SC/69A/CMP/13

Sub-committees/working group name: CMP

Adapting an acoustic sailboat survey to estimate the distribution and abundance of a fringe population of franciscana dolphin (Pontoporia blainvillei) (FMA Ia)

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Adapting an acoustic sailboat survey to estimate the distribution and abundance of a fringe population of franciscana dolphin (*Pontoporia blainvillei*) (FMA Ia).

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ABSTRACT

The franciscana (*Pontoporia blainvillei*) is a small endemic dolphin found only in the coastal waters off the eastern coast of South America (Brazil, Uruguay, and Argentina). Its distribution has been divided into management areas, known as Franciscana Management Areas (FMAs). The FMA Ia in Brazil is the northernmost isolated population unit. This study aimed to collect data on franciscana at FMA Ia using a sailboat equipped with an acoustic towed array, with the objectives of documenting the method to address detection probability and provide reliable estimates of distribution and abundance. The data was collected on a 40-foot sailboat between February 22nd and May 23rd, 2019. The acoustic recording was conducted continuously with the sailboat towing a 50m linear array of four-element) omnidirectional hydrophones encompassing the cities of Vitória, ES (20°18'S, 40°15'W) and the northern limit of the State of Espírito Santo (18°19'S, 39°39'W). The conductivity (converted to salinity), temperature, and depth data were collected using the Conductivity, Temperature, and Depth (CTD) profiler SBE 19plus (Sea-bird Electronics) with the support of auxiliary sensors at 37 stations. The audio processing was conducted with the software PAMGuard version 2.02. Perpendicular distances were calculated from the sailboat to the transect line. Truncation was applied to discard all observations beyond 100 meters. Abundance was estimated using standard line-transect methods, and detection probability was estimated using Conventional (CDS) and Multiple Covariate Distance Sampling methods. The corrected density estimate (Dc) was computed by dividing Du by 3.48 (Var=4.2) from Mura et al. (this meeting). The northern boundaries of FMA Ia could be maintained as Amaral et al. (2018) (18º20'S), and the southern limit can be extended and placed at 20°01'S. The coastline corresponding with these new proposed boundaries is 220 km. The FMA Ia population density was estimated at 0.29 (CV=0.69) individuals per km2 for the whole area. The total abundance number was 1256 (CV=0.69) individuals in this study. The study area faced serious habitat degradation due to the iron ore tailings reaching the coast, and the need for continuous monitoring was highlighted. The study also demonstrated the effectiveness of using an autonomous and automated system for abundance estimation, suppressing human perception biases and enhancing reproducibility.

INTRODUCTION

The franciscana (*Pontoporia blainvillei*) is an endemic small dolphin discontinuously inhabiting coastal waters off the eastern coast of South America between Brazil (18º20'S) and Argentina (41º10'S). The species is regarded as the most threatened cetacean in South America due to high, possibly unsustainable, bycatch levels as well as increasing habitat degradation throughout its range (Ott *et al.*, 2002; Secchi *et al.*, 2003a) and is listed as Vulnerable by the IUCN Red List of Threatened Species (Zerbini et al. 2017) and "Critically endangered" by the Brazilian Government (Ministério do Meio Ambiente [MMA in Portuguese], 2022). The species becomes especially vulnerable due to its typically coastal habitat, a region under the influence of human activities related to coastal development (Secchi, 2010; Cremer et al., 2022).

The franciscana range was divided into four management stocks (known as Franciscana Management Areas or FMAs): Two in southeastern Brazil (FMA I and II), one in southern Brazil and Uruguay (FMA III), and one in Argentina (FMA IV) (Secchi et al. 2003). The FMA I was considered an Evolutionarily Significant Unit and was split into two distinct management units termed FMA Ia and FMA Ib (Cunha et al., 2014). Constant review of the population structure has updated the population units (Nara et al. 2022). A recent book published brings a comprehensive gathering of information and knowledge about the franciscana (Simões-Lopes and Cremer, 2022).

On November 5th, 2015, the largest mining disaster occurred when the Fundão dam (owned by Samarco) collapsed and released over 50 million cubic meters of iron ore tailings into the Doce River basin in southeastern Brazil (Hatje et al. 2017; Samarco 2016; Gomes et al. 2017). The resulting pollutants traveled more than 600 km, reaching the Atlantic Ocean at FMA Ia 14 days later. This incident, now known as the Mariana disaster, gained notoriety due to the massive volume of waste and its devastating impact on the environment and cultural heritage (Fernandes et al. 2016; Carmo et al. 2017).

Metapopulation theory suggests that fringe subpopulations are highly vulnerable to extinction. The FMA Ia is isolated from all other populations (Siciliano et al., 2002, Moreno et al., 2003; Danilewicz et al., 2012; Cunha et al., 2014; Amaral et al., 2018) and is distributed along the northern coast of Espírito Santo State, Brazil. The distribution range is 173km of coastline, not exceeding 20m depth in summer (Danilewicz et al., 2012; Sucunza et al., 2020b). It encompasses an area between Santa Cruz (19o57´S) and Conceição da Barra (18o36´S).

