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# *Illustrious visitors to the world nature heritage: seabird strandings in the Ilha Grande bay, Rio de Janeiro, Brazil.*

Seabirds use the extensive Brazilian coast as a migratory corridor where they explore resources for food and reproduction. The south coast of the State of Rio de Janeiro has hundreds of islands that are habitats for several species of seabirds. In this study, we analyze the abundance, richness and seasonality of birds stranded in Ilha Grande Bay, Rio de Janeiro, Brazil, an important natural and cultural heritage of humanity. The stranding record data were obtained during 5 years of beach monitoring (2016-2021), a total of 18.7 km of coastline and over 220 km (including islands and beaches outside regular monitoring). Most of the birds were found alive and sent for rehabilitation. A total of 268 seabird strandings were recorded, belonging to five orders, eight families and 19 species. Most strandings occurred in winter, with the most frequent species being Spheniscus magellanicus, Fregata magnificens and Sula leucogaster. Most species are seasonally without stranding pattern, with only six species being added throughout the annual cycle. Ilha Grande Bay is an important tourist pole in Brazil and knowledge of the diversity and dynamics of seabirds in the region can contribute to species management and conservation plans, in addition to potentialize the implementation of environmental tourism objectives and sustainable exploration of natural resources.

**Palavras-chave:** Seabirds; Stranding; Wild life conservation; Mortality; Southwestern Atlantic.

# *Visitantes ilustres no patrimônio natural mundial: Encalhes de aves marinhas na Baía de Ilha Grande, Rio de Janeiro, Brasil.*

Aves marinhas usam a extensa costa brasileira como corredor migratório onde exploram recursos para alimentação e reprodução. A costa sul do Estado do Rio de Janeiro possui centenas de ilhas que são habitats para várias espécies de aves marinhas. Neste estudo, analisamos a abundância, riqueza e sazonalidade de aves encalhadas na Baía de Ilha Grande, Rio de Janeiro, Brasil, um importante patrimônio natural e cultural da humanidade. Os dados de registro de encalhe foram obtidos durante 5 anos de monitoramento de praias (2016-2021), perfazendo um total de 18,7 km de extensão da costa e mais de 220 km (incluindo ilhas e praias fora do monitoramento regular). A maioria das aves foram encontradas vivas e encaminhadas para reabilitação. Foram registrados um total de 268 encalhes de aves marinhas, pertencentes a cinco ordens, oito famílias e 19 espécies. A maioria dos encalhes ocorreram no inverno, sendo as espécies mais frequentes Spheniscus magellanicus, Fregata magnificens e Sula leucogaster. A maioria das espécies apresentaram sazonalidade no padrão de encalhes, sendo que somente seis espécies foram registradas ao longo de todo o ciclo anual. A baía de Ilha Grande é um importante polo turístico do Brasil e o conhecimento da diversidade e dinâmica das aves marinhas na região podem contribuir com planos de manejo e conservação de espécies, além de potencializar a implementação de estratégias de turismo ambiental e exploração sustentável dos recursos naturais.

**Keywords:** Aves marinhas; Encalhes; Conservação da vida selvagem; Mortalidade; Atlântico Sul.

Topic: **Conservação da Biodiversidade**

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## INTRODUCTION

The unsustainable exploration of natural resources has generated a series of threats on biodiversity in marine ecosystems around the world (OVERLAND et al., 2019; TIMMERMANS et al., 2020). Brazil has an extensive coastline, which offers a wide diversity of food resources and habitats for several species of marine tetrapods. Although most of these areas are considered of high environmental relevance and priority for conservation, marine ecosystems are under threat (TIMMERMANS et al., 2020). The decrease in biological diversity is associated with the loss of habitats, resulting from the accelerated process of coastal urbanization, bycatch, oil and gas exploration, input of pollutants and solid waste, especially plastic (RIBEIRO et al., 2012; PINHEIRO et al., 2019; MAYORGA et al., 2020).

