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Study on the abundance of bottlenose dolphin (*Tursiops truncatus*) in the Revillagigedo Archipelago (Mexico)

Author: Javier Contreras Abad

Tutor: Hiram Rosales Nanduca

Cotutor: José Juan Castro Hernandez

Contributor: Ángelo Santana del Pino

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Author:
Javier Contreras Abad attends Degree in Marine Sciences at the University of Las Palmas de Gran Canaria, Gran Canaria, Canary Islands, Spain.

Tutor:
Hiram Rosales Nanduca, University Professor-Researcher, Coordinator of MMAPE (Programa de Investigación de Megafauna Marina y Pesquerías) in the Autonomous University of Baja California Sur, Mexico.

Cotutor:
José Juan Castro Hernández, University Professor of zoology in Las Palmas de Gran Canaria, Canary Islands, Spain.

Contributor:
Ángelo Santana del Pino, University Associate Professor of Statistics in the Department of Mathematics at ULPGC, Canary Islands, Spain.

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Abstract

The main objective of this study was to identify and catalog the population of bottlenose dolphins (*Tursiops truncatus*) in the Revillagigedo Archipelago (REV), Mexico, to obtain a population estimate, as well as to analyze some ecological aspects, including the presence of calves and if there are movements of individuals between the different islands that make up the archipelago, San Benedicto Island, Socorro Island, and Roca Partida Island. In REV, field work with photo-identification was carried out for the period 2018-2024. A total of 191 sightings of bottlenose dolphins were made, of which 140 could be photographed. 90% of the sightings were of groups of 15 or fewer animals, and the presence of calves was documented in 25 of the sightings (13% of the total), all of which occurred in waters adjacent to Socorro Island. A total of 324 dolphins were identified, of which 15% were recaptured between two and five years, suggesting philopatry for several of the dolphins. Of the 324 dolphins identified, only two were seen on different islands. The discovery curve of new individuals did not stabilize, while the population estimate using the Lincoln-Peterson method yielded an estimate of 237 individuals, ±60 SE.

The results suggest that two population units may coexist in the adjacent waters to the archipelago. This study highlights the waters of the archipelago as an important area for dolphins and suggests evidence of a "resident-island" population, that requires systematic monitoring and comprehensive research, including molecular ecology, trophic ecology, social structure, acoustics, and morphology approaches, to determine the status of the population.

1. Introduction

The Revillagigedo Islands (REV), located in the Mexican Pacific, are of ecological and biological importance due to their rich biodiversity and the unique ecosystems they host (Mulcahy et al., 2014). These islands are renowned for their high concentration of marine life, including coral reefs, large pelagic fish, and cetaceans (CONANP, 2018). Among cetaceans, the common bottlenose dolphin (*Tursiops truncatus*) is considered a “flagship species,” a charismatic symbol that attracts public attention and support for marine ecosystem conservation strategies. This designation makes the bottlenose dolphin an emblematic species for marine conservation, as its protection can promote the preservation of other marine organisms and their habitats (Connor et al., 2000; Gómez-Lobo et al., 2024).

Revillagigedo represents a unique natural area worldwide, where little information about cetaceans is available due to the limited research conducted in this region. The scarce scientific data on bottlenose dolphins in the Revillagigedo area has been documented primarily in recent articles published since 2020, highlighting the need for further study (Carone et al., 2023; Rio et al., 2022, 2024). Beyond its ecological significance in the archipelago, this species has become a major tourist attraction in recent years for recreational divers due to its "curious and friendly" behavior. This has led to a significant increase in diving activities, as divers seek the unique experience of close interactions with dolphins (Rosales-Nanduca, personal communication). Consequently, conservationists have raised concerns, particularly regarding the increase in boat traffic and the nature and intensity of interactions (Carone et al., 2023; Rio et al., 2022; Tejeda Bravo, 2024). These circumstances underscore the importance of generating knowledge to build a robust information base about this species, which could serve as a tool for developing management plans for its conservation.

