milmann, L., Siciliano, S., Morais, I. O. B., Tribulato, A. S., Machado, R., Zerbini, A., Baumgarten, J., & Ott P. H. (2020). A review of *Balaenoptera* strandings along the east coast of South America. *Regional Studies in Marine Sciences, 37*, 101343. https://doi.org/10.1016/j.rsma.2020.101343

Milmann, L., Taguchi, M., Siciliano, S., Baumgarten, J., Oliveira, L. R., Valiati, V. H., Goto, M., & Pastene, L. A. (2021). New genetic evidences for distinct populations of the common minke whale (*Balaenoptera acutorostrata*) in the Southern Hemisphere. *Polar Biology, 44*, 1575-1589. https://doi.org/10.1007/s00300-021-02897-2

Moore, M. J., Berrow, S. D., Jensen, B. A., Carr, P., Sears, R., Rowntree, V. J., Payne, R., & Hamilton, P. K. (1999). Relative abundance of large whales around South Georgia (1979-1998). *Marine Mammal Science, 15*(4), 1287-1302. https://doi.org/10.1111/j.1748-7692.1999.tb00891.x

Moore, M. J., Mitchell, G. H., Rowles, T. K., & Early, G. (2020). Dead cetacean? Beach, bloat, float, sink. *Frontiers in Marine Science, 7*, 333. https://doi.org/10.3389/fmars.2020.00333

Moreira, S. C., Weksler, M., Sousa-Lima, R. S., Maia, M., Sukhovich, A., Royer, J. Y., Marcondes, M. C. C., & Cerchio, S. (2020). Occurrence of Omura's whale, *Balaenoptera omurai* (Cetacea: Balaenopteridae), in the Equatorial Atlantic Ocean based on Passive Acoustic Monitoring. *Journal of Mammalogy, 101*(6), 1727-1735. https://doi.org/10.1093/jmammal/gyaa130

Moura, J. F., & Siciliano, S. (2012). Stranding pattern of Bryde's whales along the south-eastern coast of Brazil. *Marine Biodiversity Records, 5*, e73. https://doi.org/10.1017/S1755267212000528

Norris, K. S. (1961). Standardized methods for measuring and recording data on the smaller cetaceans. *Journal of Mammalogy, 42*(4), 471-476. https://doi.org/10.2307/1377364

Ott, P. H., Milmann, L., Santos, M. C. O., Rogers, E. M., Rodrigues, D. P., & Siciliano, S. (2009). *Humpback whale breeding stock "A": increasing threats to a recently down-listed species off Brazilian fauna* (Publication No. IWC/SC/66b/SH/04). International Whaling Commission.

Ott, P. H., Tavares, M., Secchi, E. R., & Di Tullio, J. C. (2013). Cetacea. In M. M. Weber, C. Roman, C., & N. C. Cáceres (Eds.), *Mamíferos do Rio Grande do Sul* (pp. 457-533). Editora Universidade Federal de Santa Maria.

Pastene, L. A., Goto, M., Kanda, N., Zerbini, A. N., Kerem, D., Watanabe, K., Bessho, Y., Hasegawa, M., Nielsen, R., Larsen, F., & Palsbøll, P. J. (2007). Radiation and speciation of pelagic organisms during periods of global warming: the case of the common minke whale, *Balaenoptera acutorostrata. Molecular Ecology, 16*(7), 1481-1495. https://doi.org/10.1111/j.1365-294X.2007.03244.x

Pastene, L. A., Acevedo, J., Goto, M., Zerbini, A. N., Acuña, P., & Aguayo-Lobo, A. (2009). Population structure and possible migratory links of common minke whales, *Balaenoptera acutorostrata*, in the Southern Hemisphere. *Conservation Genetics, 11*(4), 1553-1558. https://doi.org/10.1007/s10592-009-9944-7

Pastene, L. A., Acevedo, J., Siciliano, S., Sholl, T. G. C., Moura, J. F., Ott, P. H., & Aguayo-Lobo, A. (2015). Population genetic structure of the South American Bryde's whale. *Revista de Biologia Marinha e Oceanografia, 50*, 453-464.

