OCCURRENCE, DISTRIBUTION, AND MORTALITY OF SEABIRDS IN SOUTH AND SOUTHEAST BRAZIL, 2015–2019

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ABSTRACT

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We compiled data on seabirds that use coastal and coastal/oceanic habitats, recorded alive and dead, during four years of beach monitoring in Santa Catarina, Paraná, and São Paulo states, along Brazil's south and southeast coast. This is a pioneering study, as no previous studies of this magnitude have been done in Brazil. Among the 26,900 individuals collected, 45 species were identified, distributed across four orders: Charadriiformes (29 species), Pelecaniformes (12 species), Sphenisciformes (one species), and Suliformes (three species). We determined maturity and sex for the five most abundant species: Magellanic Penguin *Spheniscus magellanicus*, Kelp Gull *Larus dominicanus*, Brown Booby *Sula leucogaster*, Neotropic Cormorant *Nannopterum brasilianum*, and Magnificent Frigatebird *Fregata magnificens*. The penguin tally was the only one dominated by young individuals (93.24%). Concerning sex, *S. magellanicus* and *L. dominicanus* were predominantly female, with 76.64% and 53.36%, respectively, while males were more frequent in *S. leucogaster* (56.21%), *N. brasilianum* (59.42%), and *F. magnificens* (55.86%). The continuation of monitoring activities will be essential for tracking cyclical patterns of seabird species occurrence and composition of coastal and marine environments in the study area.

Key words: Charadriiformes, Pelecaniformes, seabirds, Sphenisciformes, Suliformes, South America

INTRODUCTION

Knowledge of seabird occurrence in Brazil comes mainly from observation of debilitated or dead individuals stranded along the coast, from specific studies to monitor populations that occur or reproduce on oceanic islands and, in a few cases, from observations in the open sea (Mariani, 2016; Mariani et al., 2019; Petry & Fonseca, 2002; Petry et al., 2012).

According to the latest update of the Brazilian Committee for Ornithological Records in 2015, 1,919 recognized bird species have been found in Brazil, including residents and seasonal or accidental visitors (Piacentini et al., 2015). Of these, a little more than 8% are seabirds, comprising a total of nine orders, 29 families, and 148 species (Vooren & Brusque, 1999).

The high productivity of marine ecosystems maintains a wide variety of bird species (Branco, 2004; Sick, 2001). According to Schreiber and Burger (2001), seabirds are considered to be those birds that inhabit or depend on the resources available in such an ecosystem, including coastal zones, estuaries, oceans, and oceanic islands. Oceanic species seek land only during the reproductive period, when they gather mainly on islands (Brooke, 2004). Coastal birds are found mainly along beaches, living between land and sea, while estuarine birds are concentrated in the transition area between the freshwater and marine environment (Schreiber & Burger, 2001; Sick, 2001).

Anthropogenic activities affect the marine environment (Paleczny et al., 2015). For seabirds, previous works have emphasized the

effects of fishing, sea pollution, exotic species introductions on islands, and nesting site degradation, causing several species of birds to currently be at risk of extinction (International Union for Conservation of Nature [IUCN], 2025). Thus, seabirds can be considered "biomonitors" of the ecosystems they inhabit. By monitoring seabirds over time, it is possible to better understand changes in fish stocks and pollution in the marine ecosystem (Furness & Camphuysen, 1997).

Another way to monitor seabirds is through beach survey programs. Since mid-2015, a large-scale project has been underway along beaches in southeastern and southern Brazil. The Santos Basin Beach Monitoring Project (Projeto de Monitoramento de Praias da Baía de Santos, PMP-BS) is required by IBAMA, the Brazilian Institute of Environment and Renewable Natural Resources (a Brazilian Environmental Ministry agency), for the environmental licensing of oil and gas extraction and transport in offshore waters of the Santos Basin. The latter is conducted by Petrobras, the largest oil company operating in the area. Given the richness of data generated by the PMP-BS and the need to increase the knowledge of marine species in this region, the present study aims to compile information on occurrence of coastal and coastal/oceanic species by recording numbers of live and dead seabirds during four years of monitoring.

