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Revealing further insights on extralimital records of Burmeister's porpoise (*Phocoena spinipinnis*, Burmeister, 1865) in the Southwestern Atlantic Ocean

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Abstract

Burmeister's porpoise (*Phocoena spinipinnis*) is an endemic species found in both the South Pacific and Atlantic Oceans, along the coastal regions of South America. In the Southwestern Atlantic Ocean, the species is reported from Tierra del Fuego, Argentina to Santa Catarina, Brazil, and the Falkland Islands. This study provides new insights on two stranded *P. spinipinnis* specimens in Southeastern Brazil, including the first occurrence in the state of Rio de Janeiro. Despite the advanced decomposition of the carcasses, which limited necropsy findings, we provide new data on the general characteristics of the specimens found in this extralimital geographical range, such as total body length, age, sex, vertebral count, and cranial measurements.

Introduction

Burmeister's porpoise (*Phocoena spinipinnis*) is an endemic species found along the eastern and western coasts of South America. It ranges from Bahía de Paita, Peru (05°01'S) to Chile (42°30'S) in the west, and from Tierra del Fuego, Argentina (42°23'S) to Santa Catarina, Brazil (28°48'S) in the east (Brownell and Praderi, 1984; Guerra *et al.*, 1987; Simões-Lopes and Ximenes, 1989; Van Waerebeek *et al.*, 2002). Recently, Weir and Rutherford (2019) reported a stranded specimen of *P. spinipinnis* in the Falkland Islands (51°40.9'S) in the Patagonian Continental Shelf, a region not previously considered within the species' geographical range. Throughout its distribution, the species is more commonly reported in shallow inshore waters, although observations of individuals 20–50 km offshore have also been confirmed (Corcuera *et al.*, 1994; Clay *et al.*, 2018; Santillán, 2022).

Like many cetaceans, the occurrence of *P. spinipinnis* is associated with various environmental features in both the southeast Pacific and southwest Atlantic coasts of South America, such as local currents, upwelling events, and contributions from continental runoff (Molina-Schiller *et al.*, 2005). The northern geographical limits on both sides of South America are influenced by the cold waters of the Humboldt Current in Peru and the Falkland/Malvinas Current in Uruguay and Brazil (Reyes and Van Waerebeek, 1995; Molina-Schiller *et al.*, 2005). Although the holotype specimen was found in the La Plata River, Argentina, in 1865 (Burmeister, 1865; Brownell and Praderi, 1984), most knowledge about the species has come from stranded or by-caught specimens, due to its elusive and inconspicuous swimming behaviour and tendency to form small groups (Brownell and Praderi, 1984; Corcuera *et al.*, 1995; Goodall *et al.*, 1995a; Reyes and Van Waerebeek, 1995; Rosa *et al.*, 2005; Garcia-Godos *et al.*, 2007; Galatius *et al.*, 2011; Weir and Rutherford, 2019; Marchesi *et al.*, 2022; Padula *et al.*, 2023).

The first records of *P. spinipinnis* along the Brazilian coast date back to the mid- to late 1980s (Pinedo, 1989; Simões-Lopes and Ximenez, 1989) when stranded carcasses were reported in the states of Rio Grande do Sul and Santa Catarina (28°48'S) (Figure 1). This extended the known distribution northward by 900 km from its previously known range in Uruguay. A few decades later, a record of *P. spinipinnis* was reported in Anchieta, Espírito Santo, southeastern Brazil, with no further details provided other than the geographical location of the stranding (Mayorga *et al.*, 2020). This has remained the northernmost occurrence for the species in the southwestern Atlantic Ocean.

Based on two stranded carcasses found in 2014 and 2021, this study provides additional information on the occurrence of *P. spinipinnis* in southeastern Brazil in the southwestern Atlantic Ocean. It describes necropsy findings for the specimen previously reported in Anchieta by Mayorga *et al.* (2020) and a new stranding in the state of Rio de Janeiro.