Aerial survey is a commonly used method for estimating the abundance of franciscana dolphins. It allows for a wide coverage of their habitat and the detection of individuals from above the water surface. Other methods include boat surveys, passive acoustic monitoring, and mark-recapture techniques (Secchi et al. 2003, Zerbini et al. 2010, Crespo et al. 2010, Danilewicz et al. 2012, Sucunza et al. 2020a). These methods consider various species' biological characteristics to improve accuracy in estimating their population size and distribution.

Aerial surveys were conducted in 2011 and 2018 to estimate franciscana abundance at FMA Ia (Danilewicz et al., 2012; Sucunza et al., 2020b). In 2011, franciscana groups were observed as far south as Santa Cruz (19°58′). Still, recent sightings have been limited to an area approximately 20 km north of this location despite a significant increase in survey efforts (Sucunza et al., 2020b). The aerial surveys conducted during the summer suggest that the franciscanas in FMA Ia are concentrated in a relatively small area (173 km of coastline) off ES, between Conceição da Barra (18°35′S) and Santa Cruz (19°56′S). The 2018 survey divided the area into two regions (north and south) and surveyed 2986 km of coastline up to 16.5 km from shore. A total of 17 franciscana groups (41 individuals, mean group size = 2.41, CV = 0.14) were observed within 8 km from shore, and after correcting for visibility and group size biases (Correction Factor [CF] = 4.42, CV = 0.04; Sucunza et al., 2020c), the abundance was estimated to be 595 individuals (CV = 0.44).

The franciscana abundance estimates (IWC 2021a) were reviewed following a procedure developed by the SC Standing Working Group (SWG) on Abundance Estimates, Status of Stocks and International Cruises (ASI). These were subsequently endorsed by the IWC Scientific Committee (IWC, 2021b). Following recommendations from the Scientific Committee, Sucunza et al. (this meeting SC69) have updated the FMA Ia estimate to 1183 individuals (CV= 0.76).

Passive acoustic monitoring (PAM) has become more accessible and widely used to explore patterns of occurrence (Boisseau et al. 2007), identifying critical habitats (Risch et al. 2014) for several species of cetaceans (Andriolo et al. 2018, Paitach et al. 2022, Zerbini et al. 2022) and inferring about potential noise impacts over the populations (Rice et al. 2014; Pirotta et al. 2015). Acoustic methods can also offer population size estimates (Marquez et al. 2013) or correction factors when coupled with visual surveys (Jacobson et al. 2017, Martin et al. 2020). Passive acoustics can also track large-scale displacement patterns (Mellinger and Barlow 2003) and long-term population trends (Evans and Hammond 2004; Rojas-Bracho et al. 2009 Vaquita Workshop Report, Magera et al. 2013; Campbell et al. 2015).

Different sources of bias can affect estimates of animal abundance during surveys. Availability bias occurs when animals are present but not detected because they are not available for detection during the platform passing (e.g., submerged). On the other hand, perception bias occurs when animals are available for detection but not detected due to other factors (e.g., observer fatigue and poor weather conditions). It is also important to assume that animals do not respond to the survey platform before being detected, as this could affect their detectability and bias the estimates (Buckland et al., 2001).

A PAM platform with a towed hydrophone array (Barlow and Taylor, 2005; Gerrodette et al., 2011; Rankin et al., 2020) provides a detection approach that circumvents the constraints of the visual platform. Detectability can be enhanced by identifying vocalizing animals' presence underwater (thereby reducing visibility bias), assuming the animals are vocalizing within acoustic detection range and not obscured by other noise (Barlow and Taylor, 2005, Paitach et al. 2022, Zerbini et al. 2022). Passive acoustic detection is a useful method for estimating cetacean density. These animals frequently vocalize for orientation, foraging, and communication, making them ideal subjects for this approach (see Marques et al., 2013 for a review).

The franciscana produces a narrow band high-frequency pattern of echolocation clicks (Melcón et al., 2012; 2016, Paitach et al. 2022, Zerbini et al. 2022) with a peak frequency of around 139kHz. This characteristic allows easy identification and classification of the echolocation click train produced by this species, differentiating from the other cetacean species usually found in the area of occurrence of franciscana (Amorim et al., 2023). The characteristic of readily identifiable sounds provides an opportunity to use passive acoustic data to estimate animal density (Marques et al. 2013).

The VIII Workshop for the Research and Conservation of the Franciscana (Workshop Report 2015, Brazil) was defined as a priority to evaluate alternative methods to assess trends in abundance (e.g., passive acoustics monitoring). Following this recommendation, we have used a sailboat equipped with an acoustic towed array to collect data to estimate the abundance and distribution of franciscana at FMA Ia. The specific objectives of this study are:

a) Document the steps followed to address detection probability correctly (automated detection);
b) Define a reliable unsupervised protocol to be applied in the whole franciscana distribution range suitable for long-term monitoring of population trends.
c) Estimate abundance of franciscana at FMA Ia;
d) Assess species distribution range.