METHODS

Data were collected between September 2015 and August 2019 within the stretch of coast lying between the municipalities of Laguna, in Santa Catarina state (28°28′24.6″S, 048°47′02.9″W), and Ubatuba, in São Paulo state (23°26′00.4″S, 045°05′48.9″W) (Fig. 1). Live and dead birds were recorded daily through beach monitoring by the PMP-BS field teams at 361 beaches spanning 1,040.49 km (Petrobras, 2023).

Seabirds were classified according to the habitat most used by each species: coastal, oceanic, and coastal/oceanic. For this study, we report only coastal and coastal/oceanic birds, as oceanic species patterns have been discussed elsewhere (Barreto et al., 2019; Ferreira et al., 2017).

Live birds were forwarded to rehabilitation centers for treatment, while dead ones were identified and either taken to the laboratory for necropsy or buried to avoid a double count. All carcasses were categorized from Code 2 (fresh carcass) to Code 5 (mummified or skeletal remains) following an adaptation of the scale proposed by Geraci and Lounsbury (2005).

Maturity and sex were determined by necropsy and/or external dimorphisms when possible. In this study, data for maturity and sex are reported only for the five most abundant species. Carcasses

Fig. 1. Map of south and southeast Brazil showing the study area, from Laguna (bottom of the map) to Ubatuba (top of the map).

with Codes 4 and 5 usually are in poor condition and could not always be examined. Thus, data from these animals were discarded to increase reliability.

The sex ratios and age classes were compared for the expected frequency of 1:1 using a chi-square test, run in BioEstat5.0 software.

RESULTS

During the four years of monitoring, 26,900 individuals were collected. Species identification was possible for 98.51% of all birds, whereas 0.99% could only be identified at genus, 0.13% at family, and 0.37% at order levels. Overall, 45 species were recognized, distributed across four orders (Table 1). Charadriiformes was the order with the most species (n = 29), followed by Pelecaniformes (n = 12), Suliformes (n = 3), and Sphenisciformes, with only one species.

Despite having the highest species richness, Charadriiformes had a high dominance of Kelp Gulls *Larus dominicanus* (76.48%), recorded throughout all years (Table 2). The remaining species in this group totaled 925 individuals. The Red Knot *Calidris canutus* was absent in 2019; the Sanderling *C. alba*, South Polar Skua *Stercorarius maccormicki*, Pomarine Jaeger *S. pomarinus*, and Greater Yellowlegs *Tringa melanoleuca* were absent in 2018; and the Brown-hooded Gull *Chroicocephalus maculipennis* and Snowy-crowned Tern *Sterna trudeaui* were absent in 2016. Some species were recorded only in one year: Grey-headed Gull *Chroicocephalus cirrocephalus* and Solitary Sandpiper *T. solitaria* in 2015, Grey Plover *Pluvialis squatarola* and Sabine's Gull *Xema sabini* in 2016, and Pantanal Snipe *Gallinago paraguaiae* and Olrog's Gull *L. atlanticus* in 2017.

Pelecaniformes included just 168 individuals, with the most common being *Ardea alba* (n = 42), Snowy Egret *Egretta thula* (n = 38), Black-crowned Night Heron *Nycticorax nycticorax* (n = 29), and Cocoi Heron *A. cocoi* (n = 18). The Whistling Heron *Syrigma sibilatrix* was recorded only in the second year. The Bare-faced Ibis *Phimosus infuscatus* was absent in the second year, and the Western Cattle Egret *Ardea ibis* and Little Blue Heron *E. caerulea* were absent in the last year. Survey teams occasionally found terrestrial species, but as they were not target species for monitoring, they were only occasionally collected and are not discussed here.

Among the Sulidae, the Brown Booby *Sula leucogaster* made up 57.66% of records, followed by the Neotropic Cormorant *Nannopterum brasilianum* and Magnificent Frigatebird *Fregata magnificens*, with 22.44% and 18.70%, respectively.

