FAROL DAS BALEIAS PROJECT

Ecology, Health and Behavior of Southern Right Whales Through Drone Surveys in Brazil

FIELD REPORT

2024 REPRODUCTIVE SEASON

Grupo de Estudos de Mamíferos Aquáticos do Rio Grande do Sul (GEMARS)

FAROL DAS BALEIAS PROJECT

Ecology, Health and Behavior of Southern Right Whales Through Drone Surveys in Brazil

Mission and Values

We work to advance conservation practices and promote the Southern Right Whale (*Eubalaena australis*), the most iconic whale in southern Brazil. The Project serves the conservation through scientific research, training, and education, encompassing the collection and sharing of information. The Project's mission is to generate and disseminate knowledge that supports the conservation and welfare of the Southern Right Whale. The work of the Project is grounded by a set of core values: excellence, innovation, collaboration, and education.

Project execution

The execution on this project is the responsibility of Grupo de Estudos de Mamíferos Aquáticos do Rio Grande do Sul (GEMARS), a non-profit and non-governmental organization funded in 1991 in Brazil.

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Cover image: Southern Right Whale mother and calf resting in front of Itapeva beach, Torres, Southern Brazil.

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EXECUTIVE SUMMARY

The 2024 field season of the Farol das Baleias Project marked a significant advancement in the understanding of the ecology, health, and behavior of southern right whales (*Eubalaena australis*) in southern Brazil. Over a period of 106 days, the research team conducted systematic drone-based surveys and shore-based observations, yielding extensive datasets on individual whale identification, health assessments, calf development, and intraspecific interactions. A total of 420 drone flights were executed, accumulating 120 hours of operation and resulting in 45 hours of high-quality footage. This effort enabled the identification of 246 individual whales, including 26 adults re-sighted from previous years, highlighting the species' site fidelity and movement patterns. Drone photogrammetry techniques were employed to assess the body condition of 41 lactating females and 56 calves, providing crucial data on maternal investment and calf growth. Behavioral observations revealed that mother-calf pairs spent approximately 10% of their time engaging in social interactions with other whales, an aspect of their ecology that has been rarely documented. Additionally, the research team recorded six cases of whales entangled in fishing gear, all of which were later observed free of entanglements, emphasizing the importance of continuous monitoring and conservation measures.

Public outreach and science communication efforts were a major component of this field season. The project hosted educational events in Torres, RS, engaging local communities through interactive exhibits, virtual reality experiences, and citizen science initiatives. Additionally, participation in international conferences, including the Biennial Conference on Marine Mammals in Perth, Australia, provided a platform for sharing findings and fostering global collaborations. Despite some financial and logistical challenges, strategic adjustments ensured the project's continuity. The upcoming research season will focus on publishing key findings, launching a doctoral research initiative on visual health assessments, and strengthening international partnerships. Community engagement will also be expanded through the inaugural Whale Festival of Torres, aiming to enhance public awareness and support for marine conservation. The 2024 field season has laid a strong foundation for future research, reinforcing the Farol das Baleias Project’s commitment to advancing marine mammal conservation through scientific excellence and public engagement.

INTRODUCTION

The Farol das Baleias Project is conducted by the Grupo de Estudos de Mamíferos Aquaticos do Rio Grande do Sul (GEMARS) and is dedicated to advancing the conservation and understanding of southern right whales (*Eubalaena australis*) in southern Brazil. This species, a key indicator of marine ecosystem health, faces numerous environmental challenges, including habitat degradation, climate change, and human activities such as fishing and tourism. As a migratory and charismatic species, southern right whales hold ecological, economic, and cultural significance, making their study essential for promoting marine biodiversity and fostering sustainable coexistence between humans and marine life. Our project combines innovative technology with rigorous field methodologies to assess population dynamics, behavioral ecology, and overall health, contributing to informed management and conservation efforts.

The objective of this Field Report is to provide an overview of our activities during the 2024 research season, including the methodologies employed and the challenges encountered in the field. Additionally, we present preliminary findings that highlight key observations and outcomes from the season's data collection efforts. This report aims to inform stakeholders and society, including funders and conservation partners, about the progress and impact of the project.

This project was supported in 2024 by a grant from the Yacu Pacha Foundation under the initiative *Ecology, Health and Behavior of Southern Right Whales Through Drone Surveys in Brazil*.

Project Objectives

The project aims to undertake a long-term, comprehensively evaluation of the ecology, health, and behavior of the southern right whale (SRW) in southern Brazil through systematic beach and drone monitoring. In this context, the following specific objectives have been established for SRW in southern Brazil for the year 2024.

1. Evaluate the occurrence, residence, and site fidelity of SRW, examining variations within individuals.
2. Assess the SRW´s health condition through body condition analysis
3. Evaluate the behavior and development of calves in the first months of life.
4. Study respiratory ecology and surface/submersion behavior.
5. Investigate SRW´s movement on both small and large scales through photo-identification.
6. Monitor the SRW entanglements in fishing gear and scars produced by vessel collisions and seagulls.
7. Assess SRW´s reproductive parameters such as birth time and interval.
8. Study the interactions of mother-calf pairs with other pairs, including alloparental care.

FIELDWORK OVERVIEW

RESEARCH SITES AND TEAM

Fieldwork was conducted from June 15th to October 5th in northern Rio Grande do Sul (RS) and southern Santa Catarina (SC) states, the main areas of occurrence of the SRW in Brazil. The study area in RS spans 30 km and is predominantly characterized by straight sandy beaches. In SC, the study area extends to 60 km, featuring numerous bays and coves separated by rocky cliffs (Figure 1; annexes 1-2). Two protected areas are located within the study region: the Wildlife Refuge Conservation Unit (REVIS) Ilha dos Lobos in Torres (RS) and the Environmental Protection Area (APA) of SRW, located in southern Santa Catarina (Figure 1).

Eleven biology and veterinary students and professionals from across Brazil were selected to join the project. Two online meetings with all new volunteers were conducted before the fieldwork began in order to initiate the preparation for the sampling (annex 3). Three master's students from the project also took on coordination roles. Additionally, four new drone pilots were trained and prepared over two weeks to join the image data collection team (annex 4).

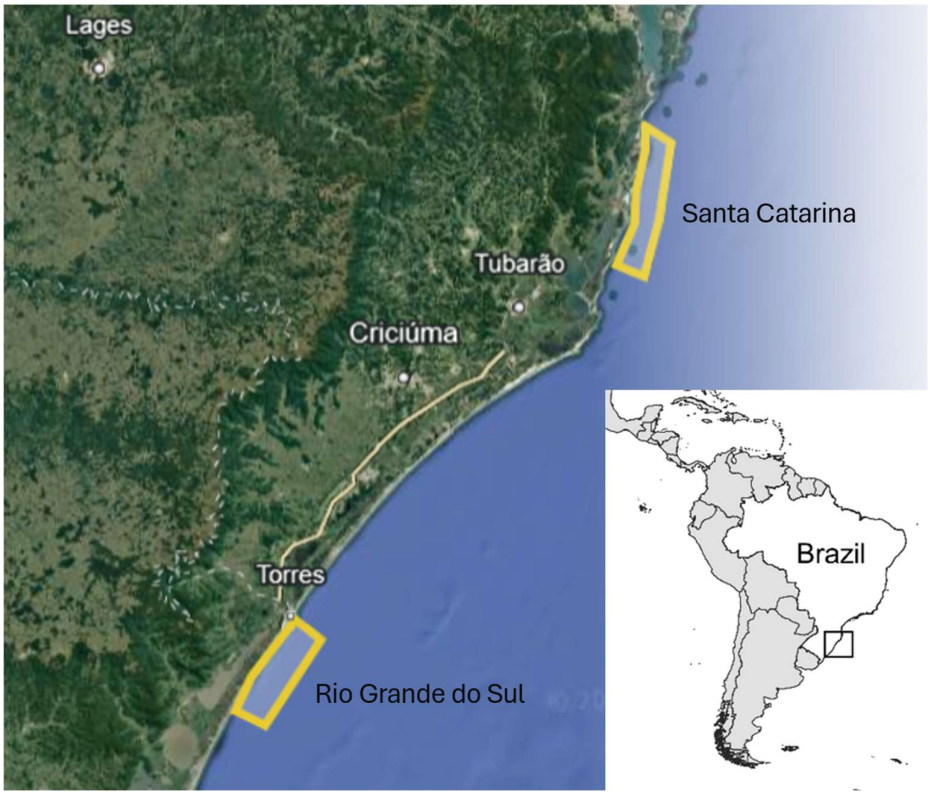


Figure 1. Map of the study area, evidencing the Rio Grande do Sul and Santa Catarina sampling sites.

DRONE SURVEYS

The search for whales was conducted actively, involving car-based monitoring along the beaches, interspersed with shore-based observations (Annexes 5-7). Fieldwork occurred whenever environmental conditions allowed. The entire area was thoroughly scanned at least once every 15 days. However, opportunistic monitoring was conducted during the intervals between these systematic scans.