Materials and methods

The Laboratório de Mamíferos Aquáticos e Bioindicadores at Universidade do Estado do Rio de Janeiro (MAQUA/UERJ) is one of the institutions that monitors marine mammal



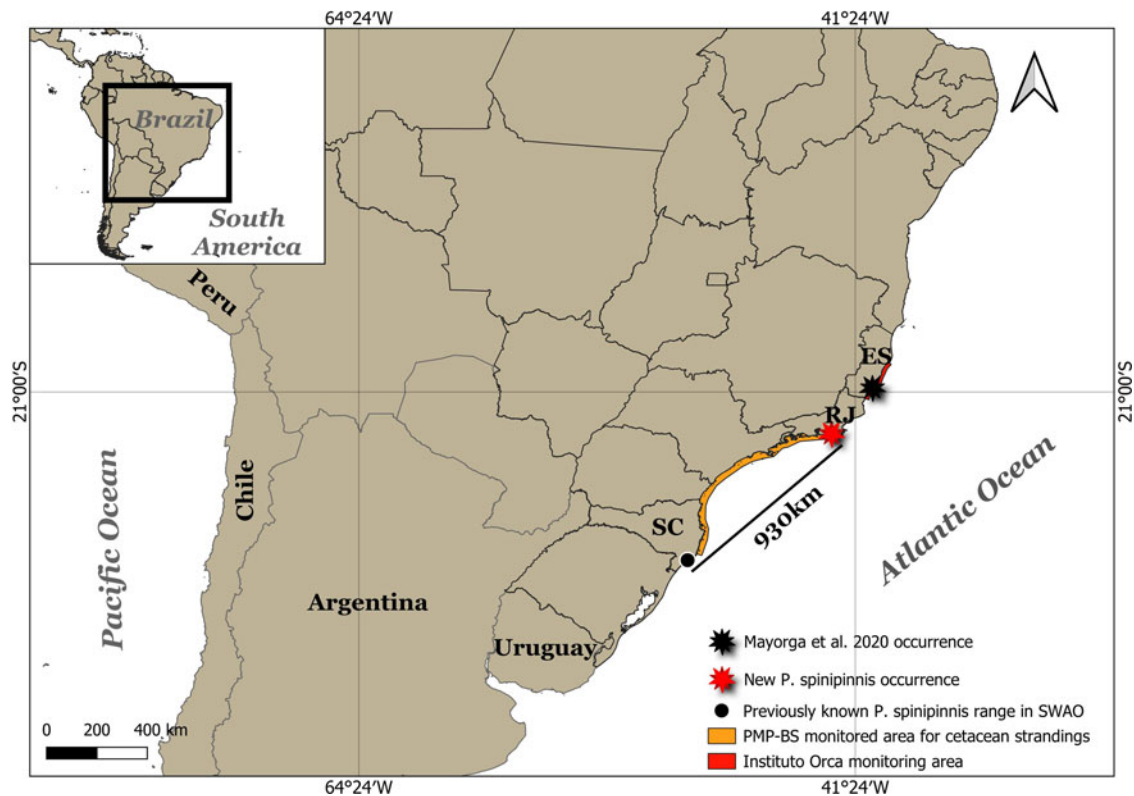


Figure 1. Previously known northernmost range of *Phocoena spinipinnis* in the Southwestern Atlantic Ocean (SWAO) in Santa Catarina state (SC) (black dot), new occurrence reported in this paper (red star) in Rio de Janeiro state (RJ) 930 km northward, and the occurrence reported in Mayorga *et al.* (2020) in Espírito Santo State (ES) (black star). The monitoring areas for PMP-BS and Instituto Orca are represented by coastal orange and red polygons, respectively.

strandings along approximately 1160 km of the central-south coast of the state of Rio de Janeiro in southeastern Brazil. Since 2017, a monitoring programme, the ‘Projeto de Monitoramento de Praias da Bacia de Santos (PMP-BS)’ has been conducted along the southern and southeastern Brazilian coast. This programme was established to meet the requirements of the federal environmental licensing institute, ‘Instituto Brasileiro do Meio Ambiente e Recursos Renováveis’ (IBAMA), for oil and natural gas production and extraction in the Santos Basin. The aim of PMP-BS is to assess the potential impacts of oil and gas activities on seabirds, sea turtles, and marine mammals through beach stranding monitoring, veterinary care to live animals, and necropsies of deceased individuals. The project covers 15 states from Laguna/Santa Catarina to Saquarema/Rio de Janeiro, spanning southern to southeastern Brazil (Figure 1). The MAQUA/UERJ team is specifically responsible for collecting and conducting necropsies on stranded marine mammal carcasses in sectors 11–15, which encompass the south to central Rio de Janeiro State (Petrobras, 2023). Carcasses are typically reported through two methods: (1) active beach monitoring by technicians and researchers, who search for carcasses, or (2) reports from residents, visitors, tourists, or anyone in coastal areas who voluntarily report strandings, primarily through institutional phone numbers.