MATERIAL AND METHODS

Study Area and Survey Design

The fieldwork was carried out in Brazil between the cities of Vitória, ES (20°18'S, 40°15'W) and the northern limit of the State of Espírito Santo (18°19'S, 39°39'W), covering the mouth of the Rio Doce, coastal and adjacent marine areas as Conservation Units APA Costa das Algas, and REVIS de Santa Cruz (Figure 1).

Sampling Methods

The data was collected on a 40-foot sailboat between February 22nd and May 23rd, 2019, totaling 90 calendar days (Table 1). The Iate Clube do Espírito Santo (Vitória/ES) was a logistical support point for the sailboat during periods inappropriate for navigation. The area was surveyed following a zigzag transect (Figure 1), except for cases where the environmental conditions did not allow following this sampling design. Visual and acoustic methods were used in the search for cetaceans. The area was divided into the north and south stratum (Table 1).

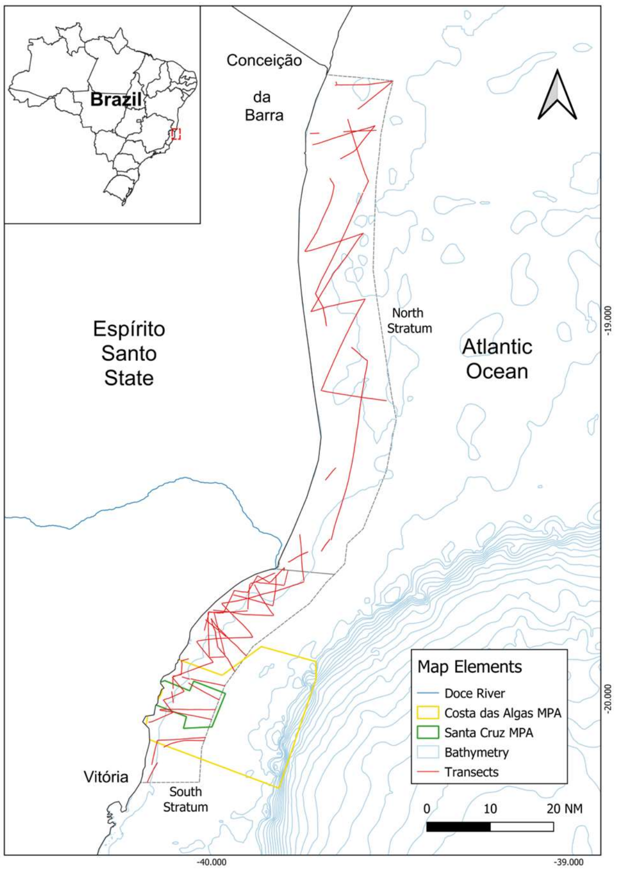

Figure 1: Transects surveyed with a sailboat in 2019 to estimate the distribution and abundance of franciscana dolphin.

Table 1 – Survey strata, covered area, transects, and survey effort for franciscana 2019 acoustic surveys in FMA Ia, Espirito Santo, Brazil.

Strata	**Area (km^2)**	**#Transects**	**Effort (km)**
(2) North	3081	43	669.90
(1) South	1258	47	448.14
Total	4339	90	1118.04

The acoustic recording was conducted continuously with the sailboat towing a 50m linear array of four-element (distances between hydrophones of 0.4, 3, and 5m) omnidirectional hydrophones (0.499 Hz high-pass filter, sensitivity of -205 dB re 1 V/lPa, preamplifier gain of 20 dB, frequency response of 265 kHz for the first pair (closer to the stern), and 160kHz for the second pair of hydrophones) (Auset Technology, Juiz de Fora, Brazil) coupled to an autonomous recording SAIL DAQ acquisition board sampling at 500kHz connected to a PAMGuard recording module (Gillespie et al., 2009). Audio files were saved in *wav* format, and the GPS data of the navigation route was recorded and kept in an appropriate database. The acoustic effort was interrupted only when the environmental conditions were unfavorable: Beaufort level six or higher of six (Castro, 2018), wave height greater than three meters, and low wind speed to maintain sailing.

The franciscana is a very shy animal that reacts to human activities, mostly submerging (Secchi and Ott, 2003). The decision to implement this method using a sailboat navigating with the engines off served two purposes: a) to try to reduce the avoidance behavior by the franciscanas, and b) to reduce the anthropogenic underwater noise (environmentally friendly). Up-to-date evidence has demonstrated that the franciscana acoustic activity is equally distributed throughout the day with no preference for daylight or nighttime (Silva et al. 2022).

Environmental variables

The conductivity (converted to salinity), temperature, and depth data were collected using the Conductivity, Temperature, and Depth (CTD) profiler SBE 19plus (Sea-bird Electronics) with the support of auxiliary sensors at 37 stations in 2019 synchronous with the acoustic surveys. The quality control of the profiles followed standard procedures (e.g., McTaggart et al., 2010), and each profile was averaged into 1 m vertical bins. Each variable's average value on the water column was calculated for each sample station.