Pinheiro, F. C. F., Siciliano, S., Moura, J., & Tavares, D. C. (2015). Severe mutilation of a baleen whale in a longline fishery off the Brazilian coast. *Marine Biodiversity Records, 8*, e129. https://doi.org/10.1017/S175526721500041X

Prado, J. H. F., Secchi, E. R., & Kinas, P. G. (2013). Mark-recapture of the endangered franciscana dolphin (*Pontoporia blainvillei*) killed in gillnet fisheries to estimate past bycatch from time series of stranded carcasses in southern Brazil. *Ecological Indicators, 32*, 35-41. https://doi.org/10.1016/j.ecolind.2013.03.005

Prado, J. H. F., Mattos, P. H., Silva, K. G., & Secchi, E. R. (2016). Long-term seasonal and interannual patterns of marine mammal strandings in subtropical western South Atlantic. *PLoS ONE, 11*, e0146339. https://doi.org/10.1371/journal.pone.0146339

Risch, D., Norris, T. F., Curnock, M., & Friedlaender, A. S. (2019). Common and Antarctic minke whales: Conservation status and future research directions. *Frontiers in Marine Science, 6*, 247. https://doi.org/10.3389/fmars.2019.00247

Rocha-Campos, C. C., & Câmara, I. G. (2011). *Plano de ação nacional para conservação dos mamíferos aquáticos: grandes cetáceos e pinípedes* (3rd ed.). Instituto Chico Mendes de Conservação da Biodiversidade.

Roman, L., Schuyler, Q., Wilcox, C., & Hardesty, B. D. (2021). Plastic pollution is killing marine megafauna, but how do we prioritize policies to reduce mortality? *Conservation Letters, 14*(2), e12781. https://doi.org/10.1111/conl.12781

Rosel, E.P., Wilcox, L.A., Yamada, T.K., & Mullin, K.D. (2021). A new species of baleen whale (*Balaenoptera*) from the Gulf of Mexico, with a review of its geographic distribution. *Marine Mammal Science, 37*(2), 577-610. https://doi.org/10.1111/mms.12776

Rossi-Santos, M. R., Filun, D., Soares-Filho, W., Paro, A. D., & Wedekin, L. L. (2022). "Playing the beat": Occurrence of Bio-duck calls in Santos Basin (Brazil) reveals a complex acoustic behaviour for the Antarctic minke whale (*Balaenoptera bonaerensis*). *PLoS ONE, 17*(9), e0255868. https://doi.org/10.1371/journal.pone.0255868

Sambrook, J., Fritsch, E. F., & Maniatis, T. (1989). *Molecular cloning: a laboratory manual* (2 ed.). Cold Spring Harbor Laboratory Press.

Santos, M. C. O., Siciliano, S., Vicente, A. F. C., Alvarenga, F., Zampirolli, E., Souza, S. P., & Maranho, A. (2010). Cetacean records along São Paulo state coast, southeastern Brazil. *Brazilian Journal of Oceanography, 58*(2), 123-142.

Secchi, E. R., Barcellos, L., Zerbini, A. N., & Dalla-Rosa, L. (2003). Biological observations on a dwarf minke whale, *Balaenoptera acutorostrata*, caught in southern Brazilian waters, with a new record of prey for the species. *Latin American Journal of Aquatic Mammals, 2*(2), 109-115. https://doi.org/10.5597/lajam00039

Seeliger, U., & Odebrecht, C. (1998). Introdução e aspectos gerais. In U. Seeliger, C. Odebrecht, & J. P. Castello (Eds.). *Os Ecossistemas Costeiro e Marinho do Extremo Sul do Brasil* (pp. 1-5). Ecoscientia.