The bottlenose dolphin has a wide distribution in tropical and temperate waters of all the world’s oceans (Figure 1). It inhabits both coastal and offshore areas, demonstrating remarkable adaptability to diverse habitats, from bays and estuaries to open ocean regions (Wells & Scott, 2018). This ecological flexibility allows the species to exploit a wide variety of prey and environments, contributing to its evolutionary success (Barros & Odell, 1990; Natoli et al., 2005; Rio et al., 2022; Santos et al., 2007). Globally and in the Mexican Pacific, bottlenose dolphin populations are divided into distinct ecotypes (Figure 2), each exhibiting adaptations to specific local conditions (Segura et al., 2006; Viloria-Gómora & González, 2015).

Coastal ecotypes tend to form smaller groups, reside in specific areas near the coast, and have a more specialized diet, showing higher levels of philopatry (the tendency of individuals to remain or return to their natal areas) compared to offshore ecotypes, which generally form larger groups, have broader movement ranges, and exhibit more varied diets (Carwardine, 2019; Shane et al., 1986). However, resident populations have also been identified around islands, combining characteristics of both ecotypes. These populations have been classified as an additional ecotype, known as the island ecotype, reflecting adaptations to the unique conditions of insular ecosystems (Castán et al., 2009; Culik et al., 2011; Kogi et al., 2004; Martien et al., 2012, 2024).

This differentiation of ecotypes underscores the importance of understanding the regional particularities of each population to implement appropriate conservation measures (Oudejans et al., 2015; Pratt et al., 2023), especially in remote and biodiverse areas such as the Revillagigedo Islands, where dolphins play a key role in the dynamics of the marine ecosystem (Aguirre-Muñoz et al., 2015).

