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Acoustic Behavior of Franciscana Dolphins (*Pontoporia blainvillei*) Around a Fishing Net During a Bycatch Event

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Accidental entanglement in gillnets poses an urgent threat to the franciscana dolphin (*Pontoporia blainvillei*), a small cetacean endemic to the Western South Atlantic Ocean (Secchi et al. 2003, 2022; Zerbini et al. 2017). The species, which inhabits shallow coastal waters from Espírito Santo, Brazil (18°25'S 30°42'W), to northern Patagonia, Argentina (42°35'S 64°48'W) (Crespo et al. 1998; Siciliano 1994), is increasingly vulnerable to both small-scale and large-scale fishing activities (Crespo et al. 2010; Danilewicz et al. 2010; Sucunza et al. 2020). The high mortality rate caused by gillnet bycatch has pushed the franciscana dolphin to the brink of extinction, making it one of the most endangered cetaceans in the Western South Atlantic. It is currently classified as Vulnerable by the International Union for Conservation of Nature (IUCN) (Secchi et al. 2022) and as Critically Endangered in Brazil (MMA 2022).

The causes of accidental entanglement of small cetaceans remain poorly understood. The prevailing hypotheses are primarily related to acoustic factors, considering that echolocation is the main sensory mechanism used by small cetaceans to perceive their environment. In this context, accidental entanglement may be associated with the inefficiency of biosonar in detecting the nylon filaments of gillnets (made of polyamide), which may not produce detectable echoes; the animals' inability to perceive the net; their failure to recognize the net as a threat; and/or the fact that they do not use biosonar continuously (Bordino et al. 2002; Kratzer et al. 2020; Read et al. 2006). In the case of franciscanas, Frainer et al. (2015) suggest that juveniles may fail to detect gillnets due to an underdeveloped echolocation system. Indeed,

the largest proportion of stranded animals found dead with evidence of gillnet interactions is juveniles (Cremer, Danilewicz, et al. 2022; Cremer, Prado, et al. 2022; Negri et al. 2016), which may further support this hypothesis.

Franciscana dolphins form family groups, where the male may remain with the female for a period after the birth of the calf, contributing to parental care (Costa-Urrutia et al. 2012; Cremer, Danilewicz, et al. 2022; Cremer, Prado, et al. 2022). They typically form groups of two to five individuals, although groups of up to 10 have also been observed in some cases (Cremer and Simões-Lopes 2005; Cremer, Danilewicz, et al. 2022; Cremer, Prado, et al. 2022; Sucunza et al. 2020). The franciscanas produce narrow-band high-frequency echolocation clicks (NBHF) (Melcón et al. 2012) and are the only species along the Brazilian coast with this characteristic. This allows for highly reliable acoustic identification of the species using passive acoustic monitoring (PAM) devices (Paitach et al. 2021). In this context, PAM has proven to be highly effective in monitoring the occurrence and behavior of the species, even under limited visibility conditions, such as during nighttime or rainy periods (Giardino et al. 2023, 2025; Melcón et al. 2012; Paitach et al. 2021). Among the opportunities provided by PAM is the ability to study the acoustic behavior of the species near gillnets by attaching monitoring equipment to them. Therefore, this study aimed to describe the acoustic behavior of franciscana dolphins recorded by a C-POD attached to a fishing net, with the goal of evaluating acoustic cues related to the incidental capture event.

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In January 2023, a C-POD (Chelonia Limited, UK), a specialized underwater click detector, was deployed at one end of a small-scale gillnet to monitor the presence and acoustic behavior of franciscana dolphins. The C-POD is designed to detect and record the presence of echolocation clicks of dolphins and other cetaceans. With the voluntary collaboration of an artisanal fisherman, the device was attached to a bottom-set gillnet targeting whitemouth croaker (*Micropogonias furnieri*). The fishing gear had a mesh size of 14 cm (measured between opposite knots), a total length of 3000 m, and a height of 3 m (Arrial et al. 2024), and was used in Laguna, Santa Catarina, southern Brazil.

Between January 30 and 31, 2023, the fisherman reported the incidental capture of a franciscana dolphin in the acoustically monitored net, which was deployed near Ilha dos Lobos (28°25'S 48°43'W) at a depth of 16 m. The net remained in the water from 14:00 on January 30, 2023, until 06:00 on January 31, 2023, totaling 16 h of fishing effort and PAM. According to the fisherman's report, the incidental capture was recorded during net retrieval on January 31, 2023. According to the fisherman, the animal was already dead and was not a calf but had an estimated length of approximately 1 m. The dolphin was entangled at the same end of the net where the C-POD was attached. It was not possible to analyze the carcass because the fisherman discarded it at sea.