Whenever a SRW group was detected, the drone was launched to sample the group (Figure 2). The sampling team comprised a pilot, a data recorder, and additional observers who assisted with the takeoff and landing processes. The observers also focused on monitoring the environment for new groups. Focal follows were performed during daylight hours. Videos were recorded during flights using Vertical Takeoff and Landing (VTOL) drone models (Figure 2). For each sampling event, the drone flew over a SRW group at a minimum altitude of 20 meters to minimize the equipment's influence on the animals' behavior. High-resolution (4K) videos were captured, with 2x and 4x zoom applied as needed for a clearer view of the whales. Recordings began once the equipment was positioned over the focal group, with a camera mounted on the drone via a gimbal, maintaining a vertical downward position at a 90° angle to the horizon.

The duration of the videos varied based on the sampling objectives. For photo-ID sampling, videos were typically brief, lasting around 3 minutes. In contrast, behavioral sampling videos could extend up to 25 minutes. After fieldwork, the videos were organized, processed, and frames capturing the SRWs were selected for analysis.

For photogrammetric purposes, a known-sized scale was filmed before each flight at a range of altitudes (10–50 m, at 5 m intervals) to create a model that converts the number of pixels representing a whale in the image into centimeters.

DATA ANALYSIS

Data analysis for the project began alongside the fieldwork phase, reflecting an integral aspect of this initiative. Volunteers are required to participate in data organization, screening, and initial analyses to enhance the decision-making process in the field. These activities are typically conducted during afternoon sessions or on days when adverse weather conditions prevent field operations.

Photo-identification catalog

Individual SRW were identified by unique patterns of thickened skin on their heads (known as callosities). These callosities included features such as the bonnet, lip patches, rostral islands, coaming, and post-blowhole island (illustrated in annex 8). In this context, still images of the dorsal view of each whale's head were extracted from the drone videos for every sampling event. The best image of each individual on each day was selected, and a preliminary 2024 ID was assigned. Accordingly, a temporary catalog for 2024 was created to organize the data and assign identities to whales for future encounters without needing to compare them to the project's official catalog.

After completing the fieldwork, the months of November and December were dedicated to the coordinators' efforts to compare the photo-identified whales from 2024 with the existing catalog. The primary goal of this comparison was to identify possible recaptures and determine which whales were

newly added to the catalog. This work is conducted entirely manually, without the use of any software or artificial intelligence tools.

This manual process requires meticulous attention to detail, as each photograph is carefully analyzed and compared with the catalog entries to ensure accurate identification. Despite being labor-intensive, this approach allows for a deeper connection with the data and ensures that subtle differences in whale patterns or markings are not overlooked. The outcomes of this effort are crucial for understanding population dynamics, tracking individual movements, and assessing the overall success of conservation strategies.

Figure 2. Drone-survey of SRW in southern Brazil.

Aerial Photogrammetry

Drone photogrammetry techniques were employed to obtain measurements and data about the size, shape, and other morphological characteristics of whales. These data are applied in life history and body condition studies currently conducted by the project. After every sampling, a volunteer was in charge of reviewing the videos and collecting the best still frames of whales to use for photogrammetric studies, according to Christiansen et al. (2020). The frames were organized by whale identity and sampling day. Two researchers are currently working on these data. Master student Judite Castedo is evaluating the

growth and body condition of calves, while MSc Lucas Oliveira is studying adult body condition. Analytical methods followed Oliveira et al. (2022).

Behavior and Intraspecific Interactions

Behavioral data were collected using drone footage, applying continuous focal group follows. The videos containing more than one pair of mother and calf of the SRW were initially filtered, and records where it was not possible to observe behaviors due to high water turbidity or excessive reflection were excluded from the analysis. Additionally, short-duration videos or those where photo-identification of the whales could not be performed were also disregarded. The interactions were classified into categories based on the group composition sampled, as follows: Calves-calves, mother-calf with solitary adults, calves-lactating females from another group, and between lactating females.

Subsequently, behavioral patterns were systematically transcribed and quantified using the Behavioral Observation Research Interactive Software (BORIS) program (http://www.boris.unito.it/). According to Altmann (1974), "behavioral states are defined as long-duration actions, while events are defined as short-duration actions, including a series of body movements identified as a unit that can be observed whenever they occur in conjunction with states."

Color Pattern

The videos were thoroughly analyzed, with the extraction of specific frames for each individual, prioritizing the assessment of dorsal and ventral markings. This process was conducted for adults and, whenever possible, for calves. Additionally, extra frames were selected for the analysis of skin molting, following specific criteria: high-resolution images, good visibility of the animal, minimal or no solar reflection, and the absence of water obstructing a complete view of the body.

For each individual, a minimum of eight frames were selected, allowing for comparisons across at least four distinct time points. The identification of dorsal and ventral marking patterns was based on a classification adapted from methodologies previously described in the literature (Figure 3). For both phenotypes and ventral marking patterns, the analysis was conducted from the head to the end of the dorsum/ventrum, excluding the caudal fin to standardize the assessment (Figure 4). Regarding dorsal phenotypes, the patterns were categorized into five distinct groups, considering the presence or absence of markings, as well as their coloration and spatial distribution.

Figure 3. Observed dorsal phenotypes. From left to right: (1) wild-type; (2) white patch; (3) gray patch; (4) white and gray patch; (5) white-calf (semi-albino).

Figure 4. Observed ventral patch patterns. From left to right: (1) white patch on the belly; (2) white patch on the chin and belly; (3) white patch extending from the chin to the belly; (4) gray patch; (5) white and gray patch; (6) multiple small patches. The "white patch on the chin" pattern was not recorded in this study.

PRELIMINARY RESULTS

Field effort

The fieldwork component of the research spanned a total of 106 days, comprising 308 hours of field activity. In Santa Catarina, field efforts took place from June 15 to October 5, totaling 113 days, while in Rio Grande do Sul, surveys were conducted from June 15 to September 21, covering 99 days.

Before initiating fieldwork, the project implemented a seven-day capacity-building program aimed at training new drone pilots. This program ensured that all field team members were equipped with the necessary skills to operate drones effectively, thereby optimizing data collection efforts.

Detailed summaries of the research effort, including the number of field trips, flight time, and whale recordings, are provided in Tables 1-4 below.

Table 1. Summary of field effort in Santa Catarina, including the number of field trips, flights, and total sampling effort (hours and minutes) per month.

Santa Catarina				
Month	**Days in the field**	**# field trips**	**# field trips without flights**	**Sampling effort (hour:min)**
June	8	10	1	25:05
July	17	23	0	55:43
August	16	21	0	47:52
September	13	13	1	33:46
October	2	2	0	5:38
Total	**56**	**69**	**2**	**168:04**

Table 2. Summary of field effort in Rio Grande do Sul, including the number of field trips, flights, and total sampling effort (hours and minutes) per month.

Rio Grande do Sul				
Month	**Days in the field**	**# field trips**	**# field trips without flights**	**Sampling effort (hour:min)**
June	2	2	0	1:20
July	21	30	9	60:12
August	24	37	9	68:56
September	3	4	1	9:08
Total	**50**	**73**	**19**	**139:36**

Table 3. Summary of drone survey effort in Santa Catarina, detailing the number of flights, total flight time, and whale recording duration per month.

Santa Catarina			
Month	**# flights**	**Flight time (hour:min)**	**Whale recordings (hour:min)**
June	47	12:06	4:04:37
July	88	26:27	7:27:10
August	100	27:48	12:31:53
September	67	20:53	10:40:30
October	13	4:12	1:45:18
Total	**315**	**91:26**	**36:29:28**

Table 4. Summary of drone survey effort in Rio Grande do Sul, detailing the number of flights, total flight time, and whale recording duration per month.

Rio Grande do Sul			
Month	**# flights**	**Flight time (hour:min)**	**Whale recordings (hour:min)**
June	3	0:43	0:12:34
July	59	10:51	2:39:21
August	56	14:06	3:40:51
September	9	2:26	0:32:12
Total	**127**	**28:06**	**7:04:58**

Photo-identification catalog

The Southern Right Whale Photo-Identification Catalog has shown significant growth over the years, demonstrating the success and consistency of our field efforts. Since its beginning in 2019, the catalog has expanded substantially, with the cumulative number of identified individuals reaching 520 in 2024.

Figure 5 illustrates the increase in photo-identified individuals per year. This continuous growth reflects the enhanced capacity of our field teams, the implementation of efficient drone-based photo-identification methods, and consistent monitoring of SRW across the study area.

The ongoing expansion of the catalog is crucial for identifying and monitoring individual whales, tracking movement patterns, assessing site fidelity, and contributing to long-term population studies. This robust dataset provides a foundation for advancing our understanding of SRW ecology and supporting effective conservation strategies.