Interpolation of environmental variables and acoustic occurrences.

The interpolation of the environmental variables and the acoustic records of cetaceans occurred through access to the original data table corresponding to the environmental variables (turbidity, apparent temperature, dissolved oxygen, and salinity), a surface of interpolation (raster file) was generated for each of these variables, using spatial interpolation methods based on Inverse Distance Weighting (IDW). This method estimates a variable in space and considers the value of the point closest to the variable to be calculated as the weight for each variable (Li et al., 2010). To determine the values used for the interpolation, the average of the values of these variables in each collection station was extracted, as these were divided according to the depth.

The environmental data corresponded with the period in which the field activities for the acoustic monitoring occurred (April and May 2019), and the spatial resolution of the generated raster was 100 m by 100 m. The reference program used for applying the function was QGIS (version 3.12).

The environmental parameters related to the points of occurrence of each localized vocalization were extracted, and a turbidity value was extracted for each point.

Analytical Methods

The unique pattern and high-frequency narrow band of franciscana clicks allow their identification through spectrograms (Melcón et al., 2012, 2016). Click trains are detection blocks to locate the vocal individual or group (Figure 2). The discrete nature of clicks in time allows for a more precise assessment of the difference in arrival time of the same signal in different channels through cross-correlation analysis. For each detection block, an event corresponding to one or more click trains was determined (Swift et al., 2009).

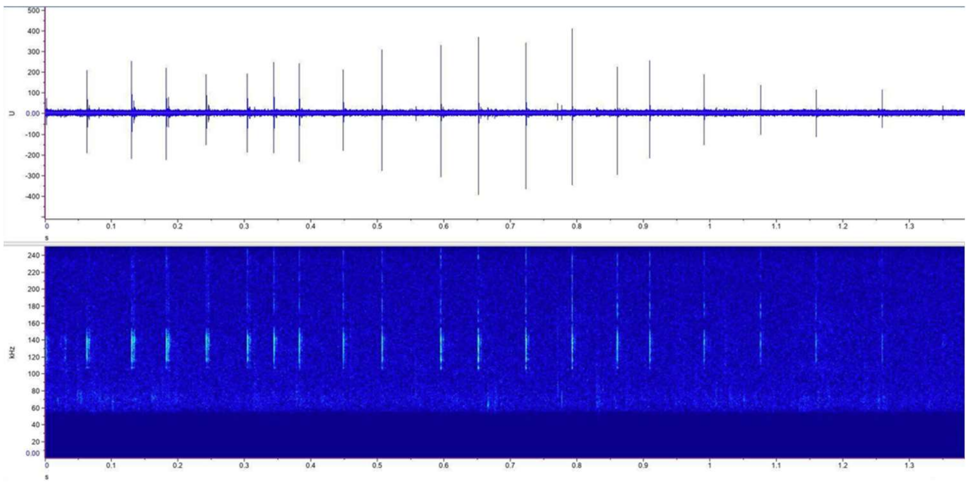

Figure 2: An example of the franciscana click train, considered the detection unit for the abundance estimation. Above: waveform visualization. Below: Spectrogram visualization (Hann window, 1024pts).

Acoustic processing

The audio processing was conducted with the software PAMGuard version 2.02. The Click detector module was used for A) detection, B) classification, C) click train identification, and D) Target Motion Analysis (Fig. 3).

A) The Click detector module has been configured to detect narrowband high frequency (NBHF) clicks, applying a high pass trigger filter at 100kHz. Hydrophones H1 and H2 were selected, spaced at just 0.4m, and optimized to detect these clicks. A threshold of 10 dB and an automated echo detector was applied. The details of the click detector configuration are shown in Figure 3A.

B) The detected clicks classification was applied by the Click classification tool, setting energy and frequency parameters as requested for franciscana`s clicks. These settings were tested with a control clip containing franciscana`s clicks and noise clicks and modified as needed to increase the accuracy of the classification. Settings details are shown in Figure 3B. This step aimed to filter the detected clicks, discarding those produced by other animals in the area, such as crustaceans or other occasional noises.

C) The Click train identification tool was applied for automatic train identification. Due to the franciscanas behavior pattern of swimming, its parameters were modified and tested several times to find the best configuration for the automatic selection of trains previously selected manually. In this way, the parameters applied are presented in Figure 3C.

D) Target Motion Analysis (TMA) was performed to assess the spatialization of each event, using the time difference of arrival (TDOA) between H1 and H2 and triangulation calcs. Thus, when an individual or group was recorded, the azimuthal angle corresponding to each click in an event was stipulated from different points along the transect line; then, the perpendicular distance of the individual or group concerning the boat was estimated (Barlow and Taylor, 2005; Lewis et al., 2007). Two TMA models can be calculated at PAMGuard: Least Squares Models and 2D Simplex Optimisation (Figure 3D) Akaike Information Criteria (AIC) and the Chi-square were used to select the most suitable model for the localization of each click train. Click trains where the TMA was impossible to calculate (e.g., inconsistent bearings, few clicks in the train – identified as false positives) were automatically excluded from the analysis.

