

**SENSITIVITY MAPPING FOR OIL SPILL RESPONSE: A COMPREHENSIVE
FRAMEWORK TO IDENTIFY WILDLIFE AND AREAS AT RISK ALONG THE
COASTLINE OF BRAZIL**

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2017-365 Abstract

The Environmental Mapping for Emergency Response at Sea Project (*Mapeamento Ambiental para a Resposta à Emergência no Mar* – MAREM, in Portuguese) resulted from a

collaborative agreement between the Brazilian Institute of Petroleum, Gas and Biofuels (IBP) and the Brazilian Federal Environmental Agency (IBAMA). In order to provide support for planning and management of response operations involving marine oil spills, MAREM's first and second phases, named Shoreline Protection and Cleanup Project (*Projeto de Proteção e Limpeza de Costa – PPLC*), created a geo-referenced database of the entire Brazilian coastline (approximately 7,500 km) in 2013. MAREM's third phase was the Wildlife Protection Project (*Projeto de Proteção à Fauna*). It started in 2015 and was developed by a consortium involving Aiuká, Witt O'Brien's Brasil and national and international experts. The Wildlife Protection Project identified, compiled and mapped relevant information on coastal and marine wildlife at risk from oil spill incidents and associated responses along the Brazilian coastline.

The Brazilian Exclusive Economic Zone was divided into 18 geographic units to facilitate the integration of marine, freshwater and terrestrial biogeographical data, regional geopolitics, and the incorporation of the zonal management of national oil production.

Standardized decision trees were developed to provide an objective and consistent method for the identification of priority species and areas for protection in the event of an oil spill within each management unit. The decision trees incorporated previously identified critical habitats or natural resources meeting international conservation strategies (such as Ramsar wetlands, Important Bird Areas and the World Heritage Convention) and the Brazilian National Action Plans for Species Conservation. Species were classified by integrating two components: (a) assessing their vulnerability to oil spills using standardized criteria, and (b) their conservation status under international, national and regional conventions to generate an assessed prioritization for protection in case of oil spills, minimizing potential impacts.

The Wildlife Protection Project has produced (i) a comprehensive dataset on species and habitat vulnerability in Brazil, and (ii) and a publicly-available WebGIS database of the

critical information relevant to oil spill responses and response management, available at www.marem-br.com.br. These two products contain key information on the biology, distribution, seasonality and behavior of the identified vulnerable species, in conjunction with operational information on the locations, biological, geopolitical and logistic aspects of the priority areas identified.

Factsheets were produced for each high-priority species and areas, compiling selected details in a readily accessible format for field teams involved in oil spill responses. The Wildlife Protection Project represents an unprecedented and unique approach for oiled wildlife planning and response in Brazil.

INTRODUCTION

The Environmental Mapping for Emergency Response at Sea Project (*Mapeamento Ambiental para a Resposta à Emergência no Mar – MAREM*) started in 2013 and was finalized in 2016. It resulted from a collaborative agreement between the Brazilian Institute of Petroleum, Gas and Biofuels (IBP) and the Brazilian Federal Environmental Agency (IBAMA). The main objective of this Project was to provide relevant information for decision-making processes during a coastal oil spill from exploration and oil and gas production activities in Brazilian waters. The third phase of MAREM was called Wildlife Protection Project (*Projeto de Proteção à Fauna*) and aimed to expand the knowledge of vulnerable species and of priority areas for protection along the Brazilian coast, serving as support for planning and management of operation responses to accidents involving oil spills. The Wildlife Protection Project Fauna was undertaken by the consortium of Aiuká and Witt O'Brien's Brasil, with the support of university researchers, national and international experts.

METHODS

The Wildlife Protection Project was based on a thorough review of all available data. The review assessed information available in the national and international scientific literature, critical national and regional compilations, novel analyses of field data from survey projects and wildlife monitoring from previous activities developed by the companies involved, and decades of accumulated professional field experience by researchers involved in the project. The data syntheses and interpretations were reviewed by the relevant and appropriate experts before release and adoption.

The methodology used here was consistent with internationally-adopted approaches for mapping wildlife vulnerable to oil, as recommended by the International Petroleum Industry Environmental Conservation Association (IPIECA, 1994, 2004, 2012, 2015), the Brazilian Ministry of the Environment (MMA, 2002, 2007). It also incorporated and expanded the experiences from similar projects in other countries (e.g. Tortell, 1992; Camphuysen and Heubeck 2001; Zengel et al., 2001).