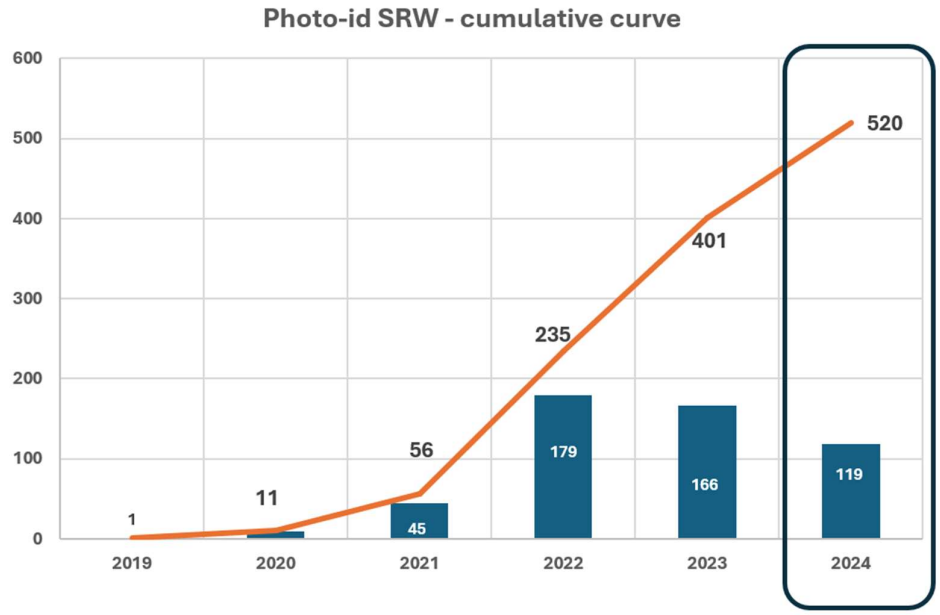


Figure 5. Annual increase in the cumulative number of photo-identified southern right whales from the study area. The expanding catalog, reaching 520 individuals in 2024, reflects improvements in field effort, the adoption of drone-based photo-identification techniques, and sustained monitoring efforts.

Occurrence, residence, and site fidelity of SRW

A master's thesis is currently being conducted by Luiza Panini within this project to investigate site fidelity, habitat use, and small-scale movements of SRWs. To date, data from the 2022 and 2023 field seasons have been analyzed. The next step is to integrate the data collected during the current campaign into the ongoing analyses. Below, we present a summary of the results obtained thus far.

Aerial monitoring using drones was conducted between 2022 and 2023, enabling the individual identification of 343 SRWs over the two study seasons. Site fidelity was quantified using a capture-recapture approach, applying four indices: occurrence, residency, periodicity, and the Standardized Site Fidelity Index (SSFI).

The distribution of sampling frequency per SRW exhibits a decreasing pattern, with most individuals recorded only a few times and a small number of SRWs exhibiting high recapture rates. A total of 111 individuals (32.36%) were sighted only once, while 232 (67.64%) were sighted at least once. The maximum number of recaptures for a single individual was 31.

Occurrence and Residency

The occurrence of SRWs within the study area showed slight variation between years, with a general pattern of higher individual concentrations between July and September. In both years, subareas III (Ribanceira and Ibiraquera beachs) and VI (Torres) recorded the highest number of sightings. In both years, occupancy extended into October.

The average residency time of SRWs within the study area increased between the analyzed seasons, from 22.06 days in 2022 to 24.74 days in 2023. The maximum recorded residency time was also higher in 2023, with one individual remaining in the area for 101 days, compared to a maximum of 88 days in 2022. Residency duration varied between States, with the longest stay recorded in Santa Catarina (91 days in 2023) and Rio Grande do Sul (55 days in 2023).

Site Fidelity

Intra-annual site fidelity was assessed with individual sighting records (captures), residency duration, and periodicity (in days) within the designated six subareas were analyzed. In 2022, Ribanceira-Ibiraquera exhibited the highest median SSFI and the widest distribution of values, indicating that this region was the most frequently used by SRWs, both in terms of recurrent returns and prolonged residency. Additionally, some extreme values (outliers) were observed, suggesting that certain individuals remained in this subarea for extended periods.

In contrast, the remaining subareas displayed median site fidelity values close to zero with low dispersion, indicating that most individual SRWs used these regions more sporadically. Torres also exhibited a significant number of outliers, suggesting consistent use by some individuals, although this was not a general trend. The results reveal clear patterns of site fidelity with spatial and temporal variation. Areas with higher fidelity (Ribanceira-Ibiraquera) stand out as key sites for species conservation, providing essential data for environmental management.

SRW´s health assessment

In this session, we will present preliminary results on the health assessment of SRW through body condition and evidence of entanglement in fishing gear. Table 5 presents the number of photographic frames used to assess SRW health in the last three years.

Table 5. Number of frames obtained each year and across the three reproductive seasons.

Year	# frames
2022	759
2023	525
2024	566
Total	1,850

Body condition - During the 2024 field season, data collection focused on the body condition of SRW through photogrammetry techniques. A total of 539 frames were captured, of which 88 frames were deemed suitable for photogrammetry analysis based on quality criteria. From the observed individuals, 56 calves were documented, with 42 included in the photogrammetric analysis. Similarly, 41 lactating

females were observed, with 18 meeting the requirements for inclusion. No solitary individuals were utilized in the photogrammetry analysis, although 15 were recorded during field observations.

The body length of all individuals included in the photogrammetry analysis was successfully estimated. Additionally, body surface area and volume were calculated whenever possible, depending on the quality and angle of the images. These estimates will be used to derive indices of body condition, providing valuable insights into maternal investment strategies, calf growth patterns, and the overall health of the population under varying environmental conditions. The master's student Judite Castedo is responsible for evaluating the growth and body condition of calves. Below, we present some preliminary results from her thesis, which is still analyzing data from 2022 and 2023 (Figures 6-7).

Calves Surface Area: The estimated surface area ranged from 1.81 to 5.21 m^2 (mean ± SD = 3.29; 95% CI: 3.02-3.55; SD = 0.91; n = 46) for the calves. For the two lactating females, the estimated values were 10.49 m^2 and 18.66 m^2, with a mean of 14.57 m^2.
Calves Body Volume: The estimated body volume ranged from 1.45 to 7.34 m^3 (mean ± SD = 3.70; 95% CI: 3.22-4.18; SD = 1.62; n = 46) for the calves. For the two lactating females, the estimated values were 15.95 m^3 and 37.61 m^3, with a mean of 26.78 m^3.

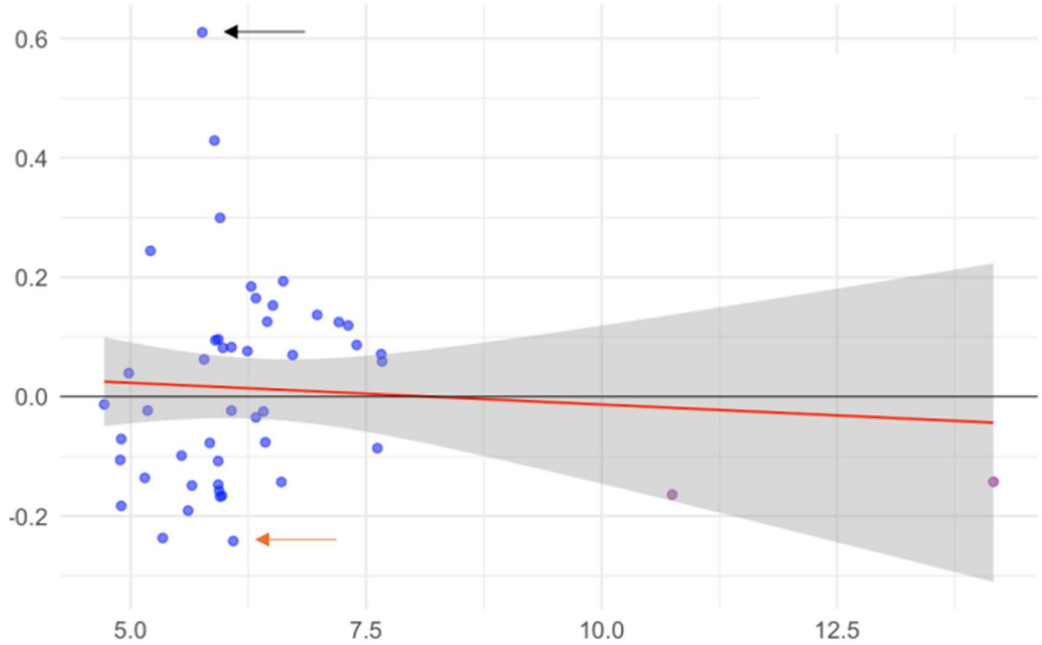


Figure 6. Relationship between body condition index and total length (m) for lactating females (purple points) and calves (blue points) of SRW, calculated from body volume (m^3). The red line represents the values predicted by the adjusted model, and the gray band indicates the 95% confidence interval. The solid black line represents the expected average of the body condition index; points above the reference line represent values above average, and points below represent values below the expected average for individuals of the same size. The black arrow at the top of the graph indicates calf (a) with the highest body condition index, and the orange arrow at the bottom indicates calf (b) with the lowest condition index, both presented in Figure 7.