On 2 April 2021, residents of Praia da Vila, Saquarema municipality (22°54'4"W; 42°29'54"S) (Figure 1) reported a stranded dolphin carcass identified by the field team as *P. spinipinnis*. The total body length (TBL), sex, body condition, decomposition code, and photographs were taken in the field to document the *in situ* conditions of the specimen as found by the research team. The decomposition code was recorded following Geraci and Lounsbury (2005). The carcass was subsequently taken to the MAQUA/UERJ laboratory, where a necropsy was performed on 14 April 2021.

On 25 June 2014, a stranded carcass of *P. spinipinnis* was found in Praia de Parati, Anchieta municipality, Espírito Santo

(see Mayorga *et al.*, 2020 for detailed methods). Necropsy was performed on 1 July 2014.

Necropsies were performed by trained personnel, including marine mammal veterinarians. Teeth were collected in order to estimate age by the dentine growth layer groups (GLGs) (Perrin and Myrick, 1980; Hohn *et al.*, 1989).

To evaluate vertebral count and cranial measurements, the carcass remains were macerated for approximately 120 days until the skeleton was completely free of tissue residue. The skeleton was then cleaned with mild soap and a brush, followed by air-drying under ambient conditions.

Thirty cranial measurements were taken using a 300 mm Vernier caliper, following Perrin (1975) and Goldin and Vishnyakova (2015). Some measurements described by Perrin (1975) were not feasible due to the loss of specific parts of the skull.

Similar stranding monitoring is also conducted by Instituto ORCA, which collects stranded carcasses along approximately 260 km of the state of Espírito Santo coast in southeastern Brazil (methods described in Mayorga *et al.*, 2020) (Figure 1). The characteristics of the specimen stranded in Anchieta, Espírito Santo and first reported by Mayorga *et al.* (2020), were also described based on necropsy findings. However, age, vertebral count, and cranial measurements were not determined for this specimen.

Results

In situ observations in Praia da Vila revealed an almost entirely skinless carcass of *Phocoena spinipinnis*, measuring 154 cm of TBL, and in late decomposition (code 4 according to Geraci and Lounsbury, 2005), with missing eyes and partially macerated jaws (Figure 2). Four suggestive *post-mortem* shark bites were also observed: A – genital slit (27 cm × 11.5 cm); B – umbilicus/