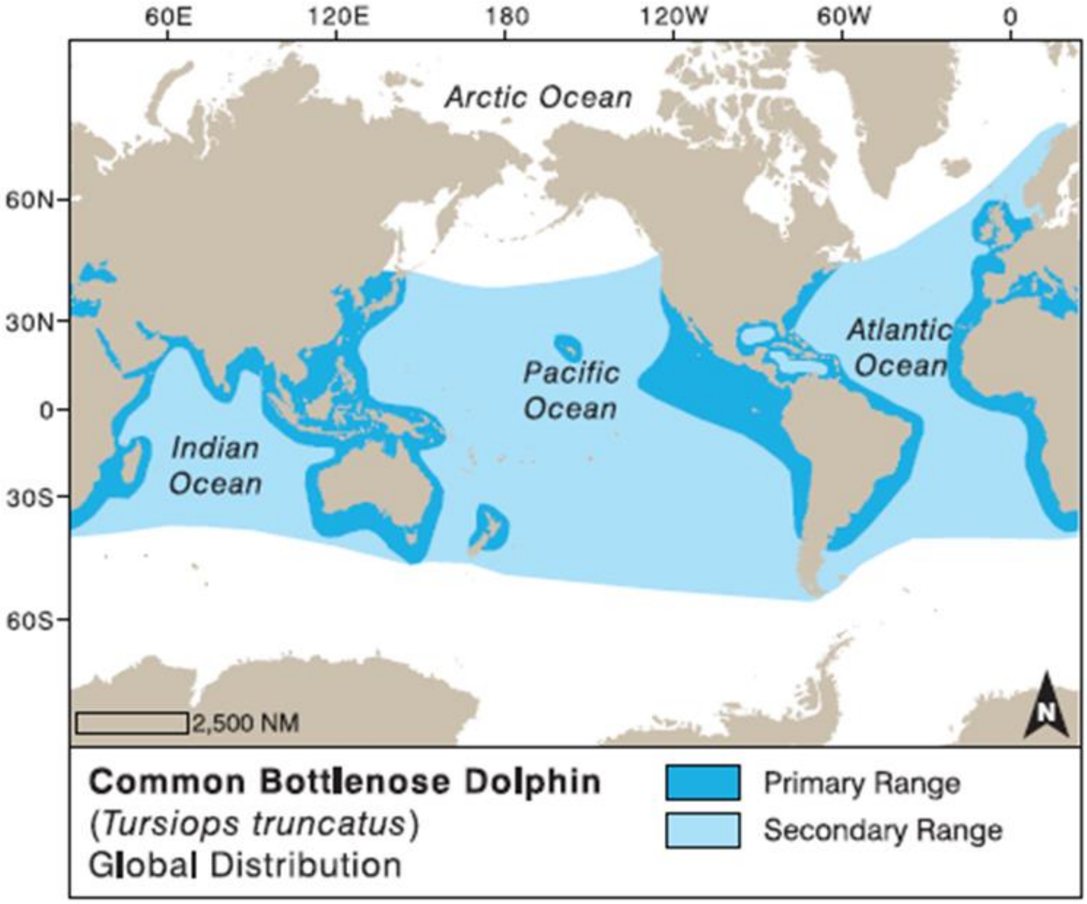


Figure 1. Global distribution of the common bottlenose dolphin (*Ttru*). taken from Wells & Scott, (2018).

Photo-identification is a technique widely used in the study of marine animals, particularly cetaceans, to identify and track individuals over time. This method relies on photographing unique and permanent physical characteristics of marine animals, such as marks, scars, pigmentation patterns, or the shape of the dorsal fin in the case of dolphins (Würsig & Jefferson, 1990). Everyone has a "profile" that allows differentiation from others, facilitating monitoring in spatial and temporal studies. For cetaceans like bottlenose dolphins, this technique not only aids identification but also provides key data on their behavior and philopatry. This makes photo-identification a crucial tool for conservation studies, as it offers detailed information about the animals' lives, residency, and migration dynamics within their habitats, and the threats they may face (Gonzalvo et al., 2014; Lanfear et al., 2014). It is particularly effective for bottlenose dolphins due to the visible marks on their dorsal fins that allow clear individual differentiation (Wells & Scott, 1990). As such, conservation studies need to provide critical insights into the animals' lives and the challenges the animals encounter (Verme & Iannacone Oliver, 2011).

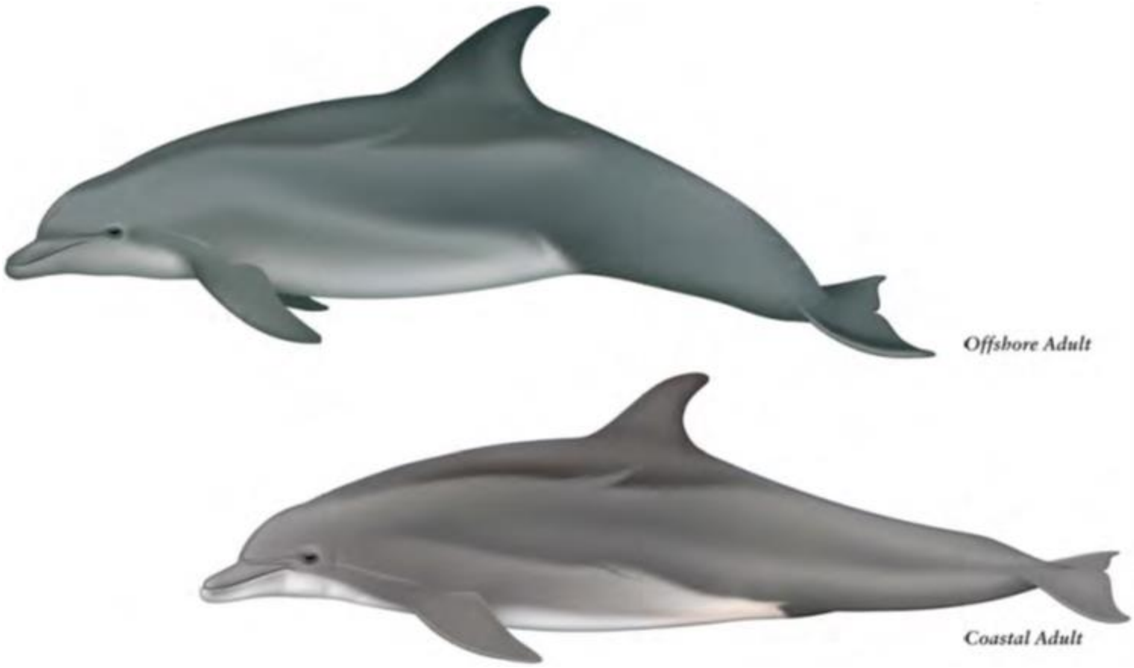


Figure 2. Generalized body shape and coloration patterns of offshore and coastal common bottlenose dolphins (*Ttru*). Illustrations by Uko Gorter, taken from Wells & Scott, (2018).