Seabirds are highly migratory animals and in the South Atlantic they use swamps and coastal islands as corridors during seasonal movements for feeding and reproduction (SICK 1983; MARIANI et al., 2019; ZHOU et al., 2019). Seabirds are highly migratory animals and in the South Atlantic they use swamps and coastal islands as corridors during seasonal movements for feeding and reproduction (OLMOS et al., 1995; MARTUSCELLI et al., 1997; LIMA et al., 2004; PETRY et al., 2004; BUGONI et al., 2007; FARIA et al., 2014; MARIANI et al., 2019). The main causes associated with seabird strandings involve predation, anthropogenic actions, stochastic climate changes or events and the availability of food resources, which can intensify intra and interspecific competition (SCHRAG et al., 1995; DASZAK et al., 2001; HAMER et al., 2002; BELL, 2008; MARIANI et al., 2019; ZHOU et al., 2019).

Among the several of seabirds that occur in tropical regions, long the coast of Brazil, brown bobby and magnificent frigatebird have the highest population densities, with *Sula leucogaster* and *Fregata magnificens* being commonly the most frequent species in stranding records (PYENSON, 2010, 2011; PELTIER et al., 2014; MARIANI et al., 2019). Considering several seabirds nest on coastal and oceanic islands throughout the year (ALVES et al., 2000), Ilha Grande Bay, in the southern region of the State of Rio de Janeiro, is considered an important resource for feeding and reproduction, since the marine relief of the place has hundreds of islands with a highly preserved Atlantic Forest.

Data from records of seabird strandings are scarce for the Brazilian coast, and such information is potential to assess diversity, geographic distribution and seasonality, providing relevant data for the preparation of management and conservation plans for the species (PYENSON, 2010, 2011; PELTIER et al., 2014; MAYORGA et al., 2020). In this study, data referring to the monitoring of the beaches of Ilha Grande Bay, Rio de Janeiro, were used to inventory the diversity of stranded seabird fauna and the effects of seasonality on species richness and abundance.

## MATERIALS AND METHODS

### Study area

The study was carried through the analysis of seabird strandings along 23 beaches and islands of Ilha Grande Bay located in the southern region of the State of Rio de Janeiro, Brazil (Fig. 1). A total of 18.77 km

of beaches were monitored daily. All islands, coasts and beaches outside regular monitoring were analyzed through weekly on-board monitoring, which covered a total of 222.92 km.


**Figure 1:** Geographic location map of the study area showing the Ilha Grande Bay, on the coast of the State of Rio de Janeiro, Brazil.

**Fauna monitoring and recording**

Data from strandings of seabirds were analyzed referring to the monitoring of the beaches carried out for 63 months, between September 2016 and June 2021. The data used was made available to the public domain on SIMBA database (Aquatic Biota Monitoring Information System) of the Santos basin beach monitoring project (PMP-BS), the interval used in this study being performed in the stretch of the Rio de Janeiro state, by the companies CTA (19/09/2016 - 19/09/2019) and Econservation (20/09/2019 to 17/06/2021). This project was started by the company Petrobrás, as a condition imposed by the Brazilian Institute of the Environment and Renewable Natural Resources (IBAMA-Brasil) to obtain environmental licensing for the production and disposal of oil and natural gas.

The beaches analyzed were monitoring daily between 6:00 e 10:00 h, walking along its entire length, beyond regular active monitoring in the beaches, was realized wide dissemination of the 0800 Central of activations for mobilization by the passive (or indirect) monitoring method, where the population informed the location of the stranded marine animals and the team moved to carry out the rescue. Monitoring of the vessel occurred weekly and covered the entire length of the Bay off the regular monitoring, including islands, rock shore and other locations not accessible by land.

For each strand registration of seabird, the initial and final status of the stranded animal (alive or dead), conservation status and, when possible, identification of the species, sex and stage of development were recorded. The conservation status assessment was carried out based on the classification created by Geraci & Lounsbury (2005) for marine mammals, in which five categories are used to define the state of the animal found: 1) animal still alive; 2) recently killed animal; 3) the state of the organism is moderately decomposed; 4) the animal in an advanced state of decomposition; 5) mummified organism or when only bones are found. Animals found in category 1, 2, 3, were sent to CRD Angra (Rehabilitation and Depetrolization Center).

**Data analysis**

For the analyzes performed, monthly values obtained were used, as well as the number of species and considering the stage of development of the specimens (adults and juveniles). Records classified as an "indeterminate" stage were not considered for analyzes involving the variable "stage of development".

