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Stranding pattern and impact of fishing interaction in franciscana dolphin (*Pontoporia blainvillei*) in the north coast of São Paulo, Brazil – Contributions to the knowledge of the Franciscana Management Area (FMA IIa)

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Abstract

This study presents the age structure and growth patterns, spatial and seasonal distribution, and anthropic interactions of franciscana dolphin *Pontoporia blainvillei*, using data from stranded individuals through a nine-year effort of daily monitoring on the northern coast of São Paulo, an important area within the Franciscana Management Area (FMA IIa). The main results are compatible with the literature for the region, *i.e.*, asymptotic growth, sexual maturity, and seasonality of stranding events, except with a higher frequency of calves and adults on the north coast of São Paulo than observed in other areas. Our results strengthen the relevance of this FMA as a region with a high occurrence of franciscana strandings, in addition to highlighting the high occurrence of the species' interaction with gillnet fishing. Approximately 60% of registered individuals presented evidence of fishing interactions. Ubatuba was the area with the highest concentration of events, underlining the need for studies on carcass drift dynamics, population structure, and local fishing, to determine the mortality cause of this species and the significant fishing threat locations.

Keywords:
age, bycatch, cetaceans, franciscana dolphin, Southwest Atlantic Ocean

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Introduction

The franciscana dolphin, *Pontoporia blainvillei*, is an endemic cetacean from South America with restricted distribution to the Atlantic coast, ranging from the coast of Itaúnas, Espírito Santo, Brazil (18°25' S) (Moreira & Siciliano, 1991) to San Antonio Bay, Patagonia, Argentina (42°35' S) (Crespo et al., 1998). With a decreasing population trend, franciscana is the most endangered odontocete in Brazil, listed as Critically Endangered by the Brazilian National List of Endangered Species (MMA, 2022) and Vulnerable by IUCN (Zerbini et al., 2017). This is a result of the increasing number of bycatches due to intense human activities related to artisanal and/or industrial fishing, especially with the use of gillnets in coastal areas, overlapping with the region where the species occurs. In addition, these dolphins have difficulty in detecting the nets, which makes the situation even worse (Corcuera et al., 1994; Pinedo, 1994; Di Beneditto & Ramos, 2001; Bertozzi & Zerbini, 2002; Ott et al., 2002; Rosas et al., 2002; Cappozzo et al., 2007; Franco-Trecu et al., 2009; Prado et al., 2021). Thus, fishing activities in the past 40 years are the main cause of population decline (Praderi et al., 1989; Bertozzi & Zerbini, 2002; Secchi et al., 2021, 2022).

Eight Franciscana Management Areas (FMAs) were defined as a conservation strategy, considering the discontinuous distribution of the species and its morphometric, ecological, and genetic variations (Cunha et al., 2014; Cunha, 2022). This classification is essential to manage different populations individually (Cunha et al., 2014; Cunha, 2022). To contribute to this management, this study focuses on FMA IIa, with an emphasis on knowledge about the species' mortality and its interaction with fishing efforts on the northern coast of São Paulo. We used stranding data obtained from over nine years of daily monitoring and a brief overview of gillnet fishing in the region. We also present detailed data on the age structure, growth pattern, and spatial and seasonal distribution of the species, which can help the understanding of their life strategy (Botta et al., 2010).

Material and Methods

Study location and data collection

Data were collected from animals rescued or found stranded during the monitoring of the 235 beaches (145.87 km of coastal ground per day) located between the municipalities of São Sebastião and Ubatuba on the northern coast of São Paulo (Fig. 1) between latitudes 23° and 24° S and longitudes 44° and 46° W. The Instituto Argonauta performs the monitoring as part of the Santos Basin Beach Monitoring Program (PMP-BS) activities. The PMP is a program administered by the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA) to fulfill the environmental licensing requirements for Petrobras' oil and gas production. The study location is placed within the Marine Environmental Protection Areas of the North Coast (APAMLN), a sustainable use conservation unit managed by the state government that covers beaches, mangroves, and islands extending to the 50 m isobath into the sea (Fig. 1).

The monitoring program relies on three different approaches: (a) active monitoring by land - performed daily on site or exceptionally once a week when conditions are restricted; (b) active monitoring on board – performed weekly on coastal areas with unfeasible or nonexistent terrestrial access; (c) on demand – assistance provided upon receiving a call from the community when observing a stranded animal at the beach or floating nearby (Petrobras, 2019a, b). The data were obtained over a nine-year period, from August 2015 to August 2024. All animals were collected under permit nbr. ABIO 1169/2019, issued by IBAMA.