Population size estimation is commonly conducted using the capture-recapture method, which is especially useful for cetaceans given the ease of classifying photographed dorsal fins (Würsig & Jefferson, 1990). This technique involves marking or identifying a group of individuals during an initial "capture" and then re-identifying the marked individuals in subsequent sampling efforts (Urian et al., 2015; Wells & Scott, 1990). The proportion of recaptured individuals allows for the estimation of the total population size by applying statistical models, such as the Lincoln-Petersen formula (Bohning et al., 2017). This method is particularly valuable in cetacean studies using photo-identification, as it enables tracking specific individuals and provides insights into population dynamics and structure without invasive techniques (Hammond et al., 1990). Understanding population size is crucial as it represents the first step in assessing the status and vulnerability of a population. This is especially important in remote ecosystems, relatively isolated from neighboring continental areas, with unique environmental conditions that shape species' population dynamics and behaviors (Gillespie, 2001; Lanfear et al., 2014; Shaffer & Samson, 1985).

Oceanic islands, such as the REV, act as hotspots for marine biodiversity and can serve as critical areas for feeding, reproduction, or resting for many migratory and/or resident species, including cetaceans (Carone et al., 2023; CONANP, 2018). Dolphins, along with sharks, other cetaceans, and large fish (tunas, groupers, etc.), occupy the highest trophic levels in the marine ecosystem. The status of their populations is a clear indicator of the overall health of the marine ecosystem (Moore, 2008; Roman et al., 2014). Therefore, monitoring these sentinel species over time can be used to assess the resilience and stability of marine habitats (Hazen et al., 2019). In this context, the present study aims to identify bottlenose dolphins around the REV to determine whether philopatry exists and to estimate population size using photo-identification techniques and the capture-recapture method. This effort provides an initial estimation of the population size of dolphins associated with these oceanic islands (Urian et al., 2015).

Recently, the IUCN has identified tourism as a threat to the viability of various marine mammal species (Bejder et al., 2022; UICN, 2021). The increasing interest in this species in the waters surrounding Revillagigedo underscores the importance of the data generated by this study, which can be used to develop management and conservation plans for the bottlenose dolphins distributed in the archipelago.

2. Materials and methods

2.1. Study area

Visual census data of dolphins were collected in the waters surrounding the Revillagigedo Archipelago (REV), specifically from the islands of Socorro (SI), Clarion (CI), San Benedicto (SBI), and Roca Partida (RPI). The archipelago is located 540 km from Los Cabos, Baja California Sur (BCS), and 890 km from the port of Manzanillo, between 18°-20° N and 110°-115° W. It lies within a transition zone between two distinct marine systems: the California Current and the warm waters of the Equatorial Current (CONANP, 2018) (Figure 3). The interaction between these water masses generates variability in sea surface temperature (SST), which ranges approximately from 20 to 30 °C, conditions considered optimal for reproductive areas (Scheidat et al., 2000).