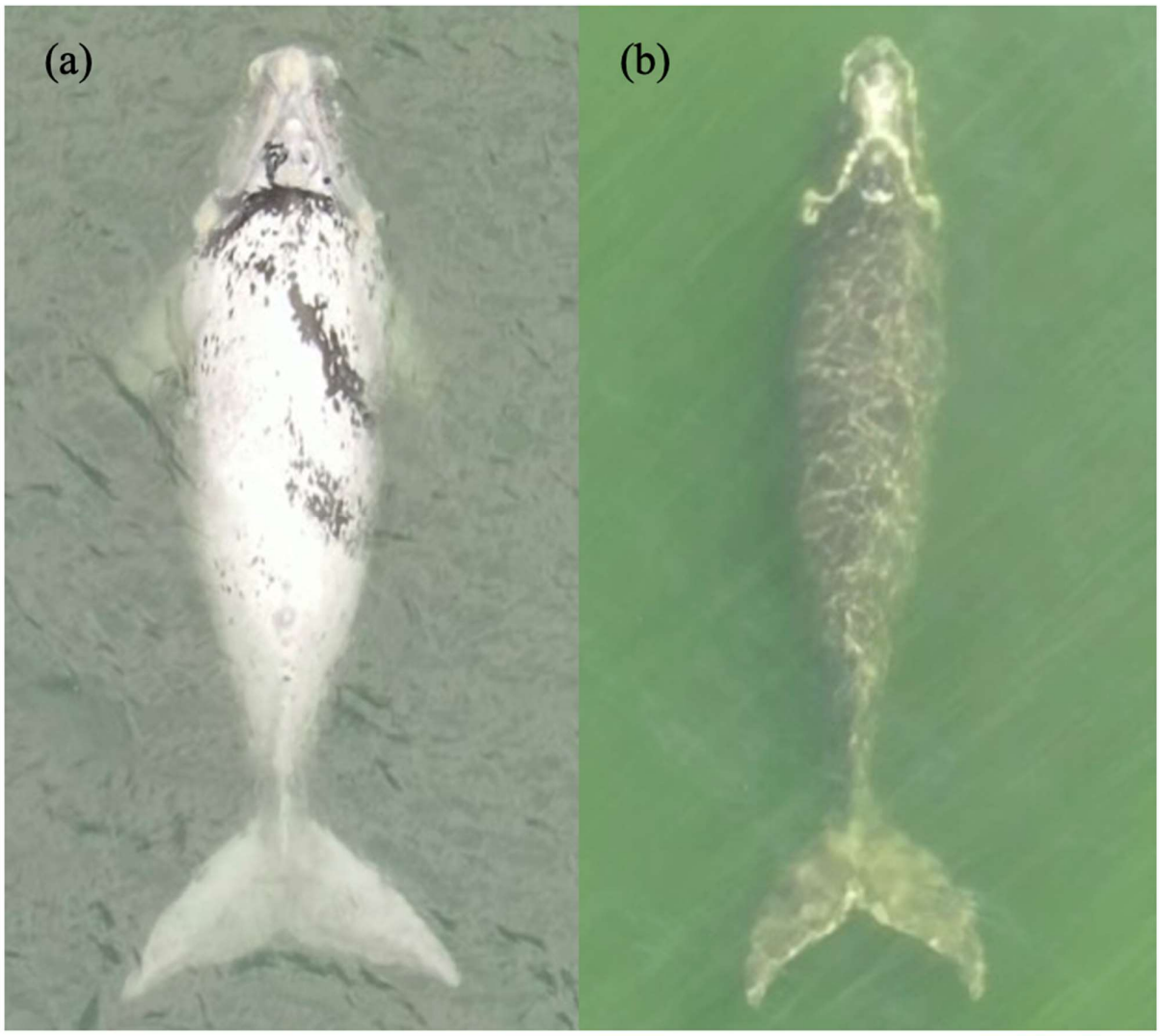


Figure 7. Comparative image between two southern right whale calves. Figure (a) shows the calf with positive body condition, while Figure (b) represents the calf with negative body condition. Both animals are represented in Figure 6 by pointing arrows.

Entanglements in fishery gear

During the 2024 season, the project recorded six adult SRW with fishing gear entangled around their bodies, all of which were located around the head (annex 9). Fortunately, no severe cases of entanglement were observed. The project advisor informed local authorities and the representative of the cetacean disentanglement group about these occurrences. Continuous drone-based monitoring of this population confirmed that these whales were later sighted without the fishing gear, suggesting that they were able to shed the entanglements naturally. These observations underscore the importance of ongoing monitoring efforts to document and mitigate potential threats to this population, contributing to broader conservation strategies for SRW in the region.

PhD research will begin in 2025 season

A comprehensive PhD research project will begin in 2025, focusing on the visual health assessment of southern right whales. This study will leverage the project's extensive long-term database, which spans multiple years of systematic monitoring, to analyze health indicators such as body condition, injuries, and potential anthropogenic impacts. The PhD student, Emanuel Ferreira (R3 Animal) will be supervised by the coordinators of the Farol das Baleias project in collaboration with the State University of Santa Cruz (UESC), located in Ilhéus, Bahia. This partnership will ensure a robust academic framework and contribute valuable data to the conservation and management of SRW in the South Atlantic.

Development of calves in the first months of life

To study calf development in the first months, in addition to body condition, growth was assessed based on total length.

Preliminary Growth Assessments of Southern Right Whale Calves

For the preliminary calculations, only frames classified with a score of “1” (excellent) for body straightness and measurability of total length were used. This approach resulted in 87 total length measurements, including 65 from calves and 22 from females.

The total length of SRW calves ranged from 4.04 m to 7.90 m (mean = 6.06 m; 95% CI: 5.87–6.26; SD = 0.79; n = 65). The estimated total length values for the calves in this study (4.04 m and 7.90 m) are consistent with those reported from other locations (Table 2). The lowest and highest recorded lengths were obtained from Australian data. In this study, we identified a calf measuring 4.04 m, the smallest recorded to date.

Calf Growth Rate

Calf growth research can be conducted using two main approaches: longitudinal and cross-sectional studies.

Longitudinal studies involve repeated measurements of the same individuals over a defined period, allowing researchers to track individual growth rates and assess the influence of environmental and maternal factors throughout development. This approach is particularly valuable for identifying growth patterns and their variations, providing a deeper understanding of the biological and ecological determinants affecting cetacean ontogeny.

In contrast, cross-sectional studies provide a snapshot of growth by sampling individuals at different developmental stages. In this approach, calves are measured only once, enabling the construction of growth curves based on the distribution of observed body sizes within a population over a specific time frame. While this method does not track individual development, it allows for population-level trend estimation and cohort comparisons, serving as an efficient alternative when continuous individual monitoring is not feasible.

In this study, the cross-sectional approach included all 65 total length measurements of calves. The longitudinal approach used 37 measurements from calves that were sampled on at least two occasions, with a minimum interval of 10 days between measurements, in three or four separate sampling events.

Cross-Sectional Study

The cross-sectional study used 65 total length estimates, assuming that each measurement represented a unique individual. The relationship between total length and Julian Days (Figures 8-9) showed variability in calf length, potentially influenced by genetic factors (growth variation), environmental conditions (nutritional availability, such as maternal milk), or birth timing differences among individuals. The mean calf growth rate estimated from cross-sectional data was 2.05 cm/day (95% CI: 1.51–2.59 cm/day).

Longitudinal Study

In the longitudinal study (Figure 10), growth rate was estimated for 15 calves and analyzed in two stages.

- First stage: Growth rate estimation was conducted for 11 calves sampled on two separate occasions with an interval of more than 10 days.
- Second stage: For four calves observed on three or more occasions, three distinct estimation methods were applied, allowing for a more detailed assessment of individual growth rates.

When comparing growth rates estimated from the two approaches, an absolute difference of 1 cm/day was observed. The cross-sectional approach estimated an average of 2.05 cm/day, while the longitudinal approach estimated 3.05 cm/day. The higher growth rate in the longitudinal approach is expected, as it tracks individual development more precisely.