Although represented by a single species, Sphenisciformes had the most records, with 18,901 individuals of Magellanic Penguins *Spheniscus magellanicus* present across all the years, mainly in winter months.

Live birds represented only 13.97% (n = 3,758) of all birds sampled, with *L. dominicanus* the most frequent (n = 1,452), followed by *S. magellanicus* (n = 897) (Fig. 2). These animals were taken to rehabilitation centers. During treatment, 63.55% died, and 36.45% were rehabilitated and released. Among the most abundant species, *L. dominicanus* was the species with best release success (47.38%), while *S. magellanicus* had the least success (23.24%).

Dead animals represented 86.03% (n = 23,142) of all birds sampled and were found in different decomposition stages. Carcasses in advanced decomposition (Code 4) represented 58.03% of all birds sampled, whereas fresh carcasses (Code 2) were only 5.53%. Animals found mummified or only as skeletal remains (Code 5) had a high percentage of no identification, apart from Sphenisciformes, which had 100% of its individuals identified, independently of decomposition code. Charadriiformes had the most individuals identified only at the genus level (71.88%) (Fig. 3), with the *Sterna* and *Stercorarius* genera representing, respectively, 39.71% and 16.52% of unidentified specimens.

Considering the classification by Piacentini et al. (2015), our records were of 28 residents and 17 migratory species in Brazil, of which four are seasonal visitors from southern South America (VS) and 12 from the Northern Hemisphere (VN). *Xema sabini* is a vagrant species [(VA)N], with irregular occurrence in Brazil.

The Common Tern *Sterna hirundo* (n = 80) was the most abundant species originating from the Northern Hemisphere, whereas *Spheniscus magellanicus* (n = 18,901) was the most abundant coming from southern South America; they were also the most abundant of all migratory species. Other visitors had lower occurrences, contributing 96 individuals, varying from one to 15 individuals per species. Three visitor species were recorded only once throughout the study: *Tringa solitaria* in April 2016, *Pluvialis squatarola* in October 2016, and *Xema sabini* in March 2017, all of them nesting in the Northern Hemisphere.

There was a decrease in species richness over the first three of the four study years: from 38 to 35 to 33 species. The state with the most occurrences and highest species richness was Santa Catarina, with 16,884 specimens (62.77%) and 38 species, respectively (Table 3).

We analyzed the five most abundant species (*Spheniscus magellanicus*, *L. dominicanus*, *Sula leucogaster*, *Nannopterum brasilianum*, and *F. magnificens*) for maturity and sex (Table 4); together, these species represented 95.76% of all records. Maturity and sex were determined for 29.30% and 18.73%, respectively, of individuals overall. Apart from *Spheniscus magellanicus*, with 93.24% being juveniles, the other four species were mainly adults. Relative to sex, *S. magellanicus* and *L. dominicanus* had higher frequencies of females, 76.64% and 53.36%, respectively. *Sula leucogaster*, *N. brasilianum*, and *F. magnificens* had a higher occurrence of males, 56.21%, 59.42%, and 55.86%, respectively.

DISCUSSION

Despite the massive number of birds recorded during this study, these are minimum numbers. Dead specimens can be underestimated due to scavenger action, tide variation, and beach cleaning in urbanized areas. Body size may also influence carcass detection since smaller birds (e.g., *Calidris alba*, White-rumped Sandpiper *C. fuscicollis*, and *T. melanoleuca*) were less frequently recorded (Ford, 2006).

Low records for Pelecaniformes likely resulted from these species predominantly inhabiting wetland areas rather than waters off beaches (Sick, 2001). Indeed, our monitoring efforts were not in areas where there would be higher densities of the group.