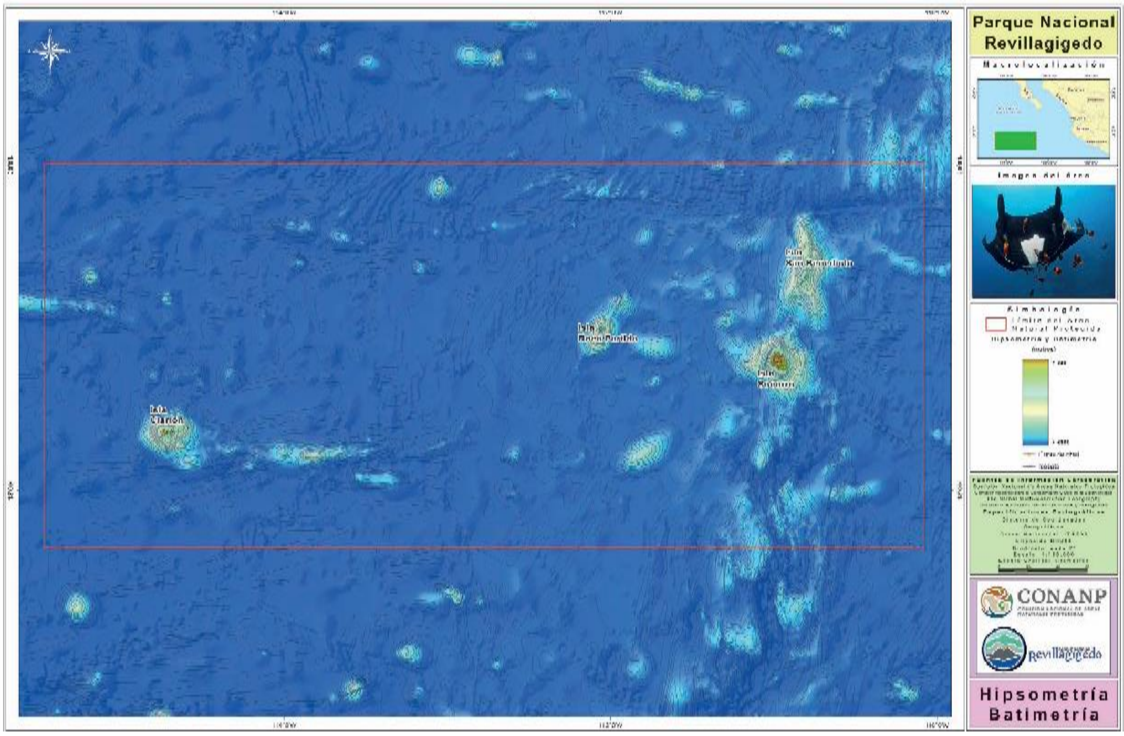


Figure 3. Geographical Location of the REV (source: CONANP, 2018).

This archipelago, designated as a National Park in 2017, constitutes the largest marine protected area in Mexico and the largest no-fishing zone in the Pacific, with an area of 14,808,780 hectares, 99.76% of which corresponds to marine surface (CONANP, 2018).

Due to its remote location and protective regulations, access to the REV is restricted and permitted only for scientific research and autonomous diving activities under special authorization. Recreational and tourism activities, such as whale watching, diving, and snorkeling with cetaceans within the REV, are prohibited to minimize human impact on these species (CONANP, 2018).

2.2. Data collection

Data collection for the study was carried out between 2018 and 2024, primarily during the winter months (November-April), depending on the resources, logistical possibilities, and personnel availability each year. During each season, vessels from the Sea Shepherd Conservation Society (SSCS), including the *Sharpie*, *White Holly*, and the sailboat *Martin Sheen*, were used to travel to the islands from Los Cabos or La Paz (Baja California Sur). Once the ship reached the islands, smaller boats such as pangas and zodiacs (provided by SSCS and the Mexico Marine Wildlife Rescue Center, based in La Paz, BCS) were used for monitoring activities.

During the field trips, all necessary information was collected to properly catalog the characteristics of each sighting or encounter (in this study, we use the term "capture" to refer specifically to photographic capture). A Nikon D7500 camera with a 70-300 mm lens was used to photograph the dorsal fins of bottlenose dolphins, as this part of their body is most frequently visible. Additionally, the dorsal fin often displays unique and long-lasting natural features that facilitate individual recognition (Würsig & Jefferson, 1990).

For each dolphin sighting, besides taking photographs, the date, time, geographic location (latitude and longitude using GPS), behavior, estimated group size, presence of calves, and any additional relevant observations were recorded.