Due to the extensive length of the Brazilian coastline (almost 7,500 km), the coast was divided into 18 geographical units for this project (Figure 1). The geographical division used was based on the integration of three critical aspects of the response to wildlife in oil spills: (1) biogeography of marine, coastal and fluvial species, (2) the existing political and administrative boundaries, and (3) the operational organization of oil and gas production activities. The archipelagos of Fernando de Noronha and São Pedro e São Paulo, Trindade Island and Atol das Rocas were not included in the scope of the project, considering that previous hydrodynamic modeling analyses indicated that these areas would not be affected in any spill scenario related to current oil and gas operations along the Brazilian coast.

It was difficult to determine exactly how many animal species are present in Brazil, especially when several areas have yet to be inventoried and a high number of species are described or taxonomically reorganized every year. To ensure the feasibility and the utility of

the project, we used widely-accepted reference lists for species. Four key references were used as base-lists of species to be considered in the project, those being developed by organizations recognized nationally and internationally (Table 1), comprising a total of 4343 species. In some exceptional cases, subspecies were also included if they had been previously considered as relevant by the Ministry of Environment for wildlife protection strategies (MMA, 2014).

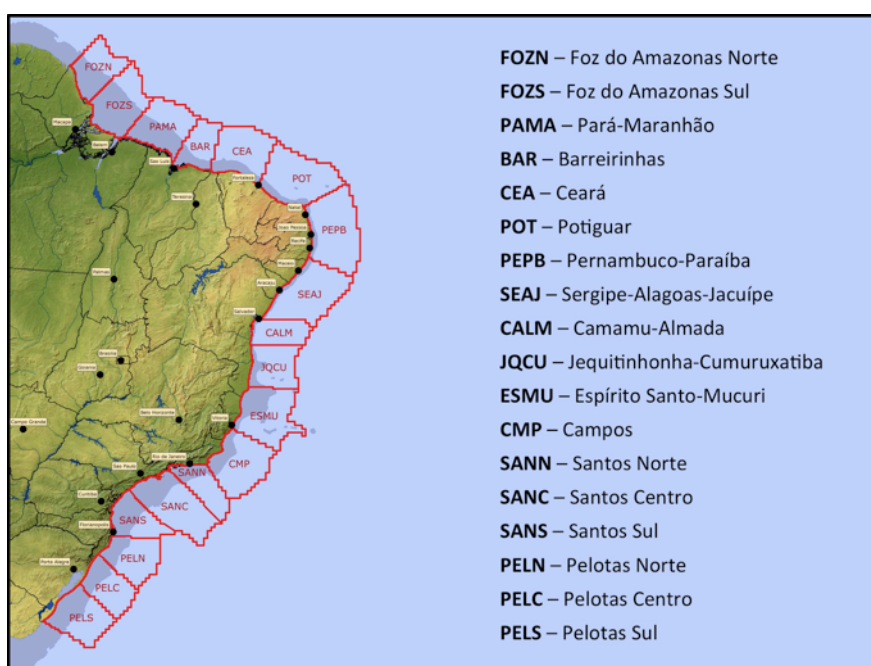


Figure 1: Geographical units identified in the coast of Brazil, based on biogeography, geopolitical and oil production operational criteria.

Table 1: References used as base-lists of species to be analyzed in Wildlife Protection Project.

Group	Species	Reference
Amphibians	1026	Brazilian Herpetological Society (Segalla et al., 2014)
Reptiles	744	Brazilian Herpetological Society (Bérnils and Costa, 2012)
Birds	1872	Brazilian Committee of Ornithological Records (CBRO, 2014)
Mammals	701	Conservation International (Paglia et al., 2012)

Information on the distribution, life habits and behavior of these species was collated from the literature in order to determine to which extent each species was vulnerable to an oil

spill off the Brazilian coast. A decision tree was established to determine which species would be deemed 'vulnerable'. Vulnerable species were defined as those that may be impacted by a coastal oil spill, whether this impact would occur through direct exposure to oil or indirectly through ecological disturbance caused by the oil spill or by response teams.

Once the list of vulnerable species had been compiled, a further decision tree was applied to identify which vulnerable species should be classified as 'priority' species. Priority species were defined as those that are endemic to small areas or Critically Endangered, or those that are otherwise threatened (Endangered, Vulnerable or Near Threatened, according to IUCN) or Data Deficient, and present habits or behaviors that lead them to be moderately or highly susceptible to oil spill impacts.