TABLE 1
Species and abundance of coastal and coastal/oceanic seabirds collected during beach surveys, sorted by state[a]

	Status	São Paulo	Paraná	Santa Catarina	Total
Charadriiformes					**3,932**
Anarhynchus collaris	R	2	-	-	2
Calidris alba	VN	4	1	6	11
Calidris canutus	VN	1	-	4	5
Calidris fuscicollis	VN	1	1	4	6
Charadrius semipalmatus	VN	2	4	1	7
Chroicocephalus cirrocephalus	R	-	-	1	1
Chroicocephalus maculipennis	R	-	1	2	3
Gallinago paraguaiae	R	-	-	1	1
Haematopus palliatus	R	-	-	22	22
Himantopus melanurus	R	-	-	23	23
Larus atlanticus	R	-	-	1	1
Larus dominicanus	R	284	214	2,509	3,007
Pluvialis dominica	VN	3	3	-	6
Pluvialis squatarola	VN	-	1	-	1
Rynchops niger	R	8	6	31	45
Stercorarius antarcticus	VS	6	2	1	9
Stercorarius chilensis	VS	3	4	5	12
Stercorarius longicaudus	VN	3	-	2	5
Stercorarius maccormicki	VS	4	-	3	7
Stercorarius parasiticus	VN	2	5	8	15
Stercorarius pomarinus	VN	3	2	1	6
Sterna hirundinacea	R	46	10	96	152
Sterna hirundo	VN	16	8	56	80
Sterna trudeaui	R	1	-	9	10
Thalasseus acuflavidus	R	44	21	60	125
Thalasseus maximus	R	11	3	5	19
Tringa melanoleuca	VN	1	-	3	4
Tringa solitaria	VN	1	-	-	1
Xema sabini	(VA)N	-	-	1	1
Unidentified	-	46	30	269	345
Pelecaniformes					**168**
Ardea alba	R	29	7	6	42
Ardea cocoi	R	14	1	3	18
Ardea ibis	E	4	1	-	5
Botaurus exilis	R	2	-	-	2
Botaurus pinnatus	R	2	-	-	2
Butorides striata	R	4	-	3	7
Egretta caerulea	R	3	-	1	4
Egretta thula	R	20	5	13	38
Nyctanassa violacea	R	1	4	1	6
Nycticorax nycticorax	R	20	6	3	29
Phimosus infuscatus	R	-	3	2	5
Syrigma sibilatrix	R	1	-	1	2
Unidentified	-	3	2	3	8
Sphenisciformes					**18,901**
Spheniscus magellanicus	VS	3,199	3,486	12,216	18,901
Suliformes					**3,899**
Fregata magnificens	R	293	143	293	729
Nannopterum brasilianum	R	153	172	550	875
Sula leucogaster	R	1,213	386	649	2,248
Unidentified	-	28	3	16	47
Total		**5,481**	**4,535**	**16,884**	**26,900**

[a] Initials after species name indicate occurrence status of species for Brazil. VS: seasonal visitors from South America; VN: seasonal visitors from North Hemisphere; (VA)N: vagrant species with irregular occurrence, coming from the north (may be a regular migrant in neighboring countries); R: resident species; E: exotic species.

TABLE 2
Distribution of species by season and year of study, sorted alphabetically by order[a,b]