2.3. Distribution

To analyze the spatial distribution of bottlenose dolphins (*Tursiops truncatus*), the statistical software R (version 4.4.2) (R Core Team, 2024), through the RStudio platform (RStudio Team, 2020) was used. Latitude and longitude data obtained from field sightings conducted between 2018 and 2024 in the REV, were analyzed. These data were processed and visualized in maps using the “ggmap” library (Kahle & Wickham, 2013), allowing for a spatial-temporal representation of the species' sightings. This approach facilitated the identification of areas with higher sighting frequencies and enabled interpretations regarding potential residency or mobility patterns, which are particularly relevant for understanding whether dolphins move between islands.

2.4. Data Processing and Photo Identification

The data processing for the development of the *Tursiops truncatus* population catalog began with the download of images and sighting data stored in the MMAPE database. Each dataset included detailed records of the location, date, time, and general characteristics of each sighting. Once downloaded, the images were organized and analyzed to identify individuals based on visible marks and scars on their dorsal fins and the dorsal area near the fin.

Three key characteristics were considered for classification: (1) photo quality, (2) the distinctiveness of the dorsal fin edge, and (3) the color pattern on the fin and dorsal area. These characteristics were chosen due to their proven utility in various individual identification studies for this species (Dinis, 2014; Urian et al., 2015).

The best photographs for each individual (*BESTS*) were selected, ensuring they clearly showed distinctive marks on both profiles of the dorsal fin: right dorsal (RD) and left dorsal (LI) (Figure 4). These images were recorded in two formats: physical logs to maintain a historical paper record, and in the MMAPE research program's database for digital storage. All records included complementary information such as location data, behavior, and specific photographic references. This initial documentation allowed for systematic structuring of the data and preparation for comparative analysis.

After completing this process for each year, the photographs were compared using ACDSee Pro 2.5 software. This software, widely used by researchers in marine mammal identification projects, including bottlenose dolphin studies (Engelhaupt et al., 2022; Meza-Fidalgo & Urian, 2023), facilitated the review of pre-cataloged individuals. It optimized the comparison process and helped identify recaptures within the same year (intra-annual) and between different years (inter-annual). To reduce uncertainty in selecting the best photos and for comparison, the photos were selected and compared by more than one person.