Therefore, to verify whether the composition of the assemblages of seabirds' species differs significantly between seasons, an analysis was used Permutational of Variance (PERMANOVA) in software R v. 3.6.1 (R Development Core Team, 2019).

**RESULTS**

A total of 268 strandings of seabirds were recorded between September 2016 and June 2021. The 19 species of birds sampled belong to eight families and five orders (Table 1; Figure 2-4). The three most frequent species were *Spheniscus magellanicus* (n = 58), *Fregata magnificens* (n =68) and *Sula leucogaster* (n = 53), which account for 63.06% of stranding records (Table 1; Figures 2 and 3). The other species had a maximum of 16 stranding records during the monitoring period (Table 1). The monthly mean of strandings was 22.3 ± 11.7.

Most stranded animals were classified in the alive animal category (code 1; n = 144; 53.7%), followed by the advanced stage of decomposition (code 4; n = 48; 17.9%), mummification stage (code 5; n = 31; 11.6%), moderately decomposed stage (code 3; n = 25; 9.3%) and by the stage of the carcass starting decomposition (code 2; n = 20; 7.5%). Most of the stranded birds were found alive and were taken to the rehabilitation center.

Adult was the predominant developmental stage among stranded individuals (n = 132; 49.2%), followed by juveniles (n = 83; 31%) and only one hatchling. In the rest of the strandings, it was not possible to determine the stage of development (n = 52; 19.4%) (Table 1).

The season with the highest number of strandings was winter (n = 109, 40.6%), followed by autumn and spring both with the same numbers (n = 55, 20.5%). The smallest number of records occurred in the summer (n = 39, 14.5%). The season of the year with the highest number of stranded exclusive species was winter (four species), and in the other seasons there was only one exclusive species. Occurrence in all seasons of the year was recorded in only six species: *Thalasseus acuflavidus*, *Ardea alba*, *Nycticorax nycticorax*, *Spheniscus magellanicus*, *Fregata magnificens*, *Sula leucogaster* (Figure 3). No significant difference was observed in the number of stranding records along the different seasons during the study period ($F_{3,421}$ = 0.756, $P$ = 0.482).

**DISCUSSION**

Strandings and mortality of marine tetrapod have been recurrent on the coast of Brazil and include species of mammals, reptiles and birds (MARIANI et al., 2019; TAGLIOLATTO et al., 2019; ZHOU et al., 2019; MAYORGA et al., 2020). Several species of seabirds use the coast and coastal islands of Brazil such as habitats

for feeding and reproduction (FREDERIKSEN et al., 2008; BOURGEOIS et al., 2008). During seasonal migration cycles, many die of natural causes, however, studies have shown that anthropogenic factors are associated with stranding of birds, especially the ingestion of solid waste such as plastics, fishing gear and collisions with vessels (TASKER et al., 2000; NEWMAN et al., 2007; MARIANI et al., 2019). In the Ilha Grande Bay region, a big tourist pole in Brazil, the traffic of tourist and commercial vessels is intense and can impact the distribution and abundance of some species of seabirds, due to the risk of collision and pollutants, or to the attractiveness of supply of food by fishing boats, with concentration of fish in fishing nets (CREED et al., 2007; ORNELLAS et al., 2011).

**Table 01**: List of species sampled by family, abundance, stage of development and condition of seabirds stranded between 2016-2021 in Ilha Grande Bay, Rio de Janeiro, Brazil.