A trained acoustician independently searched the franciscana click trains in the original audio files. It was implemented to verify the accuracy of the automated detection and evaluate the need to correct the false negative. To integrate adequately the data processed in this study with the correction factor provided by Mura et al. (this meeting SC69), it was followed the exact same steps of configuration, procedures, parameters, and criteria used by Mura et al. (this meeting SC69) to estimate the correction factor.

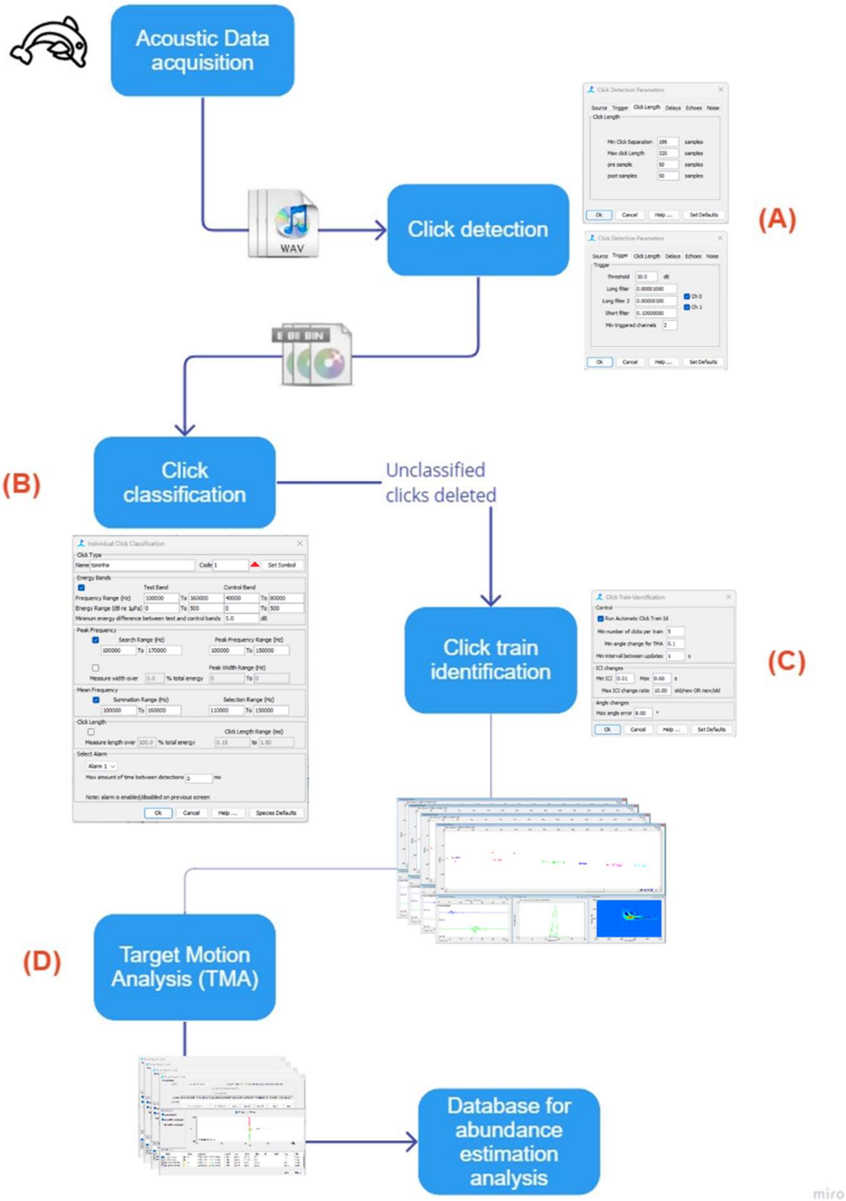

Figure 3: Flowchart of the steps followed from acoustic data collecting and processing to provide the adequate data set to perform the distance sampling abundance analysis. Same configuration used by Mura et al. (this meeting) was set to process the data of the abundance study.

Distribution

To evaluate the distribution patterns of franciscana in FMA Ia, the acoustic detections registered in the north and south strata were plotted.

Estimation of Detection Probability and Abundance Estimation

Perpendicular distances were calculated from the sailboat to the transect line. Truncation was applied to discard all observations beyond 100 meters. Abundance was estimated using standard line-transect methods (Burnham et al., 1980, Buckland et al., 1993).

Detection probability (*P*) was estimated using Conventional (CDS) and Multiple Covariate Distance Sampling methods (Buckland et al. 2001, Marques and Buckland 2003, Thomas et al. 2010). Only the half-normal and the hazard-rate key functions were proposed to fit distance data, and turbidity (numerical covariate) was considered a covariate to model distance data. Models with an acceptable fit based on visual assessment and goodness-of-fit statistics were ordered based on the Akaike Information Criterion (AIC) values. Analyses were performed using a set of customized functions (mrds v. 2.2.6, Laake et al. 2022) in R version 4.1.1 (R Core Team 2021).