	Year 1				Year 2				Year 3				Year 4			
	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN	SPR	SUM	AUT	WIN
Charadriiformes																
Anarhynchus collaris	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-
Calidris alba	-	-	5	-	2	-	2	-	-	-	-	-	1	-	1	-
Calidris canutus	-	-	3	-	-	-	1	-	-	-	1	-	-	-	-	-
Calidris fuscicollis	-	-	2	-	2	-	-	-	-	1	-	-	-	1	-	-
Charadrius semipalmatus	-	-	3	-	1	1	-	-	-	1	-	-	-	1	-	-
Chroicocephalus cirrocephalus	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Chroicocephalus maculipennis	-	-	1	-	-	-	-	-	-	-	-	1	-	-	-	1
Gallinago paraguaiae	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-
Haematopus palliatus	1	5	1	1	2	3	1	1	-	1	-	-	2	4	-	-
Himantopus melanurus	-	2	3	-	-	2	2	-	1	-	3	2	-	7	-	1
Larus atlanticus	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Larus dominicanus	273	237	178	67	379	190	200	98	214	194	157	67	244	201	192	116
Pluvialis dominica	-	1	-	-	4	1	-	-	-	-	-	-	-	-	-	-
Pluvialis squatarola	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-
Rynchops niger	2	4	3	4	3	5	6	-	-	3	4	2	1	5	2	1
Stercorarius antarcticus	-	-	3	-	3	-	-	-	-	-	1	-	1	-	1	-
Stercorarius chilensis	-	-	2	-	2	1	1	-	1	-	-	2	-	-	-	3
Stercorarius longicaudus	1	1	-	-	-	-	1	-	-	-	1	-	-	1	-	-
Stercorarius maccormicki	1	-	1	-	1	-	1	1	-	-	-	-	1	-	1	-
Stercorarius parasiticus	3	2	-	-	1	1	1	-	-	1	1	-	1	3	1	-
Stercorarius pomarinus	-	1	-	-	1	-	1	-	-	-	-	-	2	-	1	-
Sterna hirundinacea	42	3	-	8	11	-	3	11	6	-	2	24	8	1	3	30
Sterna hirundo	18	7	2	2	7	-	-	2	4	2	-	14	11	2	2	7
Sterna trudeaui	3	-	-	-	-	-	-	-	-	-	-	1	1	-	-	5
Thalasseus acuflavidus	33	16	6	3	3	6	15	8	1	6	4	6	7	5	3	3
Thalasseus maximus	2	2	-	-	-	1	-	3	1	-	4	4	-	-	1	1
Tringa melanoleuca	-	1	1	-	-	-	1	-	-	-	-	-	1	-	-	-
Tringa solitaria	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-
Xema sabini	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-
Unidentified	125	37	15	5	33	15	8	6	12	4	5	18	24	6	8	24
Pelecaniformes																
Ardea alba	1	3	4	8	-	1	6	1	1	1	2	4	2	7	1	-
Ardea cocoi	-	3	-	-	-	1	4	1	1	1	2	2	-	3	-	-
Ardea ibis	-	-	1	-	1	-	-	-	-	1	-	2	-	-	-	-
Botaurus exilis	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-
Botaurus pinnatus	-	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-
Butorides striata	-	1	1	-	2	-	-	-	-	1	1	-	-	1	-	-
Egretta caerulea	1	-	-	-	-	-	-	1	-	2	-	-	-	-	-	-
Egretta thula	-	2	5	4	5	1	1	3	1	2	6	-	2	3	3	-
Nyctanassa violacea	-	-	-	-	-	-	-	-	-	-	-	1	1	4	-	-
Nycticorax nycticorax	1	-	2	-	1	3	2	-	1	4	4	1	-	5	5	-
Phimosus infuscatus	-	-	1	-	-	-	-	-	-	-	-	2	1	-	-	1
Syrigma sibilatrix	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-
Unidentified	2	-	-	-	-	1	1	-	-	1	1	2	-	-	-	-
Sphenisciformes																
Spheniscus magellanicus	1259	39	16	830	957	17	13	1059	91	63	11	5558	6352	12	9	2615
Suliformes																
Fregata magnificens	106	100	46	41	49	43	22	24	34	19	22	44	94	37	12	36
Nannopterum brasilianum	75	32	12	15	372	105	56	19	18	16	8	33	56	14	12	32
Sula leucogaster	197	143	93	98	201	111	240	118	113	70	116	162	268	104	80	134
Unidentified	6	1	1	3	4	3	4	4	3	2	2	6	3	1	-	4

[a] The more intense the red color, the higher the occurrence of the species in each season, SPR (Spring: September–November), SUM (Summer: December–February), AUT (Autumn: March–May), and WIN (Winter: June–August).

[b] The study years were Year 1, 2015/16; Year 2, 2016/17; Year 3, 2017/18; and Year 4, 2018/19.