| Taxon | | Abundance | Development stage | | | Condition | |
|---|---|---|---|---|---|---|---|
| Family | Species | | Juvenile | Adult | Indeter. | Alive | Death |
| Ardeidae | *Ardea alba* | 16 | 1 | 13 | 2 | 12 | 4 |
| | *Bubulcus ibis* | 3 | 2 | 1 | - | 2 | 1 |
| | *Butorides striata* | 2 | 1 | - | 1 | 1 | 1 |
| | *Nycticorax nycticorax* | 10 | 6 | 4 | - | 5 | 5 |
| Diomedeidae | *Thalassarche chlororhynchos* | 9 | 1 | 5 | 3 | 2 | 7 |
| Fregatidae | *Fregata magnificens* | 58 | 4 | 45 | 9 | 46 | 12 |
| Laridae | *Anous stolidus* | 1 | 1 | - | - | 1 | - |
| | *Larus dominicanus* | 11 | - | 11 | - | 7 | 4 |
| | *Sterna hirundinacea* | 1 | - | 1 | - | 1 | - |
| | *Sterna hirundo* | 1 | - | 1 | - | 1 | - |
| | *Thalasseus acuflavidus* | 5 | 1 | 2 | 2 | 3 | 2 |
| | *Thalasseus maximus* | 1 | - | - | 1 | - | 1 |
| Phalacrocoracidae | *Nannopterum brasilianus* | 11 | 5 | 3 | 3 | 7 | 4 |
| Procellariidae | *Fulmarus glacialoides* | 1 | - | 1 | - | 1 | - |
| | *Halobaena caerulea* | 1 | - | - | 1 | - | 1 |
| | *Procellaria aequinoctialis* | 1 | - | - | 1 | - | 1 |
| | *Puffinus puffinus* | 14 | 4 | 5 | 5 | 4 | 10 |
| Spheniscidae | *Spheniscus magellanicus* | 58 | 46 | 4 | 8 | 35 | 23 |
| Sulidae | *Sula leucogaster* | 53 | 9 | 38 | 6 | 29 | 24 |
| Total | | 268 | 72 | 134 | 42 | 128 | 96 |

The pattern found in this work, with the occurrence of magnificent frigatebird and brown bobby throughout the year, is recorded for the coast of Brazil, from the south to the southeast, where the largest nests colonies are concentrated (BRANCO, 2004). Most of the strandings occurred during the winter season, a period in which many species migrate and, therefore, become more prone to risk factors, natural or anthropogenic. In addition, the reproduction season for many species of seabirds takes place between the months of April and October (ORNELLAS et al., 2011).

In the present study, six species showed occurrence throughout the year, which may indicate the potential of associated habitats to shelter bird colonies and provide resources throughout the annual cycle. Ornellas et al. (2011) also recorded the occurrence of *Thalasseus acuflavidus* in Paraty Bay in all seasons of the year, indicating that this is probably not an isolated event, and that the place can serve as a habitat capable of offering the resources necessary for this and other species to complete their life cycle, which increases the importance of the region as an area of relevant ecological interest. Among the sampled species, *Spheniscus magellanicus*, *Fregata magnificens* and *Sula leucogaster* were the most abundant. In Brazil, *S. magellanicus* has a wide geographic distribution, occurring mainly in the south of the country, but with winter

records for the southeast region, reaching the State of Rio de Janeiro (SICK, 1997; BRANCO, 2004; ORNELLAS et al., 2011; MARINI et al., 2019). Magellanic penguins migrate after the reproduction season to feed and, during winter, they often reach the Brazilian coast (WEIGRT et al., 2005).

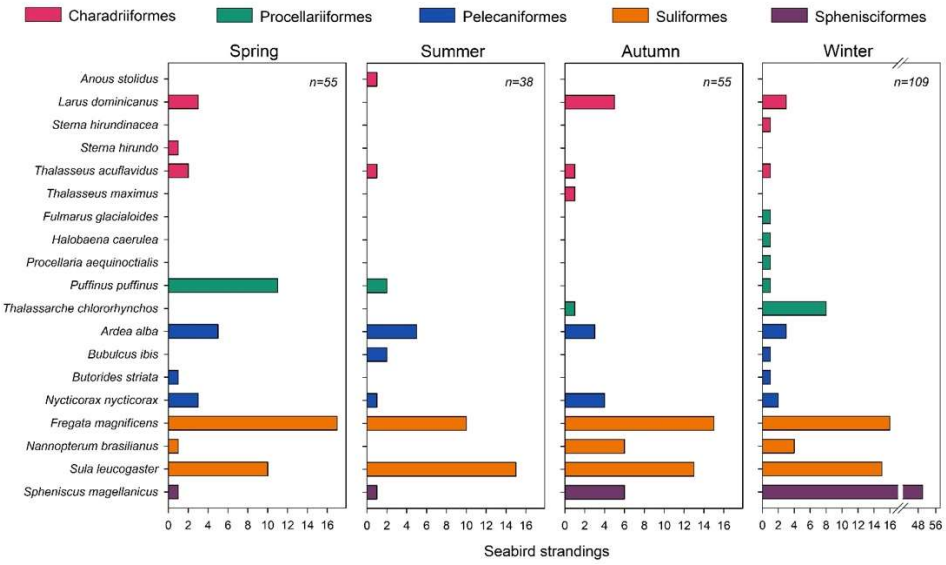


**Figure 02.** Richness and abundance of species collected in seasons at the Ilha Grande Bay, Rio de Janeiro, Brazil. Different bar colors refer to the sampled Aves Orders.