The density of franciscana click trains (*Du*) was estimated using the Horvitz-Thompson-like estimator (Borchers et al. 1998, Borchers & Burnham 2004). The variance was estimated using the analytical estimator of Innes et al. (2002).

Correction factor: acoustic cue rate

The sampling unit in bioacoustics studies is vocalizations (e.g., click trains in our study), which must be converted to a rate representing an individual. Thomas and Marques (2012) indicate the need to measure and account for inaccuracies in the detection process, i.e., false positive and false negative detections, and to convert the object counted (e.g., a click train) into the number of animals it represents, called the "cue rate". Mura et al. (this meeting SC69) proposed a correction factor to convert the acoustic detection unit (franciscana click trains) in individuals. Following the authors, it can be achieved by applying the value of 3.48 (CV=0.60), which is the number of acoustic units (click trains) expected for one individual.

The corrected density estimate (*Dc*) was computed by dividing *Du* by 3.48 (Var=4.2). Abundance was then estimated as the product of correct density, and the total area and variance were approximated by the delta method (Seber 1982). Log-normal 95% confidence intervals (Buckland et al. 2001) were computed for FMA Ia.

RESULTS

Distribution

Throughout the survey, 1118.04 km of effort was carried out, and 176 franciscana click trains (acoustic detections) were identified in the whole area (Fig. 4). The automatic detections (176 click trains) and those observed by the independent acousticians (175 click trains) were nearly identical.

Acoustic detections of franciscanas were recorded in two primary regions throughout the area, with a clear concentration in the south stratum (Table 2) near the mouth of the Rio Doce (Fig. 4).

Table 2 – Survey strata, click trains (acoustic detection unit), survey effort, and acoustic detections per unit of effort (ADPUE) for franciscana 2019 acoustic surveys in FMA Ia, Espirito Santo, Brazil.

Strata	Click trains	Effort (km)	ADPUE
(2) North	45	669.90	0.067
(1) South	131	448.14	0.292
Total	176	1118.04	0.157

Acoustic detections were documented as far north as 18°29'S, 39°33'W and as far south as 20°01'S, 40°07'W (Fig. 4).

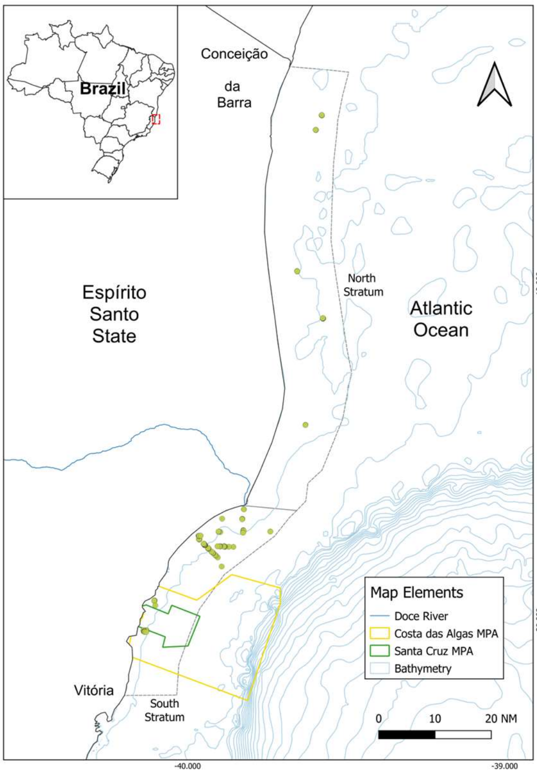

Figure 4: Distribution of franciscana acoustic detection in 2019 showing a clear concentration in the south stratum near the mouth of the Rio Doce (Dace River), Espirito Santo, Brazil.

Detection probability and Abundance

The detection probability was calculated using the click trains recorded throughout the study area (n = 176 acoustic detections) after left truncation and re-scaling of distances. The preferred model from the data was selected based on visual assessment (Fig. 5) and Cramer-von Mises (unweighted) statistics and included distance, turbidity as covariates and a hazard-rate function to fit perpendicular distance data (Model #2, Table 3).

Table 3: Best models for estimation of franciscana detection probability in FMA Ia, Espirito Santo, Brazil. Hn – half-normal key function, Hr – hazard-rate key function, AIC – Akaike's Information Criterion, $\bar{P}$ – Average probably detection, CV – Coefficient of Variation.

#	**Model specification**	**AIC**	$\bar{P}$	CV($\overline{P}$)
1	Hn + Turbidity	-848.81	0.70	0.08
2	Hr + Turbidity*	-844.50	0.67	0.11
3	Hn	-841.68	0.70	0.07
4	Hr	-840.27	0.71	0.10

* Model chosen based on the best fit.