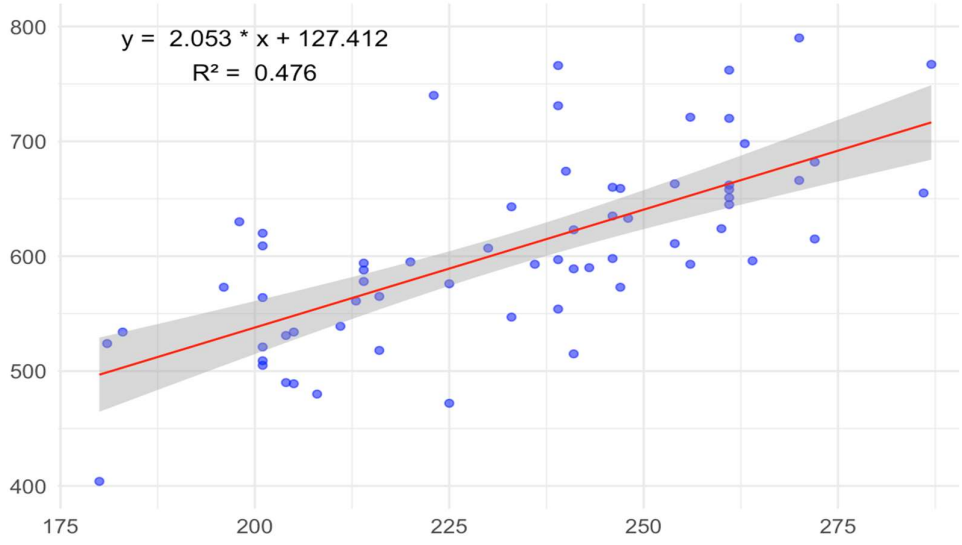


Figure 8. The relationship between total length measurements (cm) of southern right whale calves and Julian Day. The red line represents the fitted values from the linear regression model, with the equation y = 2.053x + 127.412 and a coefficient of determination R^2 = 0.476. The gray shading indicates the 95% confidence interval. The model suggests an average growth rate of approximately 2.05 cm per day over the period analyzed.

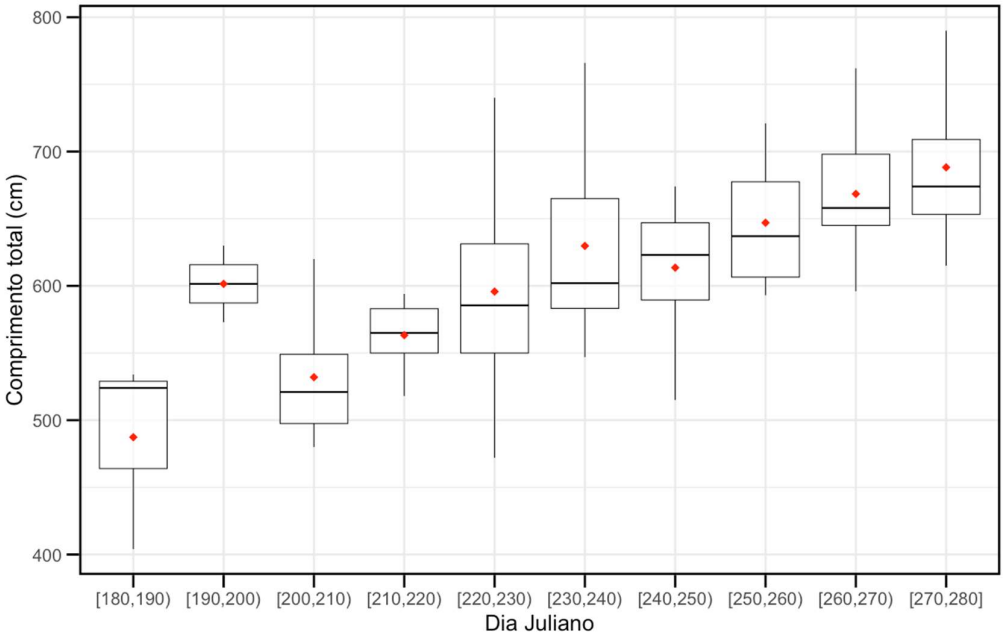


Figure 9. Representation of the total length (cm) distribution of southern right whale calves across 10-day Julian intervals. Each boxplot represents the dispersion of individual total lengths within the established time intervals. The x-axis shows the 10-day periods, while the y-axis represents the estimated total length values for each individual. The horizontal line indicates the median, while the red dots represent the mean total length for each period. The vertical lines extending beyond the boxplot boundaries indicate the data range.

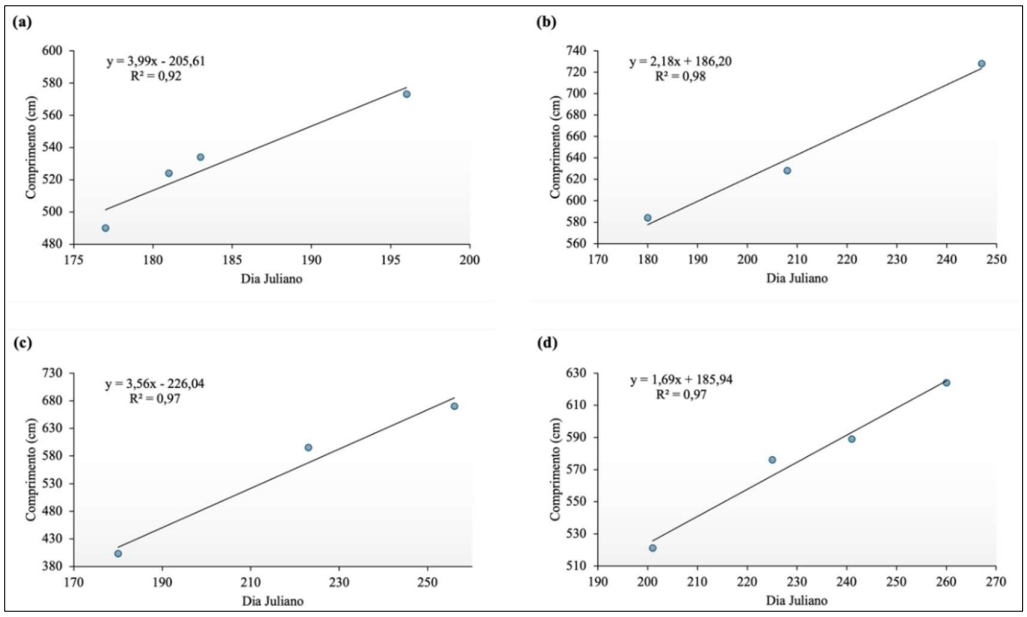


Figure 10. Relationship between total length (cm) and Julian Day for four southern right whale calves analyzed using Method 4. Each plot (a, b, c, d) represents a different individual. The black line represents the fitted linear regression for each calf, with the equation and coefficient of determination (R^2) displayed in the upper left corner of each panel.

Movements

Systematic drone monitoring throughout the season allows for the repeated identification of individual whales across different locations, offering new insights into their movement patterns. Additionally, integrating the project's records with datasets from partner institutions enhances our understanding of habitat use and site fidelity. This section summarizes the combined records from the 2024 season.

Matches with Southeastern Brazil: Four adult female SRWs were recorded in São Paulo and later in Santa Catarina by our project (Figure 11). Three were lactating, and one pregnant female was recaptured after giving birth. The minimum time interval between records varied from 15 to 75 days and the minimum distance is 550 km in straight line. Five whales were recorded both in Rio Grande do Sul and Santa Catarina, with time intervals ranging from 6 to 58 days.