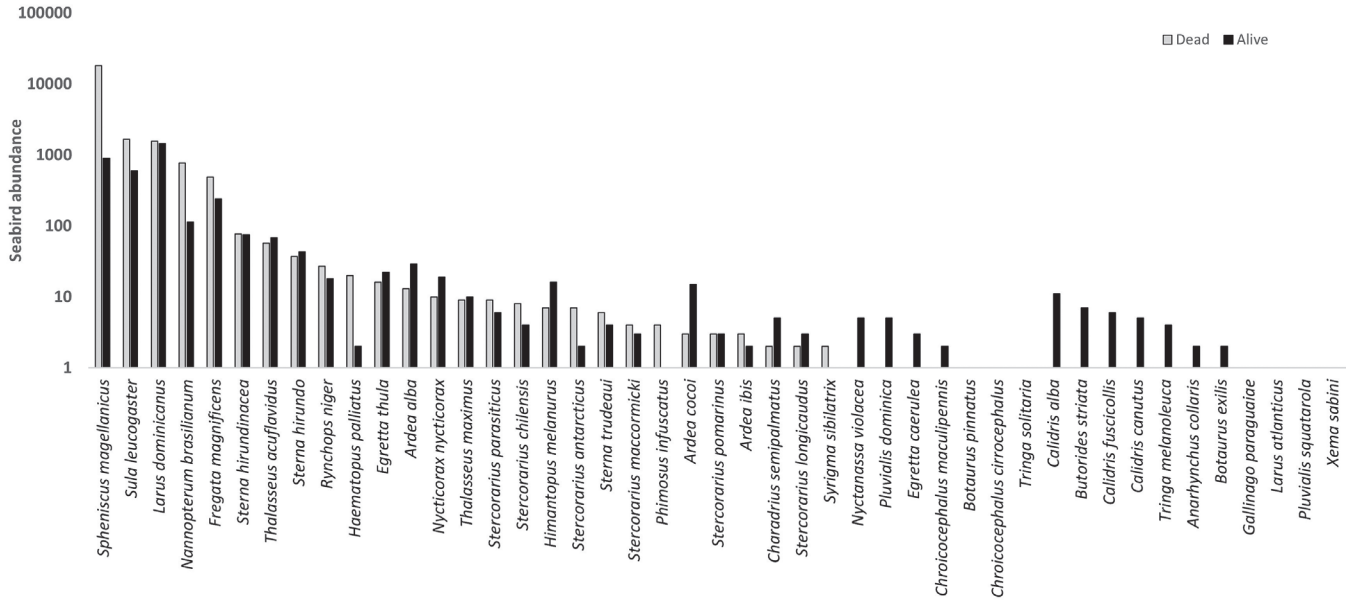

Fig. 2. Abundance of coastal and coastal/oceanic seabirds collected during beach surveys, separated according to their condition (dead or alive) when collected. Note that y-axis is logarithmic.

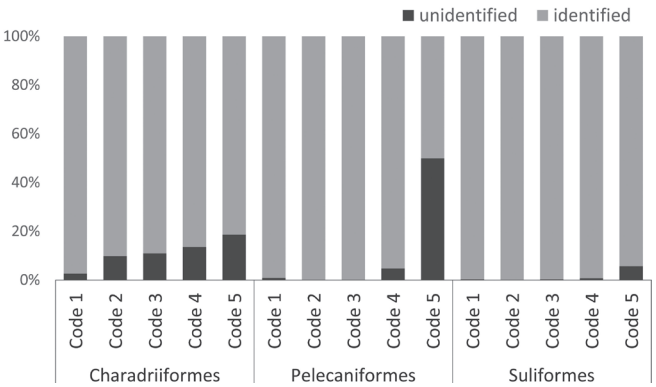

Fig. 3. Percentage of identified and unidentified individuals of each order, according to decomposition code. Code 1: Live animal, Code 2: Fresh carcass, Code 3: Carcass in moderate decomposition, Code 4: Carcass in advanced decomposition, and Code 5: Carcass mummified or skeletal remains.