The entire Brazilian coastline was evaluated to identify relevant and priority areas for wildlife protection in the event of an oil spill. Any areas along the coast comprising mangroves, salt marshes, estuaries, salt or brackish ponds and other flooded areas with communication with the sea were assessed. A review of the scientific literature on the resting and breeding areas of the species identified the locations critical for the conservation of threatened species in the National Action Plans, including areas of species endemism. Each area was classified into three categories: 'priority', 'relevant' or 'level of protection to be determined', according to the available data.

Priority areas were defined as those with primary importance for breeding (comprising areas used for nesting, incubation, nursery and juvenile care) and/or with high concentration of animal or occurrence of endemic species. Relevant areas were defined as those identified as important for wildlife conservation under national or international listings, or areas that, although not yet previously identified, support endemic species, breeding or species' concentrations or may have characteristics that can result in high concentrations of wildlife present at some time of the year (e.g. mangroves, estuaries, salt marshes, among others).

Finally, when there was no evidence to indicate that an area had to be prioritized for wildlife protection resources in the case of an oil spill, it was classified as an area for which the level of protection would be determined by the response team depending on the unique characteristics of the oil spill. It is important to highlight that although these areas were not identified *a priori* as priority or relevant, they can still be designated as such if, during the response to an oil spill incident, a concentration of wildlife in need of protection is identified, or if their use by wildlife changes during the spill.

RESULTS

Of the 4343 species of amphibians, reptiles, birds and mammals known to occur in Brazil, a total of 751 species/ subspecies was identified as directly or indirectly vulnerable to coastal oil spills. Of these, 358 taxa were identified as priority for protection in the event of an oil spill (Figure 2). Charadriiformes (shorebirds, gulls, terns and skuas), Rodentia (wild mice, wild rats and agoutis) and Anura (frogs, treefrogs and toads) were the most represented groups amongst vulnerable species, and Anura, Cetacea (whales and dolphins) and Passeriformes (passerine perching birds) were the most represented groups amongst priority species.

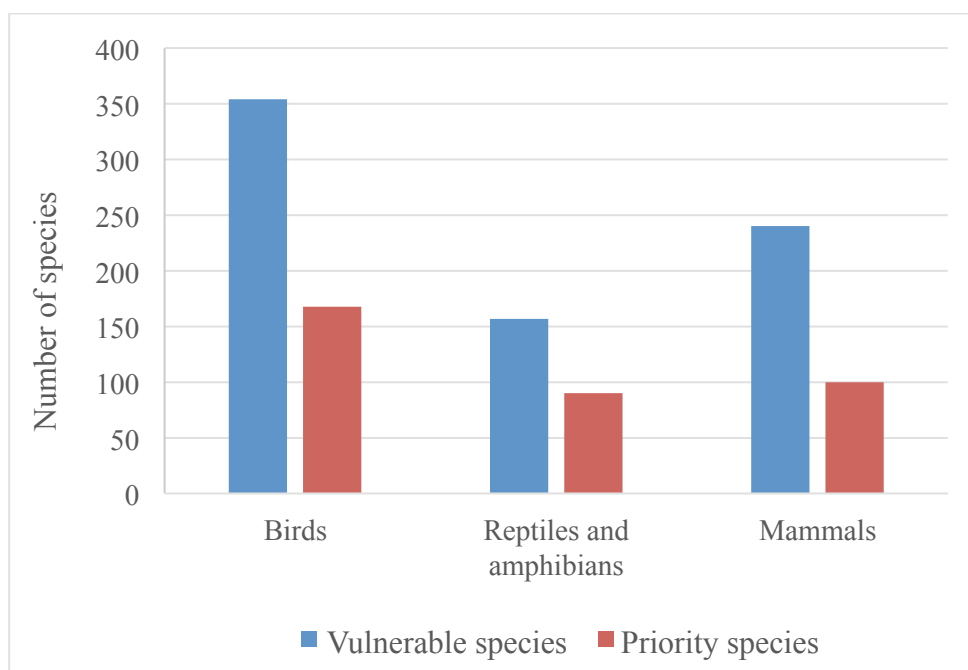


Figure 2: Frequencies of vulnerable and priority species.