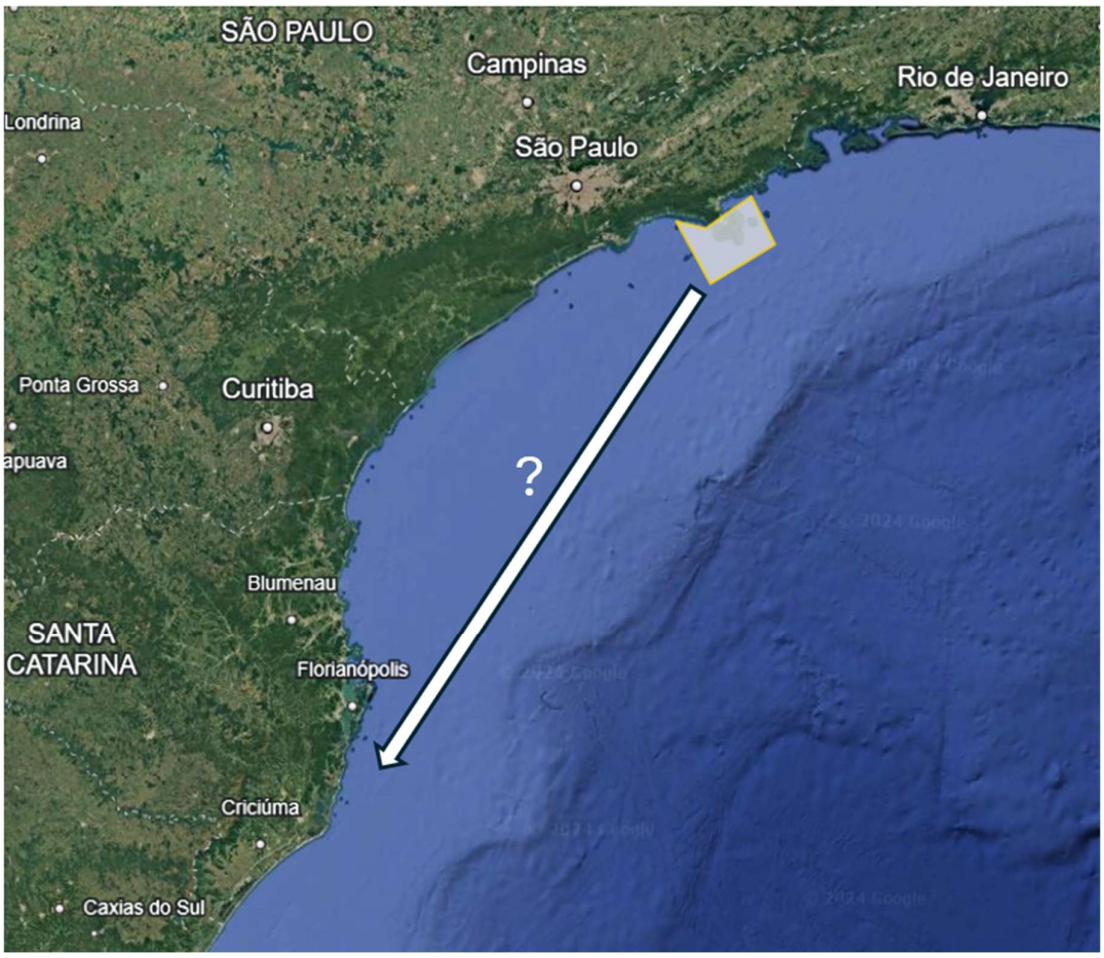


Figure 11. Movement records of 4 southern right whales between Southeastern and Southern Brazil.

Interactions of mother-calf pairs with other whales

Baleen whales typically do not form complex social networks. Aside from the bond between a mother and her dependent calf, socializations are uncommon. Interactions of mother-calf pairs with other pairs is the focus of a master's research project by a student from our study (Luciana Dores-Santos). The study aims to characterize and quantify social interactions between SRW mother-calf pairs in southern Brazil using drone imagery. Specific objectives include: (I) Describing social interaction types (calf-calf, mother-mother, and calf-mother from another group); (II) Measuring the duration of each social behavior; (III) Assessing how calf development influences interaction frequency and patterns; (IV) Evaluating maternal influence on socialization duration.

During the 2024 reproductive season, the project recorded over nine hours of SRW interactions, most of which involved mother-calf pairs interacting with other individuals (Table 6 and Figure 12). Preliminary results suggest that these interactions account for approximately 10% of the mother-calf group's time budget. The adaptive significance of this behavior is currently being investigated.

Figure 12. Southern right whale calf interacting with a subadult, with its mother (larger whale) in the same frame.

Table 6. Summary of southern right whale encounters, footage duration, group counts, and observed interactions in Santa Catarina and Rio Grande do Sul.

Santa Catarina					
Month	**# encounters**	**Footage time (hour:min:sec)**	**# groups**	**Interactions Mother-calf**	**Interactions Solitary**
June	8	00:54:00	8	2	6
July	7	01:42:00	14	5	2
August	18	02:24:00	39	16	2
September	19	01:15:00	36	19	0
October	4	00:27:00	10	4	0
Total	**56**	**06:42:00**	**107**	**46**	**10**
Rio Grande do Sul					
Month	**# encounters**	**Footage time (hour:min:sec)**	**# groups**	**Interactions Mother-calf**	**Interactions Solitary**
June	3	01:58:00	10	1	2
August	4	00:37:00	8	3	1
Total	**7**	**02:35:00**	**18**	**4**	**3**

Color patterns

This project also aims to characterize and quantify, for the first time, the dorsal and ventral coloration phenotypes of SRWs in their breeding grounds in southern Brazil. It also explores coloration variability within each phenotype, identifying potential individual differences and broader population trends. Additionally, the relationship between dorsal and ventral coloration patterns is examined to determine whether these regions are associated or independent. Beyond advancing scientific knowledge of SRWs in the region, this research enhances individual identification techniques, which are critical for population monitoring, health assessments, and habitat use studies. The following preliminary results are from the master's project of Victoria Ulman, a graduate student affiliated with GEMARS.

Since 2022, a total of 352 individuals have been analyzed, including 185 adults and 166 calves, with 19 solitary adults. Phenotypes are represented by colors and numbers as follows: (1) wild-type, (2) gray patch, (3) white patch, (4) white and gray patch, and (5) white-calf (semi-albino) (Figures 13-14).

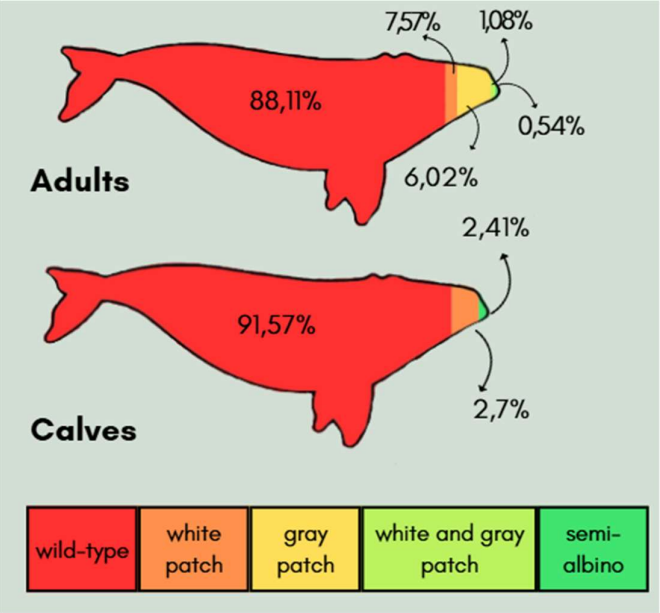


Figure 13. Schematic representation of relative frequency of southern right whale phenotypes in adults and calves.

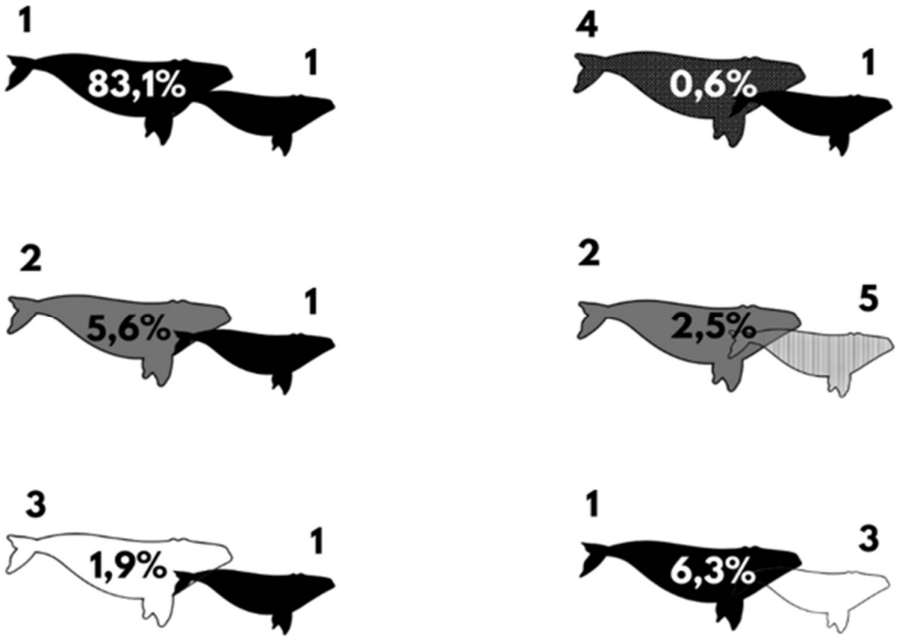


Figure 14. Schematic representation of color congruence between mothers and calves. In the illustration, mothers are positioned on the left and calves on the right. Phenotypes are represented by colors and numbers: (1) wild-type, (2) gray patch, (3) white patch, (4) white and gray patch, (5) white-calf (semi-albino). Percentages within each whale indicate the frequency of pairs exhibiting the illustrated congruence.

OUTREACH AND SCIENCE COMMUNICATION

Public Outreach Tents in Torres

As part of our commitment to science communication and community engagement, the Farol das Baleias project organized three public outreach events in the city of Torres, RS. The event featured interactive educational tents where visitors could explore marine mammal biology through hands-on exhibits.

Attendees had the opportunity to see and touch whale skulls, baleen plates, and samples, along with other biological materials that illustrate the anatomy and adaptations of these fascinating animals. A collection of scientific books, informational panels, and high-resolution images further enriched the experience. One of the highlights was the use of virtual reality (VR) goggles, which allowed the public to immerse themselves in breathtaking 360-degree images of SRW in their natural habitat.