Apart from penguins, which have quite evident diagnostic characteristics, carcass decomposition influenced species identification, as expected. This emphasizes the importance of daily monitoring to collect carcasses as soon as they arrive at beaches. Doing so increasing the chance of collecting more biological data. In the present study, beaches were surveyed daily, so the high frequency of decomposed carcasses indicates that they had died farther ashore and took some time to arrive at the beaches.

Spheniscus magellanicus stranded along all four years, with a decreasing trend from south (Santa Catarina) to north (São Paulo). This pattern confirms its well-known occurrence as a seasonal visitor from southern South America (García-Borboroglu et al., 2010; Mäder et al., 2010; Scherer et al., 2011).

The incidence of predominantly juvenile penguins is the result of dispersion. The Brazilian coast is visited by juveniles just after fledging, with adults tending to remain closer to colonies between Argentina and Uruguay (Garcia-Borboroglu et al., 2006). Divergences in foraging patterns between males and females have been studied (Marques et al., 2018; Yamamoto et al., 2019) and show that females forage in shallower waters than males and reach lower latitudes, being dominant along the Brazilian coast (Marques et al., 2018; Nunes et al., 2015; Vanstreels et al., 2013; Yamamoto et al., 2019; present study). Therefore, the non-breeding season is critical for juvenile survival, mainly for females (Stokes et al., 2014; Vanstreels et al., 2013). Our results suggest that efforts

TABLE 3
Abundance and richness of seabird species in each state in southern and southeastern Brazil, over the study years[a,b]

States	Year 1		Year 2		Year 3		Year 4		TOTAL	
	***n* ind**	***n* spp**	***n* ind**	***n* spp**	***n* ind**	***n* spp**	***n* ind**	***n* spp**	***n* ind**	***n* spp**
Santa Catarina	2,955	30	3,379	22	4,756	22	5,794	10	**16,884**	**38**
Paraná	334	14	503	18	822	17	2,876	18	**4,535**	**27**
São Paulo	1,010	24	635	27	1,640	22	2,196	22	**5,481**	**36**
TOTAL	**4,299**	**38**	**4,517**	**35**	**7,218**	**33**	**10,866**	**33**	**26,900**	**45**

[a] Species abundance is reported as number of individuals (*n* ind), and species richness is reported as number of species (*n* spp).
[b] The study years were Year 1: 2015/16, Year 2: 2016/17, Year 3: 2017/18, and Year 4: 2018/19.

TABLE 4
Maturity and sex of individuals of the five most abundant species, indicating the number of individuals where sex and maturity were determined[a]

Species[b]	Sex			Maturity		
	Female	Male	Examined (% of sample)	Adult	Juvenile	Examined (% of sample)
S. magellanicus	1,768*	539	2,307 (12.21)	264	3,641*	3,905 (20.66)
L. dominicanus	579*	506	1,085 (36.08)	1,278*	654	1,932 (64.25)
S. leucogaster	395	507*	902 (40.12)	720*	386	1,106 (49.20)
N. brasilianum	84	123*	207 (23.66)	159*	89	248 (28.34)
F. magnificens	143	181*	324 (44.44)	284*	73	357 (48.97)

[a] '*' indicates a significant difference (chi-square test, $p < 0.05$).

[b] Species listed are Magellanic Penguin *Spheniscus magellanicus*, Kelp Gull *Larus dominicanus*, Brown Booby *Sula leucogaster*, Neotropic Cormorant *Nannopterum brasilianum*, and Magnificent Frigatebird *Fregata magnificens*.

need to be taken to minimize female-biased mortality, as it could increase a male-biased sex ratio in the population. As this species has monogamous habits and biparental care, this female-biased mortality could be contributing to population declines apparent in some breeding locations (Gownaris & Boersma, 2019). For instance, data collected since 1987 at the main colony of *S. magellanicus*, in Punta Tombo, Argentina, showed a population decline of over 40%. So, to ensure species conservation, a better understanding of metapopulation dynamics is essential.