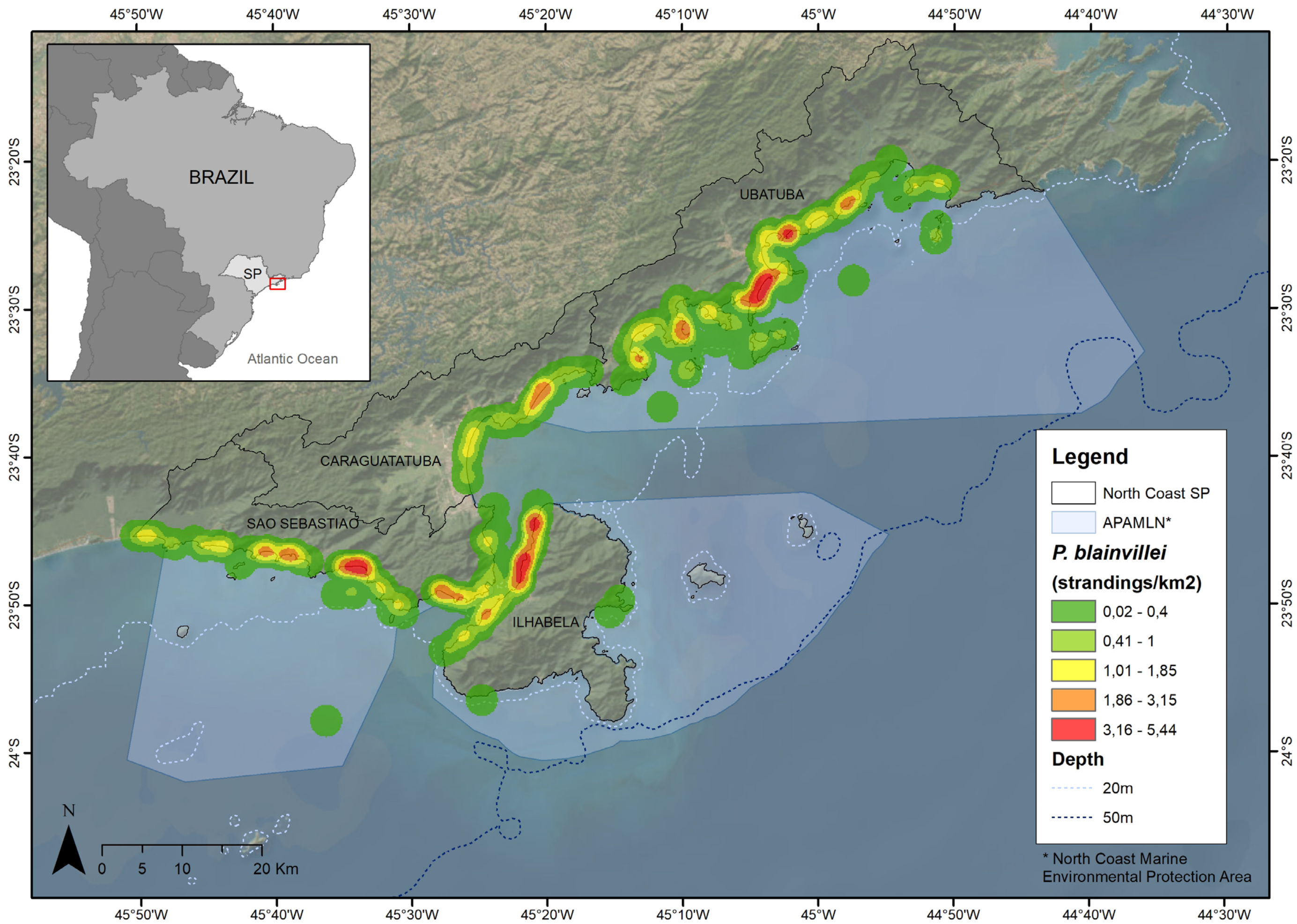

Figure 1. Study area – Northern coast of São Paulo State, southeastern Brazil, displaying the occurrence and density of franciscana *Pontoporia blainvillei* strandings, from August 2015 to August 2024.

Specimens found dead or live-stranded that died during the rehabilitation process were submitted to necropsies. Carcasses in viable conditions, up to code 3 (Geraci & Lounsbury, 2005), were evaluated to obtain the information on sex, developmental status, body score (good, fair, poor), physical integrity, lesions, and external marks of anthropic interactions, as well as biological samples (teeth and gonads for age estimation and determination of sexual maturity). Biometric measurements were recorded when the actual body size of the animal was measured. This is dependent on the integrity of the carcass; thus, several measurements in this study could not be carried out. The animals were then classified by developmental status: calf, juvenile, or adult according to the total body length of the individual (Conversani et al., 2020) and other physical characteristics, *e.g.*, in newborns the absence of teeth, presence of umbilical cord, vibrissae on the rostrum, and fetal folds.

Age estimation

Age was estimated based on osteological analyses performed by private laboratories. Teeth samples were collected and macerated, followed by drying by solar exposure, and kept dry until manipulation. The teeth chosen for evaluation were the largest, least curved, least worn, and without cracks, located in the middle portion of the left and right jaws. In the laboratory, the methodology used for processing and interpretation of the samples followed Pinedo & Hohn (2000) and Bertozzi (2009) for *P. blainvillei*. Calves without erupted teeth were categorized as 0 year.