This initiative successfully engaged people of all ages, fostering awareness about whale conservation and strengthening the connection between the community and marine research (Figure 15, Annexes 10-11). The event also provided an informal setting for discussions with researchers, allowing the public to ask questions and learn more about the importance of protecting marine ecosystems.

Figure 15. Children participating in outdoor educational tents in Torres, Brazil.

Participation in the 1st Edition of the Teacher Training Course: Citizen Science for the Conservation of Marine Fauna and Environments

In 2024, the Farol das Baleias project contributed to the 1st Edition of the Teacher Training Course: Citizen Science for the Conservation of Marine Fauna and Environments, an initiative designed to empower public school educators with knowledge and tools to integrate marine conservation topics into their teaching.

This continuing education program combined virtual lectures, in-person classes, field trips, and didactic materials, ensuring a dynamic and immersive learning experience. A total of 20 teachers participated, equipping them with scientific knowledge that they will now pass on to their students, effectively becoming multipliers of conservation awareness in their communities.

Key highlights of the course included:

- Virtual sessions covering marine biodiversity, ecosystem dynamics, and citizen science.
- In-person workshops with hands-on activities, discussions, and interactive teaching strategies.
- Field trips where teachers experienced firsthand the marine environment, observing species and conservation challenges in practice.
- Didactic materials tailored for classroom use, including lesson plans, scientific illustrations, and multimedia resources.

By actively participating in this initiative, the Farol das Baleias project strengthened its mission of democratizing scientific knowledge and fostering community engagement in marine conservation. The long-term impact of this course extends beyond the teachers themselves, as the knowledge they acquired will reach hundreds of students, helping to shape a new generation of environmentally conscious citizens.

This first edition was a significant milestone, and the project looks forward to expanding such initiatives, reinforcing the role of education as a fundamental pillar of conservation efforts.

Social Media Outreach – Instagram

The Farol das Baleias project has also leveraged Instagram as a powerful platform for science communication and public engagement. Through carefully curated posts, stories, and reels, we share research updates, conservation messages, and behind-the-scenes insights from our fieldwork.

Our content strategy includes:

Educational posts explaining whale ecology, behavior, and conservation challenges.

Photo and video highlights from drone surveys, providing unique aerial perspectives of whales.

Community engagement campaigns, encouraging people to participate in conservation efforts.

By utilizing Instagram, we have expanded our outreach beyond local events, reaching a wider audience and inspiring greater public interest in marine conservation. The platform has been instrumental in raising awareness about the importance of protecting southern right whales and their habitat, while also fostering a sense of community among marine enthusiasts, students, and conservation professionals.

Through both in-person and digital outreach, the Farol das Baleias project continues to strengthen its mission of democratizing scientific knowledge and promoting marine conservation.

Science divulgation: Conference in Perth

In November 2024, the Farol das Baleias project had the unique opportunity to participate in the Biennial Conference on Marine Mammals, held in Perth, Australia. Representing the project, two graduate students and the project coordinator delivered oral presentations, showcasing our latest research findings on southern right whale ecology and conservation (Figure 16).

The conference provided an unparalleled platform for knowledge exchange, allowing our team to engage with leading experts, receive valuable feedback, and establish new collaborations with international researchers. Attending keynote talks, specialized sessions, and networking events further enriched our scientific perspectives and strengthened the global relevance of our work.

Beyond scientific discussions, the event fostered a dynamic and inclusive environment, reinforcing the importance of marine mammal conservation worldwide. The participation of our students was particularly noteworthy, as it contributed to their academic growth, professional development, and the visibility of marine research in Brazil.

This experience underscores the significance of international outreach and engagement in advancing our project's impact. The Biennial Conference not only allowed us to share our findings but also reinforced our commitment to marine conservation and science communication on a global scale.

Figure 16. Oral presentation by Luiza Panini about the results of SRW site fidelity analysis.

CHALLENGES AND SOLUTIONS

Like any field-based research initiative, the Farol das Baleias project faced logistical and environmental challenges during this period. These challenges required adaptive strategies to ensure the continuation and success of our activities.

Financial and Logistical Challenges

One of the main difficulties encountered was the rise in prices, particularly due to fluctuations in the U.S. dollar exchange rate and the economic impacts of the flooding in Rio Grande do Sul (see more details at https://www.bbc.com/news/world-latin-america-68968987). The cost of key operational expenses, especially the car rentals, increased significantly—50% higher than originally budgeted for vehicles, for example. This unexpected cost increase threatened the financial feasibility of the planned fieldwork.

Solution Implemented

To address this challenge, we made a strategic adjustment to our field schedule. Instead of extending operations until October as initially planned, we shortened the field season in Rio Grande do Sul by 30 days, optimizing research efforts within a reduced timeframe. This decision allowed us to control costs while still achieving our core research objectives. By remaining flexible and adapting to unforeseen financial and environmental constraints, the Farol das Baleias project successfully maintained its research while ensuring responsible budget management.

NEXT STEPS

The upcoming year will focus on advancing research, strengthening collaborations, and expanding outreach efforts. Below are the detailed next steps for 2025:

1. **Scientific Publications**

- Submission of two articles on southern right whale behavior and breathing patterns observed through drone surveys by May 2025.
- Submission of a paper on SRW respiration patterns, derived from aerial observations during the first semester of 2025.

2. **Master's Program Progress**

- Four master's students involved in the project will undergo their qualification defenses with external committees in March 2025, further developing their research skills and contributing to the project's objectives.

3. **Doctoral Research**

- Launch of a PhD project on Visual Health Assessment of Southern Right Whales, utilizing the project's long-term database. This work, supervised by the project coordinators in collaboration with UESC, will officially begin in **May 2025**.

4. **Data Analysis**

- Completion of the analysis of body condition data collected during the 2024 field season, with results finalized by **April 2025**.

5. **Grant Renewals**

- Submission of a proposal for the renewal of funding from Yaqu Pacha by **March 2025**, ensuring continued financial support for the project's initiatives.

6. **Field Preparations**

- Initiation of preparations for the 2025 field season by **March 2025**, including logistics, team training, and equipment maintenance.

7. **International Cooperation**

- Establishment of a collaboration with researchers in Uruguay to study whale movements and behavior across international waters, with a potential capacity-building program for Uruguayan students starting in **May 2025**.

8. **Community Engagement**

- Joint planning with the municipal government of Torres to organize the **First Whale Festival of Torres**, with activities including a gastronomic festival and live music shows, beginning in **April 2025**.

By pursuing these objectives, the project aims to enhance its scientific impact, foster international collaborations, and strengthen its role as a leader in whale conservation and public engagement.

ACKNOWLEDGMENTS

We express our sincere gratitude to everyone who contributed to the success of this project in 2024. Special thanks to the volunteers from across Brazil, whose dedication and enthusiasm were vital to our fieldwork and research efforts. We also extend our appreciation to the master's students and researchers who brought their expertise and energy to the project.

We are deeply thankful to Yaqu Pacha for their generous financial support, which made our work possible. The Municipal Government of Torres played an important role in facilitating our activities by providing logistical support, including tents and necessary permits.

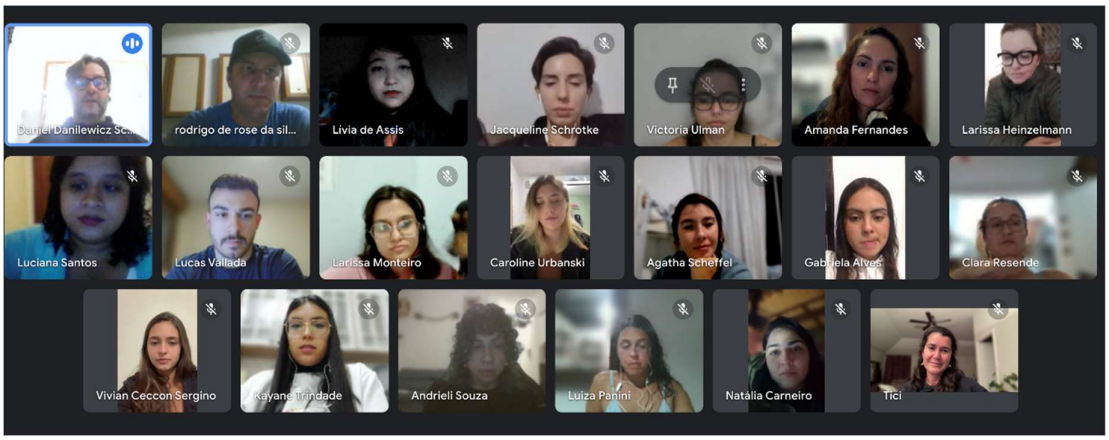
Our thanks also go to GEMARS as the institution that provided essential logistical support and to the researchers in the group for their ongoing collaboration and commitment to marine conservation. We also acknowledge the invaluable contribution of Dr. Larissa Schemes Heinzelmann, who organized and led the teacher training course, further promoting environmental education in the region. We thank MSc. Lucas Oliveira for his support on SRW photogrammetry.