The data recorded by the C-POD were stored on an SD card and processed using the CPOD.exe software, which includes an automated classifier (KERNO, Chelonia Limited, UK) capable of detecting all NBHF sounds. The acoustic parameters of the detected NBHF click trains were then exported, and the inter-click interval (ICI) of all click trains was analyzed to categorize behavioral patterns based on click repetition rates. Three behavioral categories were assessed: navigation, foraging, and communication. Regular echolocation click trains, used for navigation and movement between areas (referred to here as echolocation), enable the animals to perceive their surroundings and are characterized by a slower repetition rate with a relatively constant ICI (Martin et al. 2019; Nuutila et al. 2013). Echolocation click trains associated with foraging, known as feeding buzzes, occur during prey approach and capture and are characterized by a progressive increase in click repetition rate (Martin et al. 2019; Nuutila et al. 2013). Finally, click trains used for communication, called burst-pulses, exhibit high repetition rates throughout the entire train (Martin et al. 2019).

Behavioral categories were assigned based on the ICI criteria of the detected click trains as follows: echolocation when the minimum ICI was > 10 ms; feeding buzzes when the minimum ICI was < 10 ms and the maximum ICI was > 10 ms; and burst-pulses when both the minimum and maximum ICI were < 10 ms. Since there are no specific reference values for franciscana dolphins defining an ICI threshold for these acoustic behavior categories, classification was based on Paitach et al. (2021), adapted from studies conducted on other NBHF species (Carlström 2005; Martin et al. 2019; Nuutila et al. 2013). Although buzzing sounds can be used in social interactions (Clausen et al. 2010), the classification criteria adopted have proven satisfactory in studies with the species (Paitach et al. 2021). It is essential to highlight that, although the absence of species-specific data for franciscanas may introduce limitations in the classification of individual click trains, this study aimed to describe general

behavioral patterns by analyzing the proportion of different categories.

Statistical analyses were performed to assess the proportions and percentages of acoustic cues, used as a proxy for behavior, recorded near the fishing net. During the entire period the C-POD remained in the water, 1206 franciscanas click trains were recorded. Echolocation click trains were predominant, based on frequency of occurrence (FO) ($n = 831$, FO = 68.9%), followed by burst-pulse click trains ($n = 250$, FO = 20.7%) and feeding buzzes ($n = 125$, FO = 10.4%) (Table 1).

Franciscanas were detected near the fishing net throughout the sampling period, with the recording of feeding buzzes, burst-pulse trains, and echolocation signals recorded, suggesting feeding activity, traveling, and/or social behavior (Martin et al. 2019; Nuutila et al. 2013; Paitach et al. 2021). However, between 16:00 and 17:59, a sudden increase in detections was recorded, with 939 click trains (Figure 1). Of the 939 click trains recorded, 72.2% ($n = 678$) were echolocation signals, 17.6% ($n = 165$) were burst-pulse trains, and 10.2% ($n = 96$) were feeding buzzes (Figure 1).

The period between 16:00 and 17:59 accounted for 78% ($n = 939$) of the total click trains recorded throughout the sampling period (16 h). In comparison, the preceding and subsequent periods represented 22% ($n = 267$) of the total click trains (Figure 1 and Table 1). Additionally, the proportions of detections within and outside the peak period are directly compared in Figure 2.

This high concentration of click trains in a short time suggests the occurrence of atypical behavior, considering previous recordings of franciscana dolphin acoustic behavior near a gillnet (Arrial 2024; Giardino et al. 2023, 2025). In 3545 h of net monitoring, a pattern like that found in the present study has never been recorded (R. L. Paitach, personal communication, 2025).

The intense acoustic activity suggests the presence of multiple individuals in the area, and, considering that the shorter the distance of PAM devices from the emitter, the greater the probability of detecting acoustic signals (Todd et al. 2025), they were probably near the click detector. As the individual became entangled near the C-POD, it is likely that the acoustic activity recorded by the C-POD was related to the entanglement of the individual.

The high proportion of burst-pulses (17.6%, $n = 165$) in this hour indicates potential social communication behavior, and we suggest that the group might have exhibited epimeletic behavior because of the bycatch of an individual. Such behavior has previously been recorded for this species in the context of incidental capture (Cremer et al. 2006). The production of whistles by franciscanas, a sound typically associated with socializing behavior, was recorded for the first time during capture, tagging, and release procedures and was linked to stressful situations (Cremer et al. 2017). Unfortunately, it is not possible to record whistles with C-PODS because this equipment records only pulsed sounds. Although it was not possible to determine the exact moment when the bycatch event occurred, the abrupt change in acoustic emission patterns during this period suggests that the bycatch might have happened around 16:00 and that nearby animals might have exhibited epimeletic behavior until 17:59.