Fishing Data

The fishing information was obtained through the ProPesq platform of the Reference Laboratory for Statistical Control of Fishing Activities of the Fisheries Institute-APTA/SAA (http://www.propesq.pesca.sp.gov.br). We selected data related to fishing with gillnets from the municipalities that make up the northern coast of the State of São Paulo (Caraguatatuba, Ilhabela, São Sebastião, and Ubatuba). The period selected was from August 2015 to July 2024. The gillnet categories considered in this study were: surface gillnet, surface drift gillnet, bottom gillnet, and miscellaneous gillnets. The selected data included: year, month, municipality, type of fishing gear, type of fish, type of fishing, total catch weight in the period, number of productive units, and estimated monetary value in the period. A 'productive unit' is a vessel, or a fisherman, or a seine net or a pair trawl (Instituto de Pesca, 2024).

Statistical analysis

Statistical analyses were conducted in R Program (R Core Team, 2016) and assessed for normality using the Shapiro-Wilk test. As the data did not meet normality, the non-parametric Mann-Whitney was applied to test the difference in the length and age composition of franciscana.

Non-linear mathematical functions were used to describe growth curves. We fitted growth curves to length-at-age data using five candidate growth models appropriate for mammals (Tjørve & Tjørve, 2010), namely: two forms of the von Bertalanffy growth function (Von Bertalanffy, 1938) - the typical form and the original form; and the Gompertz, Logistic and Richards growth models (Ricker, 1975).

The candidate models were adjusted using the non-linear interactive Levenberg-Marquardt method in the "FSA" analysis package (Ogle et al., 2019). The confidence intervals of 95% from the estimated parameters were obtained via bootstrap resampling (1,000 interactions). The model's selection was based on the Akaike Information Criteria (AIC) and on corrected delta AIC values (AICc) in the package 'AIC modavg' (Mazerolle, 2019), which considers the probability value as well as the number of estimated parameters. Each model is ranked relative to the best-fitting model, and the most parsimonious is the one with the lowest ΔAIC value. Models with ΔAIC ≤ 2 are also supported (Burnham & Anderson, 2002). The growth models were adjusted separately according to male and female data due to reported sexual dimorphism in total length (Kasuya & Brownell, 1979; Pinedo, 1991). The ages at which the asymptote was reached were based on the predicted age-length calculated from the best-fitting model (Conversani et al., 2020).

Results and Discussion

We recorded a total of 523 franciscana strandings during the study period (August 2015 to August 2024), with different conditions and stages of decomposition: 9 (1.7%) code 1, 49 (9.4%) code 2, 141 (27%) code 3, 292 (55.8%) code 4, and 32 (6,1%) code 5. It was often not possible to evaluate evidence of human interaction and determine sex and/or total length in carcasses in advanced stages of decomposition. Sex was determined in 41.3% of the strandings (n = 228), and the number of females and males was 120 and 108, respectively. Similar to what was suggested by Di Beneditto & Ramos (2001), the proportion indicates there are no sex-biased areas of usage based on stranding patterns.

Age Distribution

The age of 326 dolphins was estimated from 0 to 17.5 years (Fig. 2). Calves (< 1 year of age) were the most frequent (n = 79, 24.3%), followed by juveniles from 1 to 1.9 year (n = 65, 19,9%), and adults older than 4 years (n = 114, 34,9%). Our age distribution data reveal two important differences in relation to the studies by Botta et al. (2010), Negri et al. (2014), Conversani et al. (2020), and Silva et al. (2020): the presence of more calves than juveniles

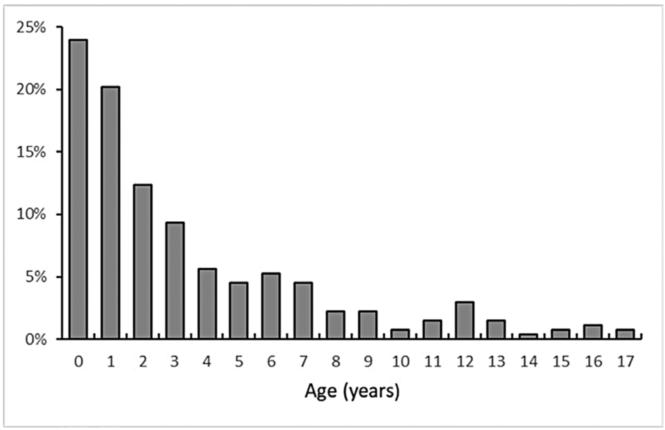

Figure 2. Age distribution of franciscana stranded (n=326) in the northern coast of São Paulo, Brazil, from August 2015 to August 2024.

Table 1. Estimated growth parameters with the 95% confidence interval and results of the five models of growth candidates to the length-age data adjustment of franciscana in the northern coast of São Paulo, Brazil.