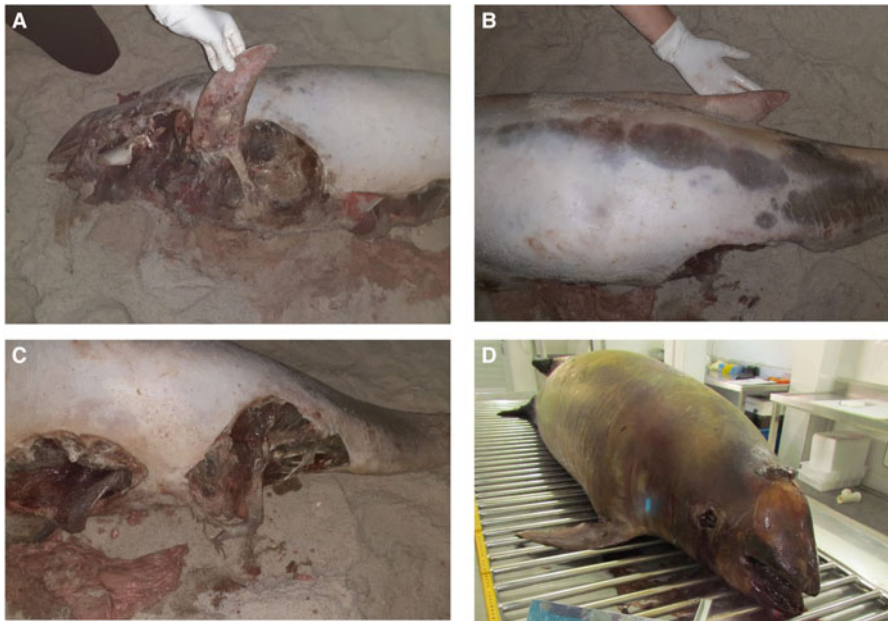


Figure 2. Stranded Burmeister's porpoise, *Phocoena spinipinnis*, in the states of Rio de Janeiro (A–C) and Espírito Santo (D), southeastern Brazil. (A) Head with partially macerated left jaw, ventral laceration by suggestive *post-mortem* shark bites, presence of teeth and absence of the left eye; (B) Suggestive *post-mortem* shark bites on umbilicus/thoracic cavity and genital slit; (C) Low, triangular-shaped canted backward dorsal fin; (D) Specimen found stranded in Praia de Parati, Anchieta, Espírito Santo.

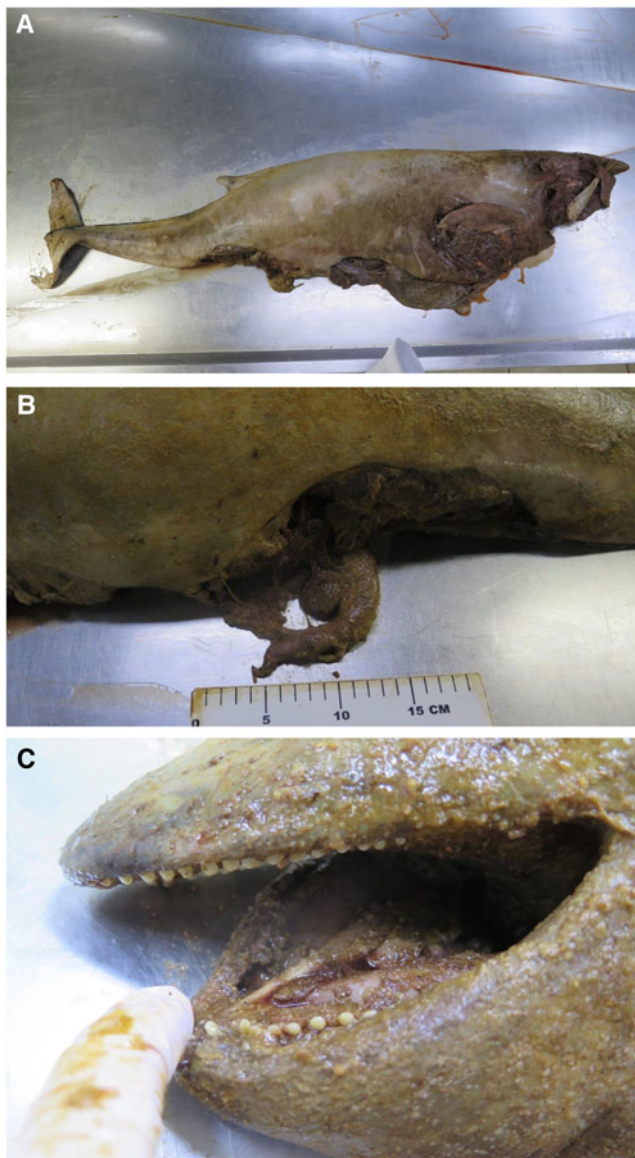


Figure 3. Specimen of Burmeister's porpoise, *Phocoena spinipinnis*, stranded in the state of Rio de Janeiro, southeastern Brazil in April 2021, during necropsy (A) and evidence of penis (B) and teeth (C).

thoracic cavity (21 cm × 11.5 cm); C – right ventral lateral thorax (29 cm × 11.5 cm); and D – ventral portion of the head (cervical to zygomatic arch) (20 cm × 11.5 cm) (Figure 2).