TABLE 1 | Total number and frequency of occurrence (FO) of pulsed sound trains emitted by franciscana dolphins (*Pontoporia blainvillei*), categorized by inter-click interval (ICI) according to Martin et al. (2019) and Nuutila et al. (2013), recorded during a bycatch event in Laguna, Santa Catarina, southern Brazil.

Presumed behavior	Navigation/displacement	Foraging	Social communication		
Hour of detection	Echolocation	Feeding buzzes	Burst pulses	Total	FO
14:00	2	4	3	9	0.7%
15:00	21	7	24	52	4.3%
16:00	589	68	96	753	62.4%
17:00	89	28	69	186	15.4%
18:00	8	2	8	18	1.5%
19:00	1	0	0	1	0.1%
20:00	3	0	0	3	0.2%
21:00	30	0	0	30	2.5%
22:00	1	0	0	1	0.1%
23:00	1	2	1	4	0.3%
00:00	10	5	15	30	2.5%
01:00	15	1	0	16	1.3%
03:00	4	0	0	4	0.3%
04:00	9	5	9	23	1.9%
05:00	25	3	24	52	4.3%
06:00	23	0	1	24	2.0%
Total	831	125	250	1206	100%

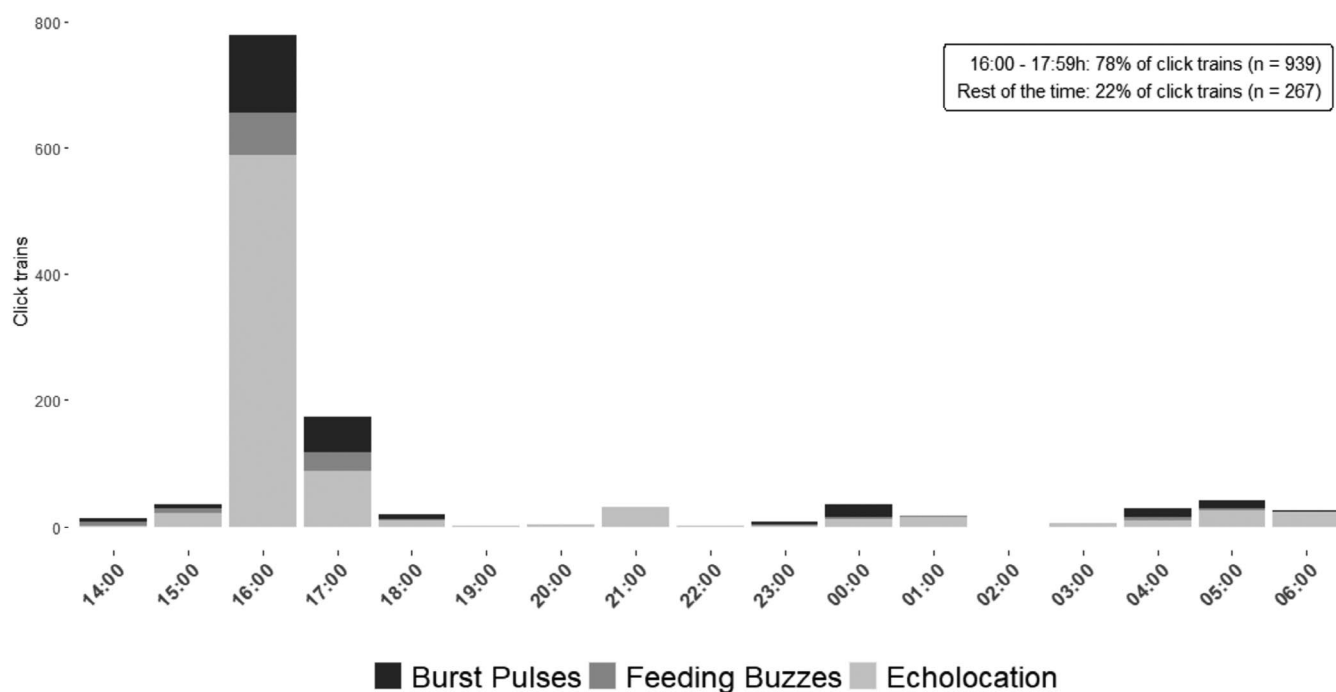


FIGURE 1 | Distribution of franciscana dolphins (*Pontoporia blainvillei*) click trains recorded with a C-POD from 14:00 on January 30, 2023, until 06:00 on January 31, 2023, near a gillnet in South Brazil: Light gray represents echolocation sounds, gray represents feeding buzzes, and dark gray represents burst-pulses.