Group	Model	L_∞ (cm) (95% CI)	L_0 (cm) (95% CI)	k; g_i (95% CI)	t_0; t_i (95% C_I)	AIC_c	ΔAIC_c
Females (n=45)	GGM	139.54 (135.78, 143.28)	-	0.81 (0.69, 1.00)	-0.42 (0.57, -0.28)	257.65	0.33
	OVB	140.08 (136.28, 144.38)	68.08 (63.64, 72.00)	0.65 (0.53, 0.81)	-	258.91	1.59
	TVB	140.08 (135.98, 144.38)	-	0.65 (0.53, 0.81)	-1.01 (1.27, -0.78)	258.91	1.59
	LGM	139.26 (135.74, 143.08)	-	-	-0.02 (0.16, 0.09)	257.32	0
	RGM	139.56 (135.77, 143.79)	-	0.78 (0.55, 0.94)	-	260.36	3.04
Males (n=42)	GGM	116.72 (113.17, 121.46)	-	1.31 (1.00, 1.72)	-0.38 (0.60, -0.23)	273.71	1.6
	OVB	117.14 (113.53, 121.25)	62.92 (53.23, 69.32)	1.11 (0.85, 1.51)	-	272.16	0.05
	TVB	117.14 (113.53, 121.78)	-	1.11 (0.83, 1.48)	-0.69 (0.97, -0.50)	272.16	0.05
	LGM	116.40 (112.90, 121.00)	-	1.52 (1.12, 1.99)	-0.14 (0.32, -0.01)	275.29	3.17
	RGM	118.90 (114.30, 127.10)	-	0.59 (0.17, 1.43)	-	272.11	0

Note: L_∞: asymptotic length (cm); L_0: length at birth (cm); k: rate of growth (year^{-1}); g_i: instantaneous growth rate at the inflection point; t_0: theoretical age at zero length; t_i: age at the inflection point; AIC_c; ΔAIC_c: corrected and delta values of Akaike's. GGM: Gompertz growth model; OVB: Original von Bertalanffy growth model; TVB: Typical von Bertalanffy growth model; LGM: Logistic growth model; RGM: Richards growth model.

and a higher percentage of adults. In the cited studies, the percentage of adults is below 20%, while in our analysis adults represent a considerably larger portion of the population. We do not have historical data from the region to determine whether this pattern has changed over time. However, gillnet fishing in the area has been reported as significant since the 1970s (Diegues, 1974; Mussolini, 1980), suggesting this activity has impacted franciscana dolphins for decades. The higher mortality rate of calves may be related to several factors that require further investigation. One of them is the increase in water pollution and contamination, which can make calves more susceptible to diseases. Marine pollution has been recognized as a growing threat to the franciscana populations (Lailson-Brito et al., 2022). Another critical issue is overfishing and the consequent reduction in food resources. It is known this has a direct impact on the diet of these cetaceans (Domit et al., 2022), hinders mothers from feeding themselves, and leads to calves being born in unfavorable nutritional conditions. In addition, orphan calves are less likely to survive on their own, leading to a direct relation to adult and calf mortality. To better understand these issues, it is essential to further investigate the causes of calves' deaths. Furthermore, studies of animals in their natural habitat, assessment of body conditions, and apparent injuries can provide a general overview of their health. The same applies to the investigation of adult mortality, seeking to understand whether fishing is the main factor or whether there are other causes, such as diseases or environmental changes.

Growth Model

Only individuals with sex, age, and length data were used in the growth models, comprising 45 females and 42 males. All five models tested presented a good fit to the data for both females and males ($\Delta AIC < 2$), except for the Richards' model for females and the Logistic model for males (Table 1). However, to facilitate the comparison with previous studies, Gompertz's model was used to describe growth for both sexes.

The total length of females ranged from 56.5 cm to 151 cm (mean of 104.48 cm) and males from 55.5 cm to 133 cm (mean of 99.53 cm). The asymptotic length was 139.54 cm, 95% CI (135.78 - 143.28) for females and 116.72 cm, 95% CI (113.17 - 121.46) for males (Fig. 3). There are no publications with this kind of data for FMA IIa for comparison; however, the results are compatible with the literature for FMA IIb (Rosas et al, 2002; Barreto & Rosas, 2006; Conversani et al., 2020; Silva et al., 2020).

Birth size and development classification

All individuals without erupted teeth or for which age was estimated (by osteological analyses) as 0 year (n = 58), stranded between September and February, indicating a period of seasonal birth during spring and summer, which is similar to observed in other regions (Rosas & Monteiro-Filho, 2002; Secchi et al., 2021; Danilewicz et al., 2022).

Based on the growth model, the predicted length at birth was 68.08 cm for females and 62.92 cm for males. However, we did not consider only the growth model to estimate birth size in franciscana, as pointed out in other studies, because the growth model becomes more accurate after one year of age

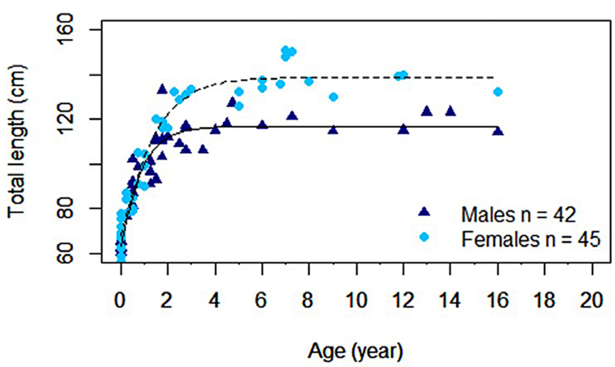

Figure 3. Growth curves predicted by the Gompertz's model for females (dashed line) and males (continuous line) of franciscana from the northern coast of São Paulo, Brazil.