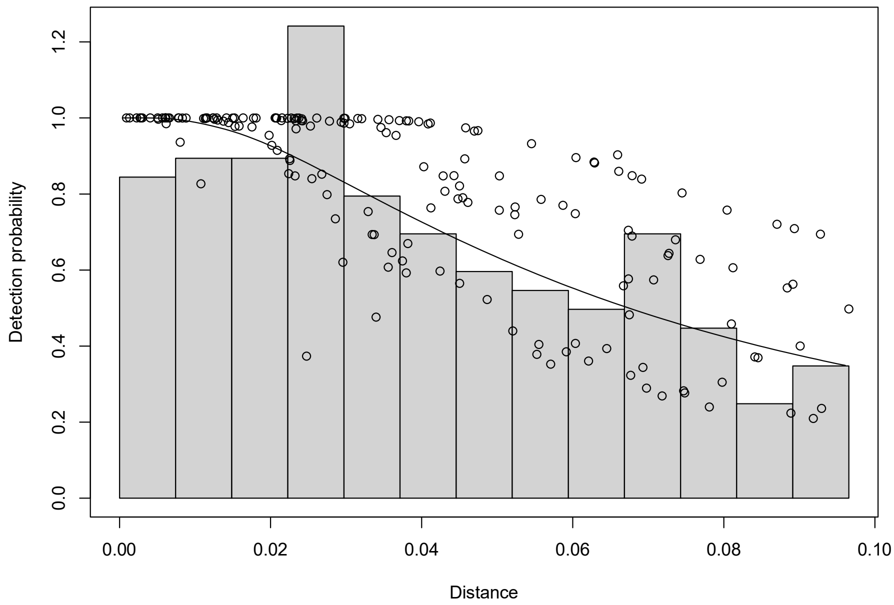

Figure 5: Detection function plot from model #2 (Hazard-rate + Turbidity) presenting distinct patterns of turbidity (plot points) effect on detection of the distribution probability (distance in meters).

Table 4: Density and abundance estimates of franciscanas in FMA Ia population Espirito Santo, Brazil. $\widehat{Du}$ – uncorrected density, $\widehat{Dc}$ – corrected density ($\widehat{Dc} = \widehat{Du}$ /3.48 according to Mura et al. (this meeting SC69), $\widehat{Nc}$– corrected abundance estimate, IC – Interval of confidence. Density is expressed in individuals/km^2.

Strata	$\widehat{Du}$ **(CV)**	$\widehat{Dc}$ **(CV)**	$\widehat{Nc}$ **(CV)**	**95% IC**
north	0.44 (0.55)	0.13 (0.80)	401 (0.80)	99 – 1570
south	2.36 (0.44)	0.68 (0.74)	855 (0.74)	235 – 3098
FMA Ia (Total)	1.00 (0.35)	0.29 (0.69)	1256 (0.69)	369 – 4214

DISCUSSION

Distribution

The Franciscana FMA Ia population inhabits shallow waters near the shore and the Rio Doce mouth. Franciscana in this region has been vulnerable to habitat loss and degradation, accidental capture in fishing nets, and pollution. The species distribution range in FMA Ia is more extensive than previously documented based on sighting and stranding data (Siciliano et al., 2002, Danilewicz et al., 2012; Sucunza et al., 2020b). Amaral et al. (2018) indicate 18º20'S as the north limit. Considering the new finds, the northern boundaries of FMA Ia could be maintained as Amaral et al. (2018), and the southern limit can be extended and placed at 20°01'S. The coastline corresponding with these new proposed boundaries is 220km (compared to 173km for the existing FMA Ia range). The newly documented area for FMA Ia's expansion must now be considered and discussed for conservation purposes and future studies on estimating abundance and density.

Abundance

For the first time, an acoustic method was applied to estimate the abundance of franciscana. The FMA Ia population density was estimated at 0.29 (CV=0.69) individuals per km^2 for the whole area, a value smaller than Sucunza et al. (this meeting SC69) of 0.48 (CV=0.76) individuals per km^2. The total abundance number was 1256 (CV=0.69) individuals in this study. Sucunza et al. (this meeting SC69) have estimated a population of 1183 (CV=0.76). In a general comparison, there were differences in the densities and the total area considered between both studies. Even so, the abundances estimated in both studies are similar and encompassed by the CVs.

The finding that the efficiency of the automatic detector and the visual (independent acoustician) in detecting franciscana click trains may be explained by the following factors: a) the franciscana click is stereotyped, b) it occurs in a cleaner high-frequency band of the spectrogram, c) the click parameters are now well-known and accurately represent the signal, and d) were appropriately applied on the software PAMGuard to maximize the automated detection.

Availability bias (e.g., submerged animals) and perception bias (e.g., sightings missed by observer fatigue and poor weather conditions) can cause severe bias in estimates of abundance using visual methods (e.g., aerial and ship surveys) if not properly accounted for. Using acoustic methods to estimate abundance can be advantageous as they do not have to account for these sources of bias.