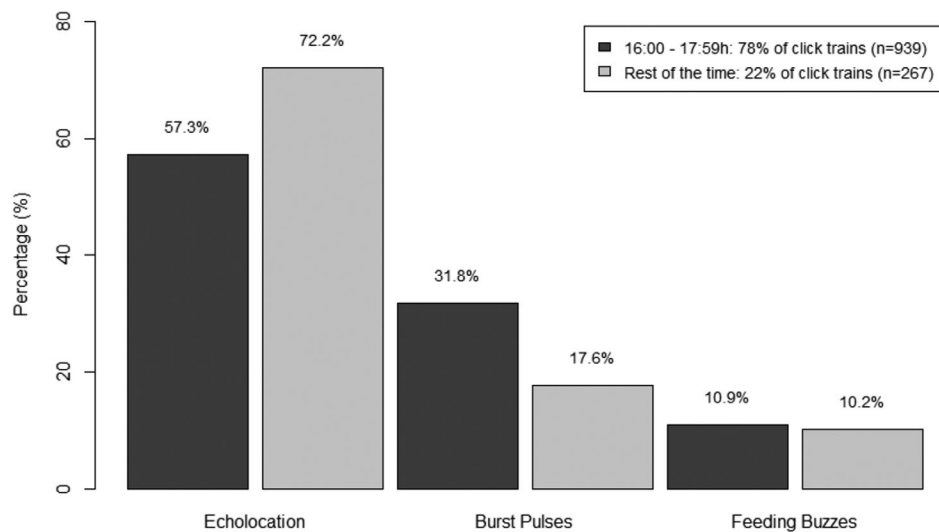


FIGURE 2 | Proportions of franciscana dolphin (*Pontoporia blainvillei*) click trains recorded within and outside the 2-h peak detection period (16:00–17:59 h) throughout the sampling period.

Considering that franciscana dolphins live in groups composed of closely related individuals (Costa-Urrutia et al. 2012; Cremer, Danilewicz, et al. 2022; Cremer, Prado, et al. 2022; Valsecchi and Zanelatto 2003), an incidental capture event likely affects the behavior of other group members, which could explain the intense acoustic activity recorded for up to 2 h, with a decline from the first to the second hour. This decline may be associated with the animals moving away from the individual accidentally captured in the net. Burst-pulses are regularly produced during social interactions within groups of odontocetes and have also been shown to be used as alarm signals (Blomqvist and Amundin 2004; Martin et al. 2019). Small cetaceans, including franciscana dolphins, generally do not survive entanglement in fishing nets for long, as they suffocate within minutes (Dolman and Moore 2017). For this reason, it is plausible to assume that other members of the group produced most of the sounds recorded during the period after the potential entanglement.

Feeding buzz click trains accounted for 10.2% ($n = 96$) of the intense acoustic activity period (16:00–17:59), with a similar proportion observed throughout the remaining sampling periods (10.9%), indicating that dolphins are potentially foraging in this area, near the island (Martin et al. 2019; Nuutila et al. 2013; Paitach et al. 2021). According to Malinka et al. (2021), buzzing sounds can also be used to discriminate fine-scale objects, and in this case, the fishing net can be considered a short-range object; furthermore, it is possible that buzzing sounds could be produced for social communication as well (Clausen et al. 2010). However, a substantial increase in social communication sounds (from 17.6% to 31.8%) and a decrease in locomotion/navigation sounds (from 72.2% to 57.3%) were observed during periods of lower acoustic activity. This pattern may indicate that the animals remained near the net where the bycatch occurred. Another relevant indicator is that social communication sounds have lower energy than navigation sounds, meaning their detection range is shorter, which suggests that the animals were near where the capture is believed to have occurred and remained there for an extended period (Jensen et al. 2012; Sørensen et al. 2018; Tyack and Clark 2000).

This study provides novel insights into the acoustic behavior of *Pontoporia blainvillei*, possibly related to a stressful situation, and we suggest that this behavior was likely a response to an incidental entanglement event. The intense acoustic activity recorded, particularly the high production of burst-pulses, highlights the species' social and communicative response to stress situations. The possibility of detecting the occurrence of franciscana dolphin bycatch through an acoustic cue could also be useful in monitoring fishing activities, at least in specific areas with higher capture rates. Despite this potential, the captured animal should be close to the acoustic device, as in this study, for better efficiency in detecting click trains, especially those at short ranges, such as burst pulses.

Future studies should further investigate and compare the variability of acoustic behavior across different contexts to enhance the use of passive acoustics technologies for monitoring franciscana dolphins. Understanding the behavioral patterns of franciscana dolphins around fishing nets contributes to understanding how these animals interact with nets. The use of PAM allows data collection around nets, which is essential to develop bycatch risk models, ultimately allowing the development of more effective conservation strategies (e.g., Macaulay et al. 2022).

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Research data are not shared.

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