Table 2. Authors' classification stages of franciscana development in the FMA IIa, northern coast of São Paulo, Brazil. Specimens with a total length outside the ranges established in the table should be classified as 'undefined' due to an overlap of characteristics between developmental categories.

Developmental stage	Osteological age (years)	Total length (cm)
Calf	≤ 0.75	≤ 87
Juvenile female	≥ 1; ≤ 2.9	≥ 106, ≤ 122
Juvenile male	≥ 1; ≤ 2.9	≥ 106, ≤ 115
Adult female	≥ 3	≥ 126
Adult male	≥ 3	≥ 117

(Ramos et al., 2000; Botta et al., 2010; Conversani et al., 2020). We recorded 16 individuals between 55.5 and 72 cm, developed with remnants of the umbilical cord. The smallest neonate (55.5 cm) had maternal milk in its stomach, evidencing it to be a newborn, not a fetus. It is further estimated that the umbilical cord remains attached from 48 to 72 h after birth (Danilewicz, 2003), indicating strandings of neonates. Therefore, birth size can be deduced to vary between 55.5 and 72 cm, a gap in which we registered newborns, extrapolating the results proposed by the growth model.

Based on osteological data and presence of milk in the stomach, lactation period was estimated between seven and nine months, depending on the geographic region (Harrison et al., 1981; Rosas & Monteiro-Filho, 2002; Denuncio et al., 2013; Danilewicz et al., 2022). Like McHugh et al. (2011), who assumed *Tursiops truncatus* can be classified as juveniles when feeding independently from maternal milk, the present study classified calves with the following characteristics: presence of milk in the stomach, absence of teeth, and less than one year of estimated age.

Using stranded carcasses to obtain as much information as possible is a unique opportunity to deepen knowledge about species. Basic information, such as developmental stage classification, is crucial for effective population monitoring over time. This classification enables us to understand the patterns of growth, reproduction, and mortality throughout the animal's life, and is crucial for identifying the survival strategies of the species.

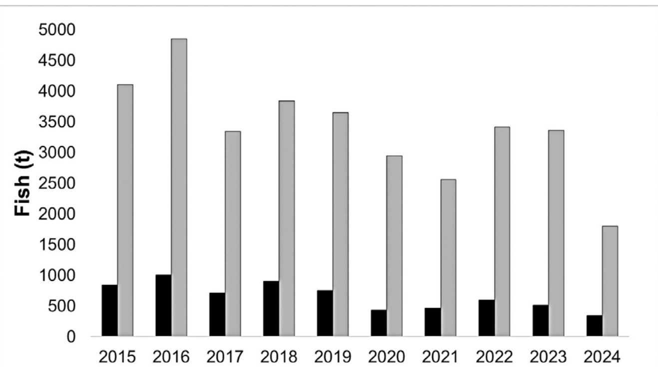

Figure 4. Landed weight of fish in tonnes along the entire coast of the state (gray columns) compared to the northern coast of São Paulo (black columns) (source: IP/APTA/SAA/SP).

Monitoring population trends is another important application of this classification. It facilitates the identification of changes in the age structure over time. For example, a reduction in the proportion of calves and juveniles may indicate problems related to reproduction or survival of the animals. In addition, it is not always possible to perform osteological examinations or assess the sexual maturity of all animals. Therefore, the classification of developmental stages based on animal length becomes a necessary tool, especially in field monitoring situations. It is, therefore, essential that this classification be carried out in a standardized manner. Based on our data, we suggest a classification (Table 2) for the franciscana of FMA IIa.

Fishing interactions

During the nine-year study period, we recorded 523 stranded franciscana carcasses in the region, averaging 58 individuals per year. Among the intact specimens that allowed a careful evaluation (n = 177), approximately 60% (n = 106) showed evidence of fishing interaction. These data demonstrate the impact of fishing activity on the species mortality in FMA IIa. As mentioned, gillnet is the main gear responsible for the bycatch of franciscana (Secchi et al., 2021). Furthermore, it is important to emphasize that stranding number does not reflect the total mortality of the species in the region, because only a small fraction of the animals that die at sea reaches the beaches (Epperly et al., 1996; Peltier et al., 2012; Prado et al., 2013).

Gillnet fishing on the north coast is of relevance to fisheries in the state of São Paulo. The comparison between the volume of catch landed from gillnet fishing throughout the state and the volume landed exclusively on the north coast, for the period studied, is presented in Fig. 4. During this period, catches on the north coast fluctuated less than the state's volume, with this region accounting for up to 23.5% of the total landed in the state in 2018 and for a minimum of 14.8% in 2020, with an overall average of 19.3% over the period. Regarding the revenue obtained from this fish sale, considering the first marketing price, the north coast corresponded to an average of 17.1% of the state's total. Despite variations over time, gillnet fishing remains in the region and is economically important for local fishermen.