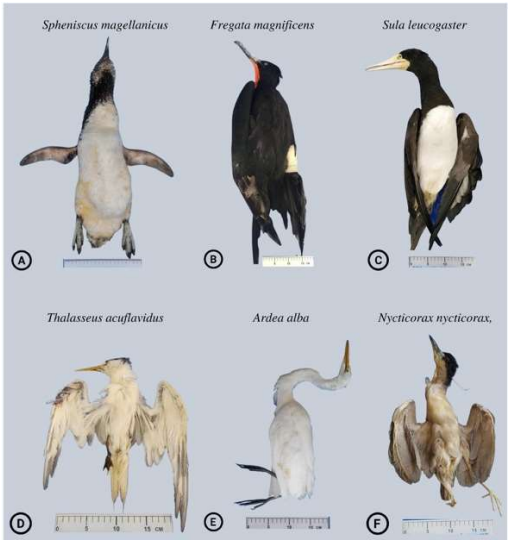


**Figure 03:** Most abundant seabird species during sampling (A-C) and those that occurred throughout the entire annual cycle during sampling (2016-2021) in Ilha Grande Bay, Rio de Janeiro, Brazil.

**Figure 4.** Seabird species (A-M) with lower reported abundance sampled (2016-2021) in Ilha Grande Bay, Rio de Janeiro, Brazil. In (N-O) example of "*on site*" sampling of stranded birds.

On the coast and islands of southern and southeastern Brazil, it has been common to record *F. magnificens*, which reproduces during the winter and spring seasons (KRUL, 2004; SCHLZ, 2004). Frigatebird were recorded with nesting behavior throughout the entire annual cycle in the Paraty Bay region (ORNELLAS et al., 2011). Frigatebirds species have the ability to reach high altitudes using updrafts of flight, increasing the visual field and the potential for locating prey, which makes other species, such as boobies, take

advantage of this ability (COELHO et al., 2004). However, boobies are more efficient in fishing and, as a reward for the tracking trail, frigatebirds attack the boobies, forcing them to regurgitate the food (RESENDE, 1987).

Boobies are the most frequent sea birds on the Brazilian coast. Some species such as *S. leucogaste*r reproduce throughout the year on rocky shores in coastal and oceanic islands and are the most recurrent tropical boobies in records for the coast of Brazil (TEIXEIRA AND NACINOVIC, 1989; SICK, 1997; ALVES et al., 2000; BRANCO, 2004; MARIANI et al., 2019). The high frequency is due to the continuous reproduction and the wide geographic distribution that extends from the northeast of the country in the State of Rio Grande do Norte to the southern region, mainly in the State of Santa Catarina (BRANCO 2004). Along the coast of Brazil the reproductive peaks of *S. leucogaster* suffer variation according to food availability and climatic conditions (ALVES et al., 1997; CAMPOS et al., 2004; KRUL, 2004; GROSE et al., 2011; Branco et al., 2013), seasonal cycles being important to optimize the use of resources and balance ecological relationships such as parasitism and predation (BORSA et al., 2010).

Most species sampled in this study had low relative abundances. However, the occurrence record in Ilha de Grande Bay contributes to the understanding of the dynamics of seabird populations in the region, in addition to the fact that some species are important indicators of productivity and, therefore, potential in conservation and protection strategies for coastal habitats (MARIANI et al., 2019; ZHOU et al., 2019; SIMEONE et al., 2021). The stranding data can contribute to the understanding of the causes of mortality associated with anthropogenic factors, being relevant for decision making in management plans and environmental education strategies, with sustainable practices in economic exploration activities, including the development of ecological tourism. Acknoledgements to the field monitors of the CTA AND Econservation company who daily recorded strandings and photographics records._Hentique Gonçalves for logistical support for data analysis.

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