The identified vulnerable species were organized in standardized spreadsheets comprising information on their ecology and distribution in the regions, including relevant characteristics such as taxonomical classification and general description, conservation status and diet. It also included information on their susceptibility and sensitivity to oil exposure, and possible strategies for mitigation of oil spill impacts. These detailed spreadsheets were designed to enhance rapid interpretation of relevant data on the species at a given area, allowing oil spill response teams to quickly prioritize actions and plan field activities.

Additionally, individual factsheets were prepared for each of the priority species containing photographs and instructions for field identification, general information regarding its habitat, diet, behavior and population status, and recommendations for teams capturing or handling the species (Appendix 1). These factsheets were designed to provide critical and relevant information for field teams in a rapid and objective manner, ensuring that they can recognize priority species in the field and respond accordingly.

A total of 525 coastal areas were evaluated for prioritization, covering 282 municipalities in 17 states. Within these, we identified 246 priority and 279 relevant areas for protection in case of an oil spill (Figure 3). For each one of these, a factsheet was prepared with maps and information on the general characteristics, species expected to occur in the area, legal protection and logistical recommendations. These factsheets were designed to assist oil spill response teams to plan field activities and coastal protection strategies. An example is presented on Appendix 2 and can be downloaded from http://dados.marem-br.com.br/dados/FICHA_FAU_AREA_PRIORI/Fichas%20Areas-SP_Ilha%20de%20Alcatrazes.pdf

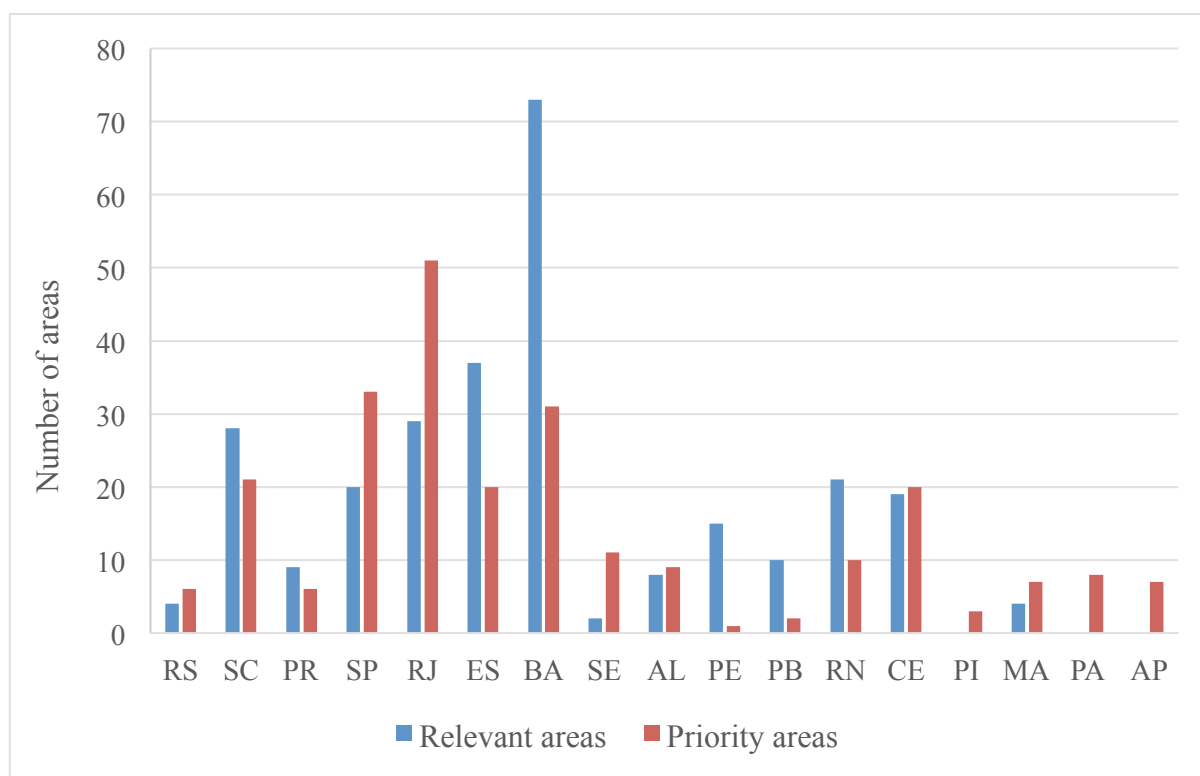


Figure 3: Priority and relevant areas for wildlife protection identified along the Brazilian coast presented by state.