Sholl, T. G. C., Moura, J. F.., Ott, P. H., Bonvicino, C. R., Reis, E. C., Tavares, D. C., & Siciliano, S. (2013). Cytochrome *b* sequencing for the species identification of whale carcasses washed ashore in Brazil. *Marine Biodiversity Records, 6*, e30. https://doi.org/10.1017/S1755267212001157

Siciliano, S., Santos, C. O. M., Vicente, A. F. C., Alvarenga, F. S., Zapirolli, E., Brito Jr, J. L., Azevedo, A. F., & Pizzorno, J. L. A. (2004). Strandings and feeding records of Bryde's whales (*Balaenoptera edeni*) in south-eastern Brazil. *Journal of the Marine Biology Association UK, 84*(4), 857-859. https://doi.org/10.1017/S0025315404010082h

Siciliano, S., Emin-Lima, N. R., Costa, A. F., Rodrigues, A. L. F., Magalhães, F. A., Tosi, C. H., Garri, R. G., Silva, C. R., & Silva Jr, J. S. (2008). Revisão do conhecimento sobre os mamíferos aquáticos da costa norte do Brasil. *Arquivos do Museu Nacional, 66*(2), 1-21.

Siciliano, S., Moura, J. F., Emin-Lima, R., Arcoverde, D. L., Souza, M. E. M., Martins, B. M. L., Silva Jr, J. S., Tavares, M., Santos, M. C. O., & Ott, P. H. (2011). *Large baleen whales on the coast of Brazil: a review of post-1997 data on strandings and sightings* (Publication No. IWC/ SC/63/SH2). International Whaling Commission.

Silveira, I. C. A., Schmidt, A. C. K., Campos, E. J. D., Godoi, S. S., & Ikeda, Y. (2000). A Corrente do Brasil ao largo da costa leste brasileira. *Revista Brasileira de Oceanografia, 48*(2), 171-183.

Simões-Lopes, P. C., & Ximenez, A. (1993). Annotated list of the cetaceans of Santa Catarina coastal waters, southern Brazil. *Biotemas, 6*(1), 67-92.

Southall, B. L., Finneran, J. J., Reichmuth, C., Natchtigall, P. E., Ketten, D. R., Bowles, A. E., Ellison, W. T., Nowacek, D. P., & Tyack, P. L. (2019). Marine mammal noise exposure criteria: updated scientific recommendations for residual hearing effects. *Aquatic Mammals, 45*(2), 125-232. https://doi.org/10.1578/AM.45.2.2019.125

Tardin, R. H., Chun, Y., Simão, S. M., & Alves, M. A. S. (2017). Modeling habitat use by Bryde's whale *Balaenoptera edeni* off southeastern Brazil. *Marine Ecology Progress Series, 576*, 89-103. https://doi.org/10.3354/meps12228

Van Waerebeek, K., Baker, A. N., Félix, F., Gedamke, J., Iñiguez, M., Sanino, G. P., Secchi, E., Sutaria, D., van Helden, A., & Wang, Y. (2007). Vessel collisions with small cetaceans worldwide and with large whales in the Southern Hemisphere, and initial assessment. *Latin American Journal of Aquatic Mammals, 6*(1), 43-69. https://doi.org/10.5597/lajam00109

Wada, S., Oishi, M., & Yamada, K. (2003). A newly discovered species of living baleen whale. *Nature, 426*, 278-281. https://doi.org/10.1038/nature02103

Zerbini, A. N., Secchi, E. R., Siciliano, S., & Simões-Lopes, P. C. (1996). *The dwarf form of the minke whale,* Balaenoptera acutorostrata *Lacépède 1804, in Brazil* (Publication No. IWC/ SC/47/SH18). International Whaling Commission.

Zerbini, A. N., Secchi, E. R., Siciliano, S., & Simões-Lopes, P. C. (1997). *A review of the occurrence and distribution of whales of the genus* Balaenoptera *along the Brazilian Coast* (Publication No. IWC/ SC/48/SH4). International Whaling Commission.

Zerbini, A. N., Secchi, E. R., Bassoi, M., Dalla Rosa, L., Higa, A., Souza, L., Moreno, I. B., Möller, L. M., & Caon, G. (2004). *Distribuição e abundância na Zona Econômica Exclusiva da região sudeste-sul do Brasil.* Instituto Oceanográfico - USP.