Despite its advanced decomposition, necropsy revealed a male specimen confirmed by the preservation of the penis (Figure 3). The stomach was absent, preventing any analysis of its contents. Autolysis had compromised all organs, including those of the respiratory, cardiovascular, reproductive (testicles), endocrine, lymphatic, haematopoietic, and nervous systems, making further investigation impossible. Teeth were preserved, totaling to 15 and 17 pairs in both lower and upper jaws, respectively (Figure 3).

The vertebral count was 7 cervical (Cv) (Cv1–3 fused), 13 thoracic (Th), 15 lumbar (L), and 27 caudal vertebrae (Cd) (Figure 4). Except for a few caudal vertebrae, epiphyses were not fused. There were also 13 pairs of ribs, with articulations present on the first eight pairs. The age was estimated to be 3 years based on the count of growth layer groups (GLGs). Table 1 shows the 30 cranial measurements obtained from the specimen sampled in Rio de Janeiro.

Necropsy observations of the *P. spinipinnis* specimen found on Praia de Parati, Anchieta municipality, Espírito Santo reported a 162 cm male individual in a late decomposition state (Figure 2), with small patches of preserved skin tissue on the caudal peduncle and the tip of the dorsal fin; eyes were absent and internal organs exhibited gas formation. Two unidentified teleost fishes were found in the stomach content. The testicles measured between 12 and 15 cm each. Teeth were preserved, adding up to 13 and 17 pairs in both lower and upper jaws, respectively (Figure 5).

Discussion

We report here the two northernmost occurrences of *P. spinipinnis* in the Southwestern Atlantic Ocean to date and the first record of the species in Rio de Janeiro State, to our knowledge. This phocoenid species is described as not exceeding a total body length of more than 200 cm (Goodall *et al.*, 1995a). One of the main characteristics of *P. spinipinnis* described by Goodall *et al.* (1995a) is the blunt head without a distinct beak, with the forehead dropping rather abruptly to the rostrum tip. Additionally, the species is noted for a short gape and eyes positioned forward of the blow-hole. In addition to the spatulate teeth typical to phocoenids, one of the species' diagnostic features is the low, triangular canted

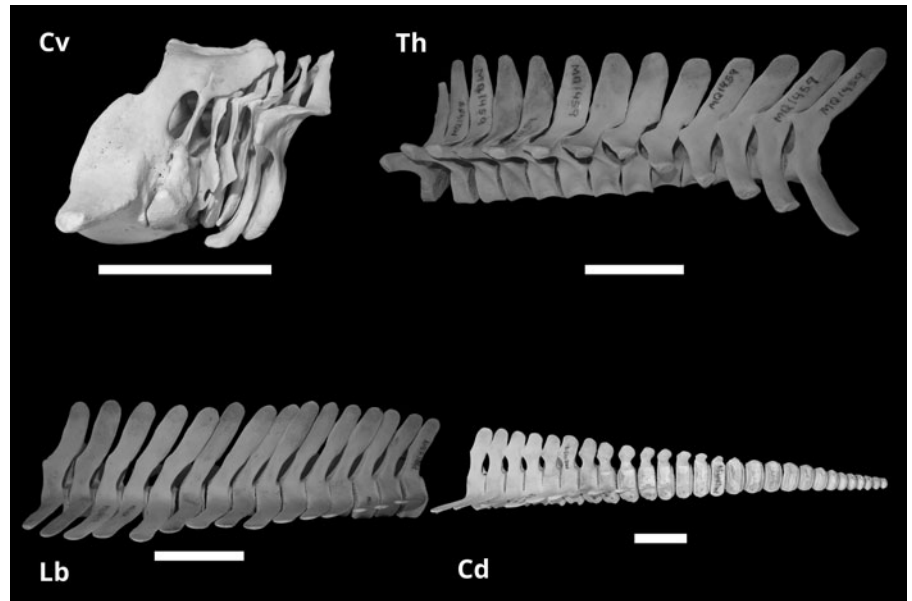


Figure 4. Vertebral structure of a Burmeister's porpoise, *Phocoena spinipinnis*, stranded in the state of Rio de Janeiro, southeastern Brazil in April 2021. Cv – cervical; Th – thoracic; Lb – lumbar and Cd – caudal. Scale bars: 5 cm.