All information produced through the Wildlife Protection Project were integrated into Geographic Information Systems (GIS) and consolidated into a database with more than 80,000 geo-tagged photographs (Figures 4 and 5), including a comprehensive mapping of the

Brazilian coastline’s Environmental Sensitivity Indices (ESI), protected areas, security facilities, hospitals, ports and airports, and detailed information on relevant sea turtle nesting areas.

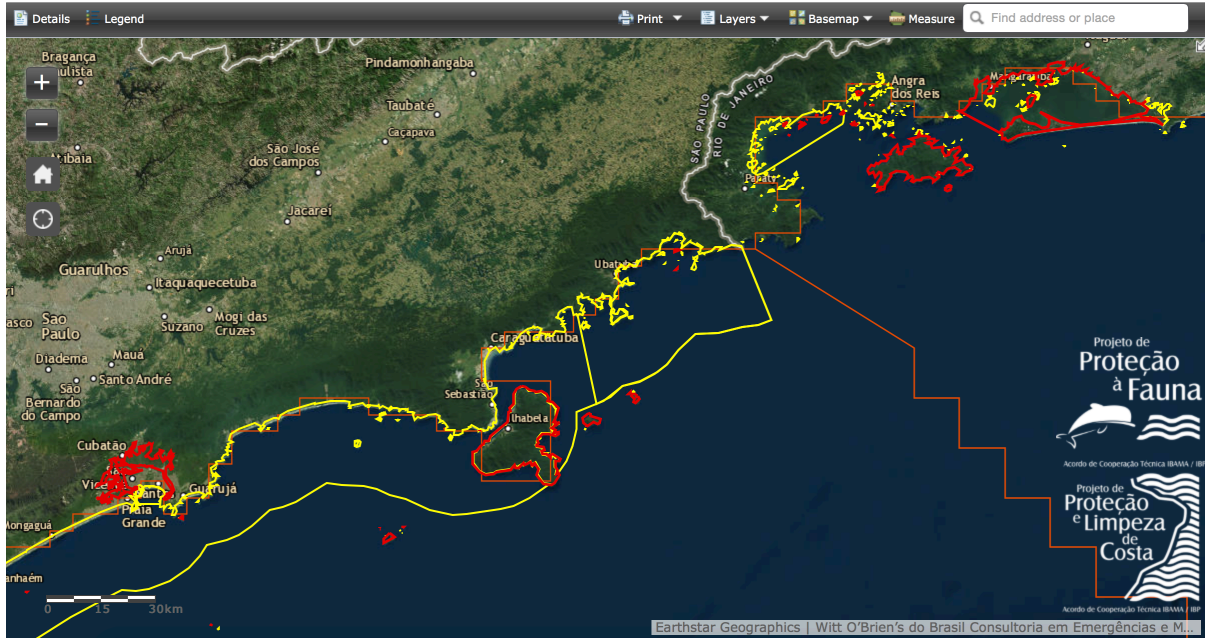


Figure 4: Example of the spatial data mapping for a section of the Brazilian coast. The orange lines indicate the extents of Geographical Units; yellow lines indicate relevant areas; and red lines identify priority areas for protection).