The dominance of *L. dominicanus* among resident species may result from its high local abundance, with colonies in Brazil being slightly behind Argentina (Yorio et al., 2016). A higher abundance in Santa Catarina is probably associated with more breeding sites there. São Paulo beaches exhibited a low presence as it has fewer breeding sites (Branco et al., 2009; Tavares, 2017).

Studies performed along Santa Catarina (Branco et al., 2009), Paraná (Krul, 2004), and São Paulo (Barbieri, 2008; Campos et al., 2004) report a seasonal movement of *L. dominicanus*, with birds going from beaches to breeding sites starting in April and returning from October onwards. That pattern was consistent with patterns of seasonal numerical occurrence in this study. Dantas et al. (2010) reported a 1:1 sex ratio for *L. dominicanus* on ten islands along the Brazilian coast, of which three were in São Paulo and four in Santa Catarina states. This ratio differs from our sample, with females being more frequent than males (1.14:1). However, when analyzed in smaller groups, the difference became non-significant for Santa Catarina and Paraná, exhibiting a significant difference only for São Paulo. A long-term study could help to verify if the observed ratio is dynamic or if beached animals are really biased to females.

The occurrence of more females in *Sula leucogaster* could be due to the existence of different sex-based foraging strategies (Lewis et al., 2005). Foraging closer to shore could lead to more dead females being found on beaches, even if the overall sex ratio at sea was even. The dominance of adults is clear, with a decreasing abundance southward, probably related to the presence of fewer breeding sites. Indeed, the Moleques do Sul archipelago is the most austral breeding colony in South America (Branco et al., 2010).

According to BirdLife International (2018), *Nannopterum brasilianum* is a resident species throughout South and Central America; its southernmost breeding colony is in Uruguay. A lack of studies prevents us from evaluating the causes for males' and adults' dominance in our sample.

Fregata magnificens features a particular parental care strategy in which males spend a short time in nests, whereas females remain together with their offspring for more than six months (Osorno, 1999). This pattern can contribute to males being more susceptible to stranding, explaining the males' higher presence in our sample. The dominance of adults was evidenced in all states and could be related to the presence of the two main breeding sites, the Alcatrazes and Moleques do Sul archipelagos, respectively, in São Paulo and Santa Catarina (Branco & Machado, 2011).

Even though many other studies have been done in the past in the same area, no previous studies have simultaneously sampled these three states with such an intensive effort as was and is being done by the PMP-BS. The continuity of these activities is essential for monitoring cyclical patterns of occurrence and the composition of species that use coastal and offshore environments in the south and southeast of Brazil. This study's focus species included species with diverse spatial and temporal distributions, which in most cases are poorly understood. Animals at the top of the food chain, especially birds, play an important role in coastal and marine environments and can act as biomonitors of these ecosystems. The total number of individuals sampled reflects the importance of systematic monitoring and the need to have many institutions involved in rehabilitating marine fauna.

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AUTHOR CONTRIBUTIONS

CBB: Conceptualization (lead), writing—original draft preparation (lead), writing—review & editing (lead), project administration. AMS: Conceptualization (equal), writing—original draft preparation (equal), formal analysis (lead). SBL: Writing—original

draft preparation (equal). TAB: Writing—original draft preparation (equal). GF: Writing—original draft preparation (equal), formal analysis (equal). DFG: Data curation (equal), resources (equal). HC: Data curation (equal), resources (equal). PVC: Data curation (equal), resources (equal), writing—review & editing (supporting). KRG: Data curation (equal), resources (equal). CKMK: Data curation (equal), resources (equal). JLD: Data curation (equal), resources (equal). MJC: Data curation (equal), resources (equal), writing—review & editing (supporting). CD: Data curation (equal), resources (equal), writing—review & editing (supporting). RRV: Data curation (equal), resources (equal). AM: Data curation (equal), resources (equal). MKB: Formal analysis (supporting), writing—original draft preparation (equal), writing—review & editing (equal). HG: Funding acquisition, supervision. ASB: Resources (lead), software (lead), writing—review & editing (supporting).

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