Table 1. Skull measurements (mm) of a Burmeister's porpoise (*Phocoena spinipinnis*) specimen stranded in Praia da Vila, Saquarema, Rio de Janeiro, southeastern Brazil in April, 2021

1	Condylbasal length	272
2	Rostrum length	118
3	Width of rostrum at base	82
4	Width of rostrum at 60 mm anterior to line across hindmost limits of antorbital notches	50
5	Width of rostrum at mid-length	51
6	Width of premaxillaries at mid-length of rostrum	27
7	Width of rostrum at 3/4 length, measured from posterior end	39
8	Distance from tip of rostrum to internal nares (to mesial end of anterior transverse margin of right naris)	143
9	Preorbital width	126
10	Orbital width	123
11	Greatest postorbital width	138
12	Least supraorbital width	120
13	Greatest width of external nares	32
14	Greatest width of premaxillaries	39
15	Parietal width	128
16	Zigomatic width	156
17	Greatest length of left posttemporal fossa, measured to external margin of raised suture	55
18	Greatest length of left posttemporal fossa at right angles to greatest length	53
19	Major diameter of left temporal fossa proper	38
20	Minor diameter of left temporal fossa proper	26
21	Distance from foremost end of junction between nasals to hindmost point of margin of supraoccipital crest	12
22	Length of left orbit-form apex of preorbital process of frontal to apex of postorbital process	49
23	Length of antorbital process of left lacrimal	28
24	Length of upper left tooth-row – from hindmost margin alveolus to tip of rostrum	62

25	Length of lower left tooth row – from hindmost margin of hindmost alveolus to tip of mandible	81
26	Greatest length of left ramus	208
27	Greatest height of left ramus at right angles to greatest length	56
28	Length of left mandibular fossa, measured to mesial rim of internal surface of condyle	84
29	Condylar width	74
30	Condylar height (left)	46

backward dorsal fin located posterior to the midpoint of the body and covered with tiny tubercles similar to spines on its leading edge.

Due to the advanced stage of carcass decomposition, we were unable to determine the coloration of either specimen. However, in both cases, the presence of spatulate teeth, the blunt head, and the distinctive dorsal fin shape matched the previously described characteristics of *P. spinipinnis*, making misidentification highly unlikely. The vertebral count for the Rio de Janeiro specimen was similar to that previously reported in the literature (Brownell and Praderi, 1984; Reyes, 2018), although a lower number of caudal vertebrae was observed in this study. Additionally, we could not rule out some skeletal loss due to shark bites, despite the specimen appearing to be well preserved.

The total body length and epiphyseal fusion, observed in less than 10% of the vertebral column, suggest a physically immature individual in Rio de Janeiro (Corcuera *et al.*, 1995; Reyes and Van Waerebeek, 1995). Male *P. spinipinnis* were previously reported to not attain sexual maturity between 158 and 175 cm (Goodall *et al.*, 1995a; Reyes and Van Waerebeek, 1995). However, Corcuera *et al.* (1995) observed physically mature male specimens at 169 cm and 3 + GLGs. At this stage, the authors also reported a vertebrae fusion of more than 40%, contrasting with our findings for the studied specimen. An important observation regarding the skull of the Rio de Janeiro specimen is that it was clearly not fully fused, suggesting an immature individual with a condylbasal length attaining 272 mm. In contrast, Molina-Schiller (2006) reported that males attain physical maturity when the condylbasal length is ≥ 266 mm. Although this difference may be due to



Figure 5. Dorsal, ventral, and lateral view of the skull, and inner and outer side of the left mandible of a Burmeister's porpoise, *Phocoena spinipinnis*, stranded in the state of Rio de Janeiro, southeastern Brazil, in April 2021. Scale bars: 5 cm.

geographic variations among populations, the authors did not have a sufficient sample size from Brazilian waters ($n = 2$) to confirm significant differences. Recent data on maturity for *P. spinipinnis* reported pubescent individuals ranging from 142 to 154 cm (Vega *et al.*, 2022), providing further evidence to classify the maturity status of the Rio de Janeiro specimen. Accounting for total body length, the specimen found in Espírito Santo could be classified as mature according to previous studies (Goodall *et al.*, 1995a; Reyes and Van Waerebeek, 1995). Furthermore, Vega *et al.* (2022) reported mean testicle and total body lengths of 119.4 mm and 166.39 cm, respectively, which corroborate findings for the Espírito Santo specimen.