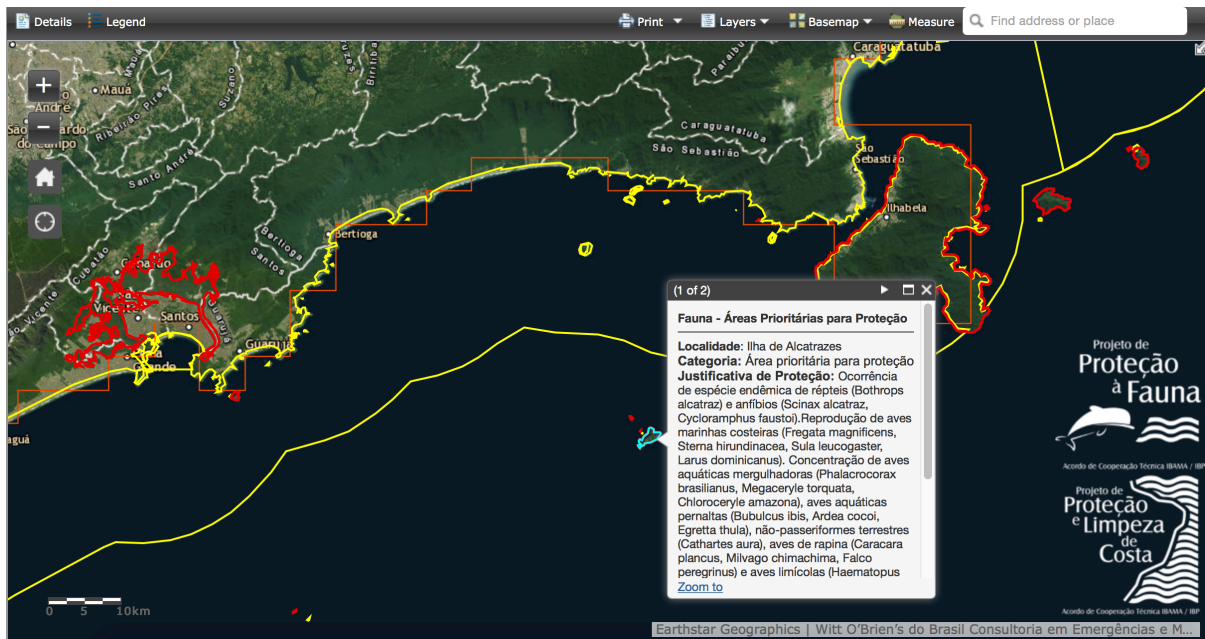


Figure 5: Example of the link from a priority area to the area’s factsheet.

The Wildlife Protection Project represents an unprecedented effort to integrate physical, operational and environmental information in a common data framework to inform decision-making processes in planning and managing oil spill responses along the Brazilian coast. The Project is a landmark for the oil production industry and coastal and marine conservation management in Brazil, and is clearly a critical step in preventing or reducing environmental impacts arising from oil spills and emergency response activities, contributing towards environmentally-sensitive response efforts.

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REFERENCES

- Bérnils and Costa. Répteis brasileiros: Lista de espécies. Versão 2012.1. Available on: <http://www.sbherpetologia.org.br/>. Brazilian Herpetological Society, 2012.
- CBRO. Lista das aves do Brasil. Available at: <http://www.taxeus.com.br/lista/2582>. Brazilian Committee of Ornithological Records, 2014.
- Camphuysen, K. C., Heubeck, M. Marine oil pollution and beached bird surveys: the development of a sensitive monitoring instrument. *Environmental Pollution*, v.112, p.443-461, 2001.
- IPIECA - Petroleum Industry Environmental Conservation Association. Sensitivity mapping for oil spill response. IPIECA and International Maritime Organization, 1994.
- IPIECA. A guide to oiled wildlife response planning. IPIECA, London, 2004.
- IPIECA. Sensitivity mapping for oil spill response. IPIECA, International Maritime Organization and International Association of Oil & Gas Producers, 2012.
- IPIECA. Wildlife response preparedness: Good practice guidelines for incident management and emergency response personnel. IPIECA and International Association of Oil & Gas Producers, 2015.
- MMA - Ministério do Meio Ambiente. Especificações e Normas Técnicas para Elaboração de Cartas SAO. Ministério do Meio Ambiente e Secretaria de Mudanças Climáticas e Qualidade Ambiental, 2002.
- MMA. Atlas de Sensibilidade Ambiental ao Óleo da Bacia Marítima de Santos. Ministério do Meio Ambiente e Secretaria de Mudanças Climáticas e Qualidade Ambiental, 2007.
- Paglia, A.P., Fonseca, G.A.B. Da, Rylands, A. B., Herrmann, G., Aguiar, L. M. S., Chiarello, A. G., Leite, Y. L. R., Costa, L. P., Siciliano, S., Kierulff, M. C. M., Mendes, S. L., Tavares, V. Da C., Mittermeier, R. A. & Patton J. L. Annotated Checklist of Brazilian Mammals. 2nd Edition. *Occasional Papers in Conservation Biology*, No. 6. Conservation International, Arlington, VA. 76pp, 2012.



Segalla, M.V.; Caramaschi, U.; Cruz, C.A.G., Grant, T.; Haddad, C.F.B.; Langone, J.A.;

Garcia P.C.A. Brazilian amphibians: list of species. *Herpetologia Brasileira*, v.3, p.37-48, 2014


Tortell, P. Coastal Zone Sensitivity Mapping and its Role in Marine Environmental Management. *Marine Pollution Bulletin*, v.25, p.88-93, 1992.