To everyone who supported the project in various ways, we offer our deepest gratitude.

ANNEXES

Annex 1. Coast of Rio Grande do Sul, southern Brazil.

Annex 2. Coast of Santa Catarina, southern Brazil.



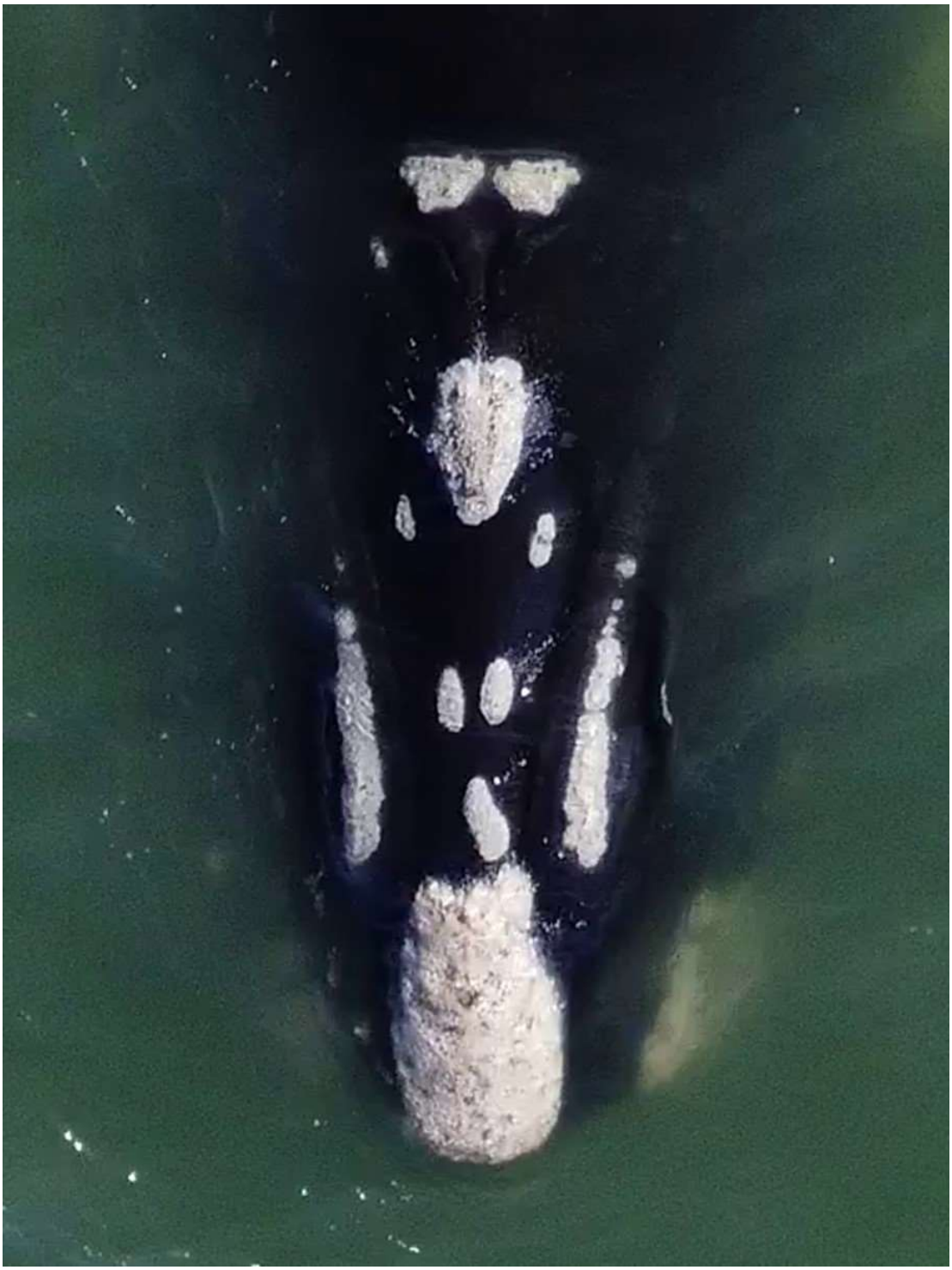
Annex 3. Preparation online meetings with project volunteers.

Annex 4. Capacity building of volunteers.

Annex 5. Shore-based observations of SRW in Rio Grande do Sul, southern Brazil.

Annex 6. Drone-survey of SRW in southern Brazil. Research team search the whales onboard a vehicle and start sampling every time a SRW group is sighted.

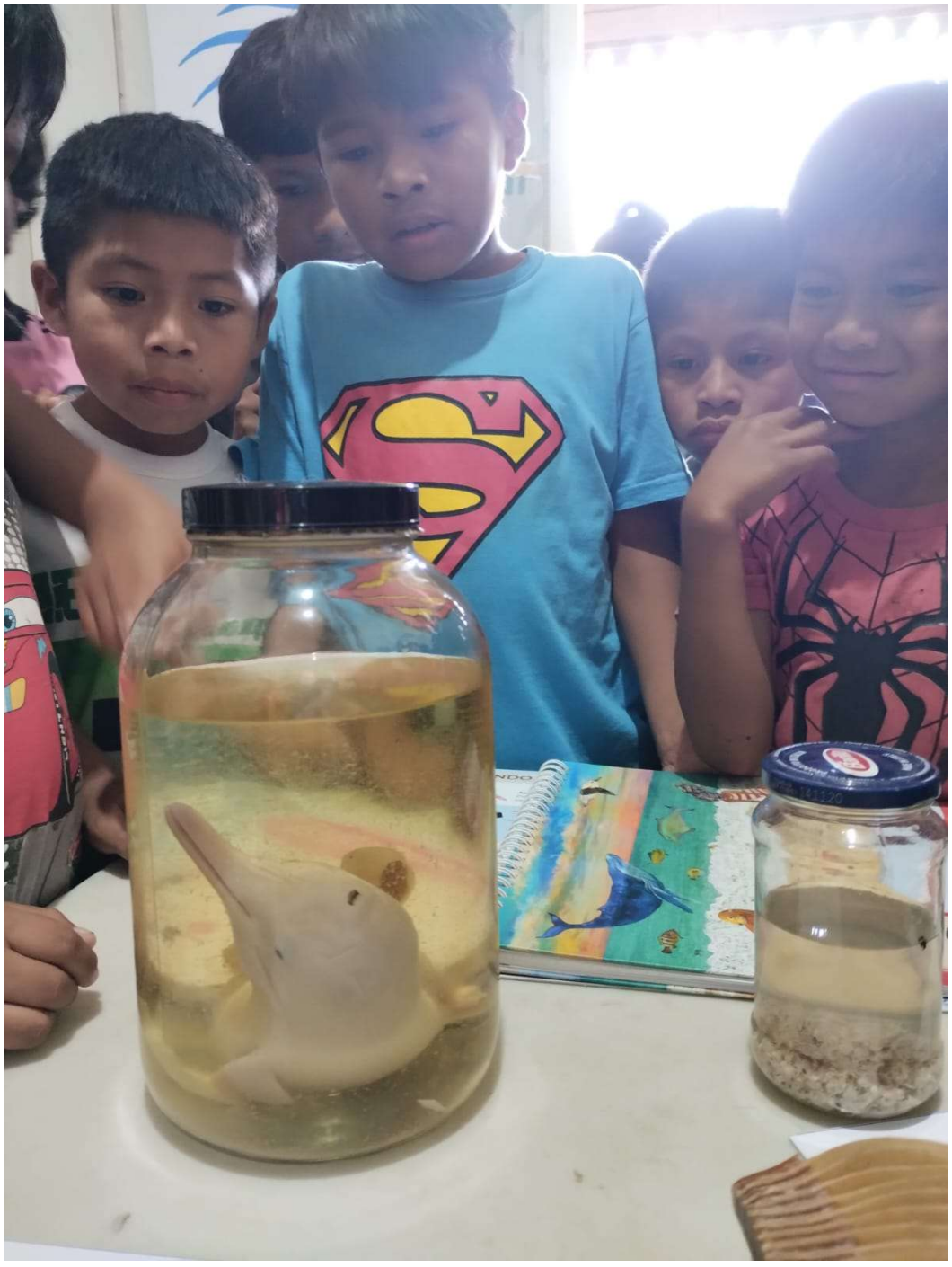
Annex 7. Drone-survey of SRW in southern Brazil.



Annex 8. Dorsal view of the SRW head evidencing its callosity patterns that allow the individual identification in this species.

Annex 9. Southern right whale recorded with a fishing net entangled around its head.

Annex 10. Children participating in educational activities promoted by the project.



Annex 11. Children participating in educational activities promoted by the project.