Regarding fishing activity in the study area, when analyzing the gillnetting methods under several parameters, such as the number of landings, the quantity of fish landed, and the productive units, we observed that Ubatuba stands out in comparison to the other municipalities in the region, followed by São Sebastião,

Table 3. Number of landings, quantity of fish landed, and number of productive units in the municipalities that make up the northern coast of São Paulo, from August 2015 to August 2024 (source: IP/APTA/SAA/SP).

Municipality	Number of landings [n, (%)]	Quantity of fish [t, (%)]	Productive units [n, (%)]
Ubatuba	34,301 (40.1)	4,422 (73.5)	1,227 (41.8)
São Sebastião	24,136 (28.2)	951 (15.8)	759 (25.9)
Caraguatatuba	16,124 (18.8)	327 (5.4)	264 (9.0)
Ilhabela	11,038 (12.9)	313 (5.2)	682 (23.3)

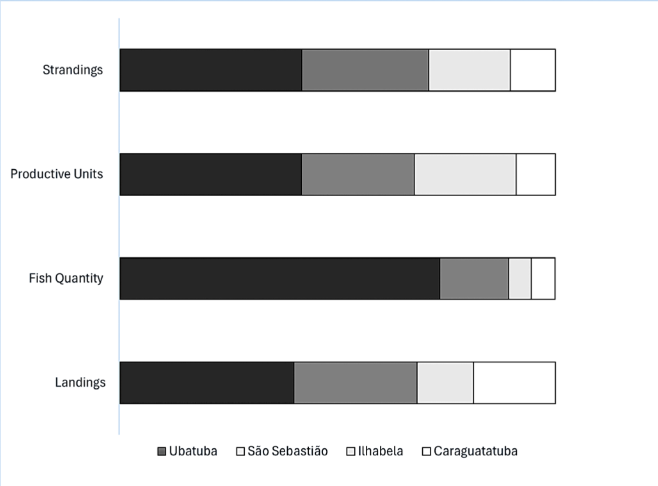

Figure 5. Percentage of franciscana strandings, productive units, quantity of fish, and landings from gillnet fishing in the four municipalities (Ubatuba, São Sebastião, Ilhabela and Caraguatatuba) of São Paulo state.

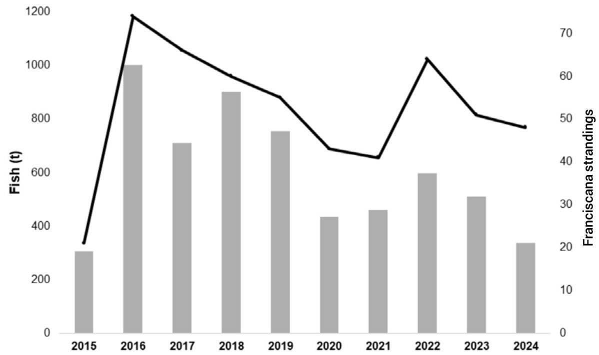

Figure 6. Number of franciscana strandings (line) and total in tonnes per year of fish landings (columns) carried out by municipalities on the northern coast of São Paulo from August 2015 to August 2024 (source: IP/APTA/SAA/SP).

Caraguatatuba, and Ilhabela (Table 3). The only exception occurs in the parameter of productive units, in which Ilhabela has a higher number (n = 682; 23.3%) than Caraguatatuba (n = 264; 9.0%).

This pattern of fishing activity distribution in the different municipalities is directly reflected in the data on franciscana stranding events (Fig. 5). Most strandings on the northern coast of São Paulo occurred in Ubatuba (n = 219; 41.9%), followed by São Sebastião (n = 152; 29.1%), Ilhabela (n = 98; 18.7%), and Caraguatatuba (n = 54; 10.3%).

Franciscana is a species that occurs along the entire northern coast of São Paulo, and, considering its state of decline, the preservation of its entire range is crucial for its survival. Our data reveal that Ubatuba is the municipality where the fishing impact on the species is most notable, which can be attributed to its high fishing activity, especially in relation to the use of gillnets. Furthermore, the mapping carried out (Fig. 1) indicates that the central region of Ubatuba stands out on the concentration of franciscana strandings. This same region is also where we recorded the highest number of species sightings on the north coast (Instituto Argonauta, unpubl. data). Therefore, the high number of strandings may also be related to the population density in this area, resulting in a higher incidence of gillnet interactions.

Seasonal patterns

When analyzing fishing activity parameters over the years, it is possible to observe a significant variation characterized by a sharp drop in landed volume of fish during the Covid-19 pandemic in 2020 and 2021. A recovery process followed this reduction in 2022. Likewise, records of franciscana strandings also showed a reduction in this period (Fig. 6). It is worth noting that the monitoring effort of the PMP-BS remained constant throughout this period.