Zengel, S., Hayes, M.O., Michel, J., White, M., Benggio, B., Mosher, E., Lopez, F., Touw, S. Integrated planning from the mountains to the sea: Environmental sensitivity mapping in the Caribbean. *Papers of the 2001 International Oil Spill Conference*, p. 1113-1117, 2001.

APPENDIX 1 – Example of a priority species factsheet

Acordo de Cooperação Técnica IBAMA / IBP


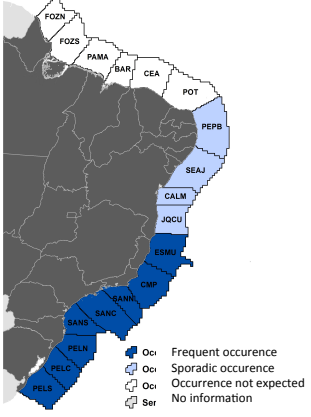


MAGELLANIC PENGUIN
Spheniscus magellanicus
Penguin (Sphenisciformes: Spheniscidae)

BRAZILIAN CONSERVATION STATUS

Not listed

SENSITIVITY TO HUMAN PRESENCE	DANGER TO HUMANS	SUSCEPTIBILITY TO OIL	DIRECT SENSITIVITY TO OIL	INDIRECT SENSITIVITY TO OIL	SENSITIVITY CAPTIVITY
Medium	Medium	High	High	High	Low

Fonte: Valeria Ruoppolo

IDENTIFICATION

Body mass: 3000-8000 g. It has a distinct white line above the eyes, and two black bands on the neck and upper chest.

HABITAT AND BEHAVIOR

It is the most common species of penguin along the Brazilian coast, occurring from Rio Grande do Sul to Alagoas. Juveniles and adults leave their breeding colonies in Argentina between May and August, heading north and reaching the Brazilian coast. Individuals tagged with satellite transmitters travelled more than 100 km during foraging during the breeding season, and sometimes more than 600 km between different colonies in Argentina. Penguins are loyal to their breeding sites, and most birds return to the colony where they were born to breed. Adults use the same nest or burrow year after year. They are also loyal to their partners, usually mating with the same individual each year.

FEEDING HABITS

It feeds mainly on fish and mollusks (cephalopods) that live near the surface of the ocean.

REPRODUCTION AND LIFE CYCLE

Magellanic penguins breed on the Atlantic and Pacific Ocean coasts of South America, such as Gulf of San Matias in Argentina and Puerto Montt in Chile. There are also breeding colonies on oceanic islands, including the Falkland Islands. Adult individuals arrive at the colonies in September, and after forming the breeding pair, they lay usually two eggs. Both adults incubate the eggs for 39 to 42 days. Between 40 and 70 days after the chicks hatch they go out to sea, and the adults molt their feathers before returning to the sea.

POPULATION

The world population is estimated at 1.3 million pairs. Population trends differ among colonies; the two largest colonies in Argentina had a decrease in the last decade, but other smaller colonies have seen an increase. Overall there is a significant decrease in some areas, with substantial mortality due to various threats such as oil pollution, industrial fishing and egg collection.

RELEVANT PARTICULARS FOR WILDLIFE RESCUE TEAMS

It is a strong and robust bird, which does not stand on flat surfaces for extended periods; care must be taken to avoid bumblefoot. They can be fed sardines. Their pecking can be dangerous, and whoever handles birds must wear personal protective equipment.



Acordo de Cooperação Técnica IBAMA / IBP



MAGELLANIC PENGUIN

Spheniscus magellanicus

Penguin (Sphenisciformes: Spheniscidae)

SEASONALITY

Geographic Unit	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Foz do Amazonas - Norte (FOZN)												
Foz do Amazonas - Sul (FOZS)												
Pará-Maranhão (PAMA)												
Barreirinhas (BAR)												
Ceará (CEA)												
Potiguar (POT)												
Pernambuco-Paraíba (PEPB)												
Sergipe-Alagoas-Jacuípe (SEAJ)												
Camamu-Almada (CALM)												
Jequitinhonha-Cumuruxatiba (JQCU)												
Espírito Santo-Mucuri (ESMU)												
Campos (CMP)												
Santos - Norte (SANN)												
Santos - Centro (SANC)												
Santos - Sul (SANS)												
Pelotas - Norte (PELN)												
Pelotas - Centro (PELC)												
Pelotas - Sul (PELS)												

Legenda:

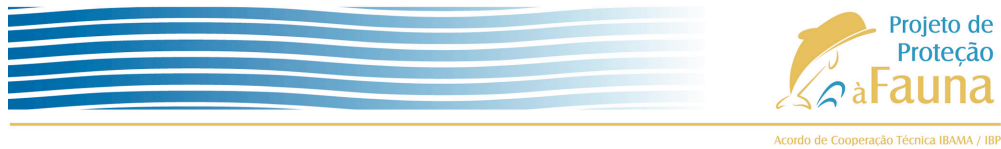
- Frequent occurrence
- Irregular/sporadic occurrence
- Occurrence not expected
- No information about occurrence
- Breeding
- Breeding (sporadic)
- No information

CONSERVATION STATUS / LEGAL PROTECTION

International (IUCN Red List 2015.2)	Near threatened
National - Brazil (Portaria MMA nº. 444/2014)	Not listed
Pará (SECTAM List 2006)	Not listed
Espírito Santo (Decreto Estadual nº. 1499-R/2005)	Not listed
Rio de Janeiro (Portaria SEMA nº. 01/1998)	Not listed
São Paulo (Red Book 2009)	Least concern
Paraná (Red Book 2007)	Near threatened
Santa Catarina (CONSEMA Resolution nº. 02/2011)	Not listed
Rio Grande do Sul (State Decree nº. 41.672/2002)	Not listed
International (CITES 14/09/2014)	Not listed

Source: Aiuká / Witt | O'Brien's Brasil, 2016

APPENDIX 2 - Example of a priority area factsheet

**ALCATRAZES ISLAND (ARQUIPELAGO OF ALCATRAZES)****São Sebastião (SP)**

24°06'06" S / 45°41'26" O (Datum: SIRGAS2000)

GEOGRAPHIC UNIT**Santos - Centro (SANC)****GENERAL CHARACTERISTICS**

Alcatrazes Island is located about 20 nautical miles (40 km) from Boraceia Beach, at Bertioga-SP, and has a perimeter of approximately 9 km. It is the largest island of the Archipelago of Alcatrazes, characterized by a rocky coast of high slopes and talus deposits, supporting vegetation on its upper slopes. The island is internationally important for bird conservation (Important Bird Area - IBA BR180).

JUSTIFICATION OF WILDLIFE PROTECTION PRIORITIZATION

Occurrence of priority species of reptiles (*Bothrops alcatraz*) and amphibians (*Scinax alcatraz*, *Cycloramphus faustoi*). Breeding by marine coastal birds (*Fregata magnificens*, *Sterna hirundinacea*, *Sula leucogaster*, *Larus dominicanus*). Concentration of aquatic diving birds (*Phalacrocorax brasilianus*, *Megaceryle torquata*, *Chloroceryle amazona*), herons (*Bubulcus ibis*, *Ardea cocoi*, *Egretta thula*), terrestrial non-passerines (*Cathartes aura*), birds of prey (*Caracara plancus*, *Milvago chimachima*, *Falco peregrinus*) and shorebirds (*Haematopus palliatus*, *Actitis macularius*, *Arenaria interpres*, *Calidris alba*, *Calidris fuscicollis*).

LEGAL PROTECTION

The archipelago is under protection as a conservation area: Estação Ecológica dos Tupinambás (full federal protection, decree nº 94656, July 20, 1987).

ACCESS AND LOGISTICS

Starting from Federal Highway BR-101, at São Sebastião-SP, access Antônio Januário do Nascimento Avenue and cross the ferry to Ilhabela-SP. Continue through the main road at Ilhabela (State highway SP-131), head north for approximately 5,5 km to Praia do Saco da Capela. From this point onwards, a boat is required to reach Alcatrazes Island. There are other locations where vessels are available to go to the island. Currently, only small groups of researchers get authorization to approach and disembark at Alcatrazes Island.

RELEVANT PARTICULARS FOR WILDLIFE RESCUE TEAMS

It is highly recommended to pay attention to oceanographic conditions to ensure safe transport and anchorage for all operations at and around the island. Supplies and equipment need to be estimated in advance, considering there is no infrastructure and services available at these locations. Vessels and materials must be previously inspected to check for the presence of non-native fauna and flora, so incidental introduction of invasive species does not occur. It is fundamental that the wildlife response team consults the environmental authorities before using visual and auditory techniques for hazing and deterring birds. The same recommendations apply to the relocation of nests and individuals/populations from one area to another on the island.

Source: Aiuká / Witt | O'Brien's Brasil, 2016