The data obtained through acoustic methods, with click train as the detection unit, was sufficient to create a reliable detection curve. However, when a vessel approaches, animals near the transect dive to avoid it, causing their calculated distance to reflect their dive. This behavior possibly explains the results in a detection peak around 25 meters from the transect line. Nonetheless, animals cannot be at zero distance, as they must be on the surface directly in front of the hydrophone matrix, which poses a danger of collision with the boat. The hazard-rate fitted model can help mitigate this effect on the overall analysis. Mura et al. (in this meeting SC69) also observed a similar characteristic in the distribution of distances in Ubatuba, Brazil (FMA IIa). Applying the correction factor based on the calculation provided by Mura et al. (in this meeting SC69) tends to alleviate significant issues in the analysis.

Subsequent surveys using a systematic and consistent method over the years can produce a reliable population trend curve. Besides the total number, the population trend is essential to establish the alert level for the conservation priorities.

Conservation

The study area was under serious habitat degradation due to the iron ore tailings that reached coastal waters (Hatje et al. 2017; Samarco 2016; Gomes et al. 2017). Thus, the need for continuity of monitoring for a long-term evaluation of the effects produced is highlighted. The species was registered in the two Conservation Units, which arise the importance of the areas encompassing an endangered species. This fact also increases the need to incorporate specific strategies for this species into the Conservation Units Management Plan.

The species is considered the most endangered cetacean in South America, primarily due to potentially unsustainable high levels of bycatch and escalating habitat degradation across its distribution range (Ott et al. 2002 and Secchi et al. 2003a). Besides, its typically coastal habitat, a region influenced by human activities related to coastal development, makes the species especially vulnerable (Secchi, 2010; Cremer et al., 2018; Wells et al., 2022). This finding leads to an even greater concern for the survival of FMA Ia individuals. The loss of a fringe population of an endangered mammalian species is a tragic event that highlights the pressing need for conservation efforts. The FMA Ia is isolated from all other franciscana populations (Siciliano et al., 2002, Moreno et al., 2003; Danilewicz et al., 2012; Cunha et al., 2014; Amaral et al., 2018) and is distributed along the northern coast of Espírito Santo State, Brazil. This fringe population is a relatively small, isolated group of animals at the northern edge of the species' range. They are particularly vulnerable to extinction due to their small size and limited habitat. Metapopulation theory suggests that fringe subpopulations are highly vulnerable to extinction (Ceballos and Ehrlich, 2002). When a fringe population is lost, it significantly affects the species' overall population and genetic diversity.

Conservation efforts are underway to protect the franciscana dolphin (IWC Conservation Management Plan and Brazilian National Franciscana Action Plan) and its habitat, including implementing measures to reduce bycatch and establishing protected areas along its distribution range.

Challenges and Advances

There are challenges to applying the acoustic methods, such as the large volume of generated audio files that require compatible hardware, storage capacity, big data processing, and consideration of background noise in different habitats. Despite these limitations, the great advance in using the acoustic approach is automatizing the whole process. A completely independent system, with no human supervision, can prevent biases and enhance reproducibility, allowing different groups in different locations to apply the same technique and achieve comparable results.

Automation still requires human intervention, but the technician does not have to interfere, judge, or evaluate from his perspective on any part of the process. So far, the person must be trained to check if the steps only produce the correct output.

The acoustic method for estimating abundance is another important tool for monitoring franciscanas. With its validation and possible improvements, it can be widely used throughout the species' range of occurrence, generating comparable data.

CONCLUSIONS

1. Expansion of the distribution limits for FMA Ia to support better conservation strategies.
2. Despite the broad distribution range in the study area, the FMA Ia franciscana population is significantly concentrated around the Rio Doce mouth.
3. The franciscana dolphin population at FMA Ia was estimated through the acoustic method in 1256 (CV=0.69)
4. The possibility of implementing autonomous and automated systems for data collection and analysis exists.
5. It demonstrated the effectiveness of a completely independent system for abundance estimation supplanting human perception biases and enhancing reproducibility.
6. In conclusion, the potential loss of FMA Ia is a stark reminder of the urgent need for conservation efforts. By protecting these isolated groups, we can help ensure the survival and recovery of endangered species and the ecosystems they inhabit.

ACKNOWLEDGMENT

We thank Gustavo A. Miranda from Auset for technical orientation and support, Marco Aurélio from Atlântico Mar Azul, the crew of the Kahuna Sailboat, Bruna Duque for collecting and organizing the data, the RDDM FEST Team, and the CTBio. We are thankful to A. Martins and A. P. Farro for the Annex 6 Coordination, and the team of Annex 3 for providing the environmental data, R.D. Ghisolfi and G. Mill. The support provided by the Iate Clube do Espírito Santo was essential for the field activities. I. Lima and A.F. Azevedo provided initial ideas and discussion at the beginning of the project. We recognize the tireless effort of the environmental agencies IBAMA and ICMBio, and the IUCN Rio Doce International Panel.

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