In contrast, gillnet fishing in the region does not show marked seasonal variation when analyzed in relation to landed volumes. Considering all municipalities, we observed that, of a total of 85,599 landings, 28% occurred in autumn, 27% in winter, 24% in spring, and 22% in summer. For strandings, however, the pattern is distinct, with most records occurring in spring (n = 186; 35.6%), followed by winter (n = 141; 26.9%), summer (n = 137; 26.2%) and, less frequently, in autumn (n = 59; 11.3%). This pattern, of higher volume of strandings in spring and fewer in autumn, has already been observed in other regions (Santos et al., 2002; Cremer et al., 2022).

Thus, it is understood that, while gillnet fishing remains relatively stable throughout the seasons, franciscana mortality shows seasonal behavior. Given this, it is necessary to investigate why, despite fishing not presenting significant seasonal variations, strandings vary throughout the year. Spring is the main calving period, and this group may be susceptible to fishing interactions. Our age distribution data reinforce this hypothesis, as they indicate a higher proportion of calf strandings than observed in other studies.

Another factor that may contribute to this analysis is the variation in the fishing target species (Table 4). Whitemouth croaker (*Micropogonias furnieri*) stands out among the catches, with the highest volumes recorded in autumn and winter. During winter, there is also an increase in Lebranche mullet (*Mugil liza*), Leatherjackets (guaivira; *Oligoplites* spp.), and sharpnose shark catch (*Rhizoprionodon* spp.), while Southern king weakfish (*Macrodon atricauda*) is predominant in summer. Serra Spanish mackerel (*Scomberomorus brasiliensis*) and mixed fish are more frequent in the autumn, and kingcroackers (*Menticirrhus* spp.), requiem sharks (*Carcharhinus* spp.), and mixed fish during the spring. When relating the captured species to the different types of gillnets, among the nine species analyzed, only two are not captured by bottom gillnet, being recorded exclusively in surface/drift gillnets capture.

In addition to being the fishing target species, *Micropogonias furnieri* and *Menticirrhus* spp. also comprise the franciscana diet (Henning et al., 2018). This overlap raises a question: during periods of reduced fish stocks, could the franciscana approach the nets in search of food, thereby increasing the risk of gillnet entanglement? During our recordings, we documented an individual with a fishing net fragment stuck to its rostrum, immobilizing its jaw and maxilla. In addition, in the animal's first stomach, we found a fish of the Sciaenidae family next to a piece of entangled fishing net, suggesting a possible direct interaction between predation and bycatch. As mentioned, fishing has been a consistent practice over the years, and franciscana remains

Table 4. Ranking of the main fish species captured by gillnets on the northern coast of São Paulo from August 2015 to August 2024. These species account for 81.49% of the total catch. Seasons with the largest catches are indicated in bold.

Common Name	Scientific Name	Total	%	Autumn (t)	Winter (t)	Spring (t)	Summer (t)	Gear Type
Whitemouth croaker	*Micropogonias furnieri*	3,401.01	56.54	**1,345.77**	**1,314.45**	405.50	335.28	Bottom gillnet
Lebranche mullet	*Mugil liza*	424.57	7.06	167.71	**226.86**	4.190	25.81	Surface/drift gillnet
Leatherjackets (guaivira)	*Oligoplites* spp.	193.74	3.22	61.68	**67.09**	33.82	31.16	Bottom gillnet
Southern king weakfish	*Macrodon atricauda*	185.64	2.01	36.66	36.60	49.34	**63.05**	Bottom gillnet
Serra Spanish mackerel	*Scomberomorus brasiliensis*	168.35	2.80	**83.2**	77.42	3.67	4.06	Surface/drift gillnet
Requiem sharks	*Carcharhinus* spp.	139.71	2.32	19.17	20.90	**55.67**	43.98	Bottom gillnet
Mixed fish		102.05	1.70	**29.36**	23.79	**28.6**	20.30	Bottom gillnet
Sharpnose sharks	*Rhizoprionodon* spp.	94.96	1.58	22.04	**28.77**	21.13	23.02	Bottom gillnet
Kingcroakers	*Menticirrhus* spp.	64.13	1.07	7.74	10.26	**27.64**	18.49	Bottom gillnet

the cetacean with the highest stranding numbers on the North Coast (Petrobras, 2019a). To better understand this mortality trend, a more comprehensive temporal analysis is essential.

This study covers the period from August 2015 to August 2024, during which the annual average stranding number was 58 individuals. However, preliminary data indicate a significant increase in mortality in the last four months of 2024 alone, in which we recorded 53 strandings (Fig. 7), a value similar to the annual average observed over nine years. There is a need to conduct a fisheries assessment during this period to understand whether a pattern is influencing the increase in stranding.

This scenario raises fundamental questions. If the species population is declining and fishing effort remains low, wouldn't a decline in strandings be expected over time? Alternatively, are these animals interacting more frequently with fishing nets due to reduced prey availability? To explain these questions, studies aimed at investigating the cause of death, health status, and live animal monitoring are needed. Sightings to estimate group size and identification of species use areas are also essential. Finally, continued stranding patterns monitoring will allow a more robust analysis of variations over the years.