Although the carcasses were highly decomposed, it seems unlikely that they drifted from its known previous northernmost range in southern Brazil (Simões-Lopes and Ximenez, 1989) to the states of Rio de Janeiro and Espírito Santo, which are 930 and 1280 km further north, respectively. The strandings were reported right after the end of the austral summer in Rio de Janeiro and the beginning of the austral autumn in Espírito Santo. These timings are not consistent with a strong northward movement of Subtropical Convergence (the encounter of a cold northward flow of Falkland/Malvinas current with a warmer southward flow of Brazil current), occurring primarily during the austral winter, and previously recognized as one of the main oceanographic features influencing the occurrence of *P. spinipinnis* in Brazilian waters (Molina-Schiller *et al.*, 2005). Given the rarity of these stranding events, this suggests a potential occurrence of *P. spinipinnis* further north in Brazilian waters.

While the influence of the Subtropical Convergence seems unlikely in our case, at least three other factors should be considered: (1) the species' unobtrusive swimming behaviour and small group formation (Goodall *et al.*, 1995b; Santillán, 2022); (2) the South and Southeastern Brazilian continental shelf, which varies in width from 70 to 230 km offshore with depths of ≤ 200 m (Mahiques *et al.*, 2010); and (3) the presence of the nutrient-rich South Atlantic Central Waters (SACW) in mid- and outer continental shelf, along with its upwelling near the study area (Castelão and Barth, 2006). The former may suggest more challenging conditions for sightings by scientific expeditions, while the second supports the possibility of groups travelling further north within deeper waters of the continental shelf. *Phocoena spinipinnis* was already reported in waters up to 100 m in depth (Clay *et al.*, 2018), resulting in decreased sighting probability due to limited

scientific effort in offshore waters and rough sea conditions. The presence of nutrient-rich waters supports the occurrence of the species in a highly productive area. The water temperatures and salinities are below the representative values known to limit species' geographical distribution in both the Pacific and Atlantic coasts (>24 °C and >36 psu, respectively) (Molina-Schiller *et al.*, 2005). In some areas of the South Brazilian Bight, including the Rio de Janeiro coast, SACW are characterized by cold waters (<20 °C) and salinities ranging from 35 to 36 psu (Stramma and England, 1999; Brandini *et al.*, 2014; Castro, 2014), comprising oceanographic features previously associated with *P. spinipinnis* occurrences (Goodall *et al.*, 1995a; Molina-Schiller *et al.*, 2005; Reyes, 2018).

Despite no evidence of bycatch being found, a fourth, albeit remote, possibility is that both specimens were taken as bycatch further south and subsequently dumped at sea. Despite these hypotheses, *P. spinipinnis* is extremely rare in Brazilian waters. Analyses of stranding data spanning over 30 years of effort in Southern Brazil reported only one specimen in the state of Santa Catarina and six in the state of Rio Grande do Sul (Prado *et al.*, 2016; Vianna *et al.*, 2016). The report from Vianna *et al.* (2016) is the same specimen reported by Simões-Lopes and Ximenez (1989), making it the only record for Santa Catarina state to date. It is noteworthy that both studies describe systematic efforts within their local stranding monitoring programmes, thereby enhancing their chances of encountering dead mammals washed ashore and underscoring the rarity of the species and the robustness of the analysed data.

The information presented here results from systematic cetacean stranding monitoring, which involves continuing engagement with the public. Through this engagement, local residents and visitors actively contribute by reporting stranding occurrences to the scientific community enhancing the effectiveness of the monitoring programme. While these occurrences of *P. spinipinnis* may be considered extralimital, we report the first record in the state of Rio de Janeiro, Southeast Brazil, and provide new biological information on the species along its northernmost distributional range on the South American Atlantic border. Although no evidence of allopatric dispersion was investigated, the occurrence of pubescent and mature male individuals in such a distant location from southern Brazil is noteworthy. Finally, the continuation of these stranding monitoring efforts should enable further investigation into the species' biological aspects in case of future occurrences.

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Competing interests. The authors declare no conflicts of interests.

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