Given the significant impact of bycatch on franciscana mortality, it is essential that mitigation strategies be developed in cooperation with fishermen. Fishing plays a fundamental role in food security, the local economy, and society. Therefore, fishermen are essential agents in the search for sustainable solutions. The implementation of effective measures to reduce bycatch must consider the fishermen's traditional knowledge and include collaborative approaches, such as the development and testing of alternative technologies, improvement of fishing regulations, maritime zoning, and encouragement of more selective practices. The franciscana bycatch is a challenge

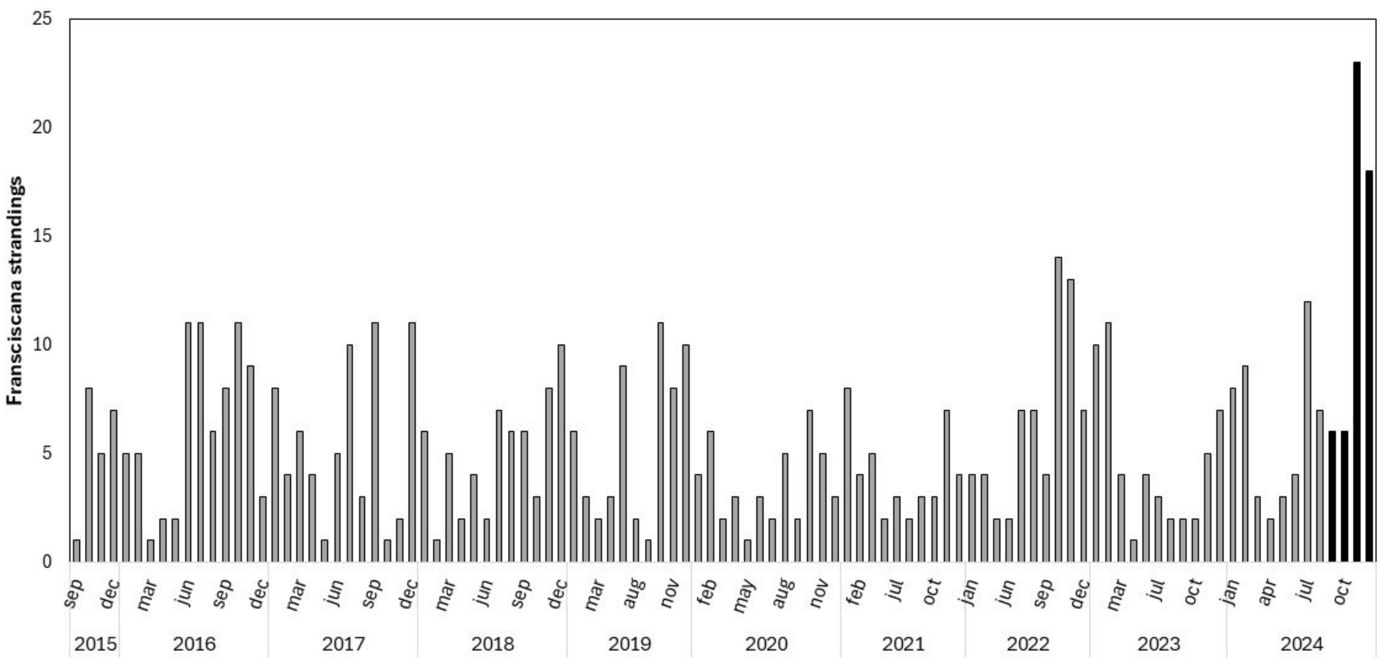

Figure 7. Number of franciscana strandings over the months (2015-2024). Black columns are recent data outside this study period.

that englobes more than just this species and must be treated as a socio-environmental demand, requiring the engagement of different sectors of society and ensuring the conservation of the species without compromising the livelihood of fishing communities.

Conclusion

Our results reinforce the relevance of the northern coast of São Paulo, especially the Ubatuba region, as an area with a high occurrence of *Pontoporia blainvillei* strandings, in addition to highlighting the increased incidence of interaction between the species and gillnet fishing. The high frequency of calves and adults indicates mortality patterns distinct from those observed in other regions, although the reason is unclear and deserves further investigation.

Approximately 60% of the specimens analyzed showed evidence of fishing interaction, indicating that mitigation measures to prevent bycatch are urgently needed for species conservation. The use of acoustic devices or other alternatives that reduce fishing gear interaction, combined with effective monitoring, can decrease the number of irregular nets and strengthen zoning areas used by the species, thereby ensuring stricter control of fishing activity in these regions. It is important to emphasize that these and other measures must be developed together with the fishermen. Continued monitoring of strandings is essential to assess population trends and guide adaptive management policies, as is the need for new research into the health and cause of death of animals and their environment.

Based on our findings, franciscana occurs throughout the region and Ubatuba should be considered a priority municipality for species conservation action in FMA IIa, structuring coordinated efforts between environmental agencies, the fishing community, and research institutions to reduce the high incidental mortality and ensure the survival of the population in the region.

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