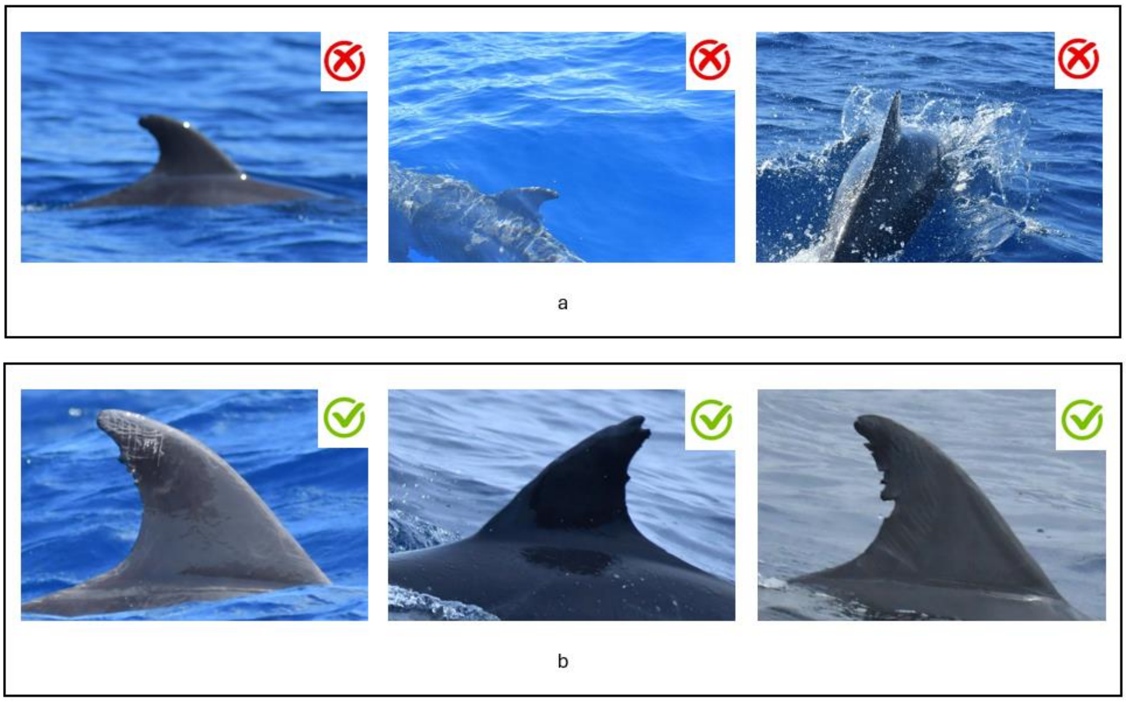


Figure 4. The figure illustrates the characteristics that determine whether a photograph is selected or discarded for photo-identification purposes. Panel (a) shows examples of low-quality photographs that are unsuitable due to issues such as blurriness, partial submersion of the individual, or poor profiling of the dorsal fin. Panel (b) displays examples of high-quality photographs that are suitable, as they clearly capture features necessary for individual identification.

When uncertainties arose, ACDSee Pro 2.5 allowed for adjustments such as manipulating photo perspectives, cropping irrelevant parts to streamline the comparison, and editing brightness or applying grayscale to enhance the visibility of subtle body marks, improving the accuracy of individual comparisons. From this analysis, the most representative images for each individual were selected and labeled as "BESTS." These images were renamed following a standardized code, which included information such as the individual number, date, and fin profile, example: A24_Rev_29Mar2022_6444_DD.

Once all final viable images, classified as the "best" for each individual across all years, were obtained, a Photo-ID analysis was conducted to determine the total number of identified *Tursiops truncatus* individuals. This included individuals for which identification was available for both sides of the dorsal fin or only one side.

The final product of this process was a population catalog that includes the best (*BESTS*) images of the dorsal fins of bottlenose dolphins from the REV. These images were organized by individual and renamed with a final identification tag using the code "MMAPE_Ttru__Rev_####." In addition to documenting the presence and distinctive characteristics of each individual's dorsal fin, this catalog enables long-term analyses of population dynamics and recapture patterns within the REV. This structured approach ensured efficient data management and the generation of reliable results.

2.5. Philopatry

To determine whether individuals exhibit site fidelity (philopatry), an analysis was conducted using the spatiotemporal distribution data of photo-identified dolphins. This analysis involved calculating the percentage of individuals recaptured across different years of the study by dividing the number of recaptures by the total number of individuals identified throughout the entire study period and multiplying the result by one hundred.

$$Philopatry\ (\%) = \left(\frac{Number\ of\ recaptured\ individuals}{Total\ number\ of\ identified\ individuals}\right) \times\ 100$$

This calculation estimated the proportion of individuals returning to the study area during the sampling period, enabling the identification of potential residency patterns.

2.6. Discovery curve

The discovery curve refers to the appearance of new individuals within the sample. In this study, it represents the cumulative number of new identifications over time, with each newly identified individual added to the sample. This type of analysis is useful for generating information about the studied population and is essential for determining whether the attributes of the population align with those of a closed or open population (Bolaños-Jiménez et al., 2021; Schreiber & Moore, 2018). The accumulation curve of new individuals was constructed using the "ggplot2" package in R (Wickham, 2016).

2.7. Population estimate

To estimate the population size of *Tursiops truncatus* in the REV, the Lincoln-Petersen method, a capture-recapture technique designed for closed populations, was employed (Pollock, 2000; Silva, 2016). This method calculates the total population size based on the proportion of marked individuals in the first capture that is recaptured in a second session. Using data obtained through photo-identification, the Lincoln-Petersen formula was applied, providing a robust and non-invasive estimation suitable for cetaceans in marine environments.

$$N = \frac{(M \times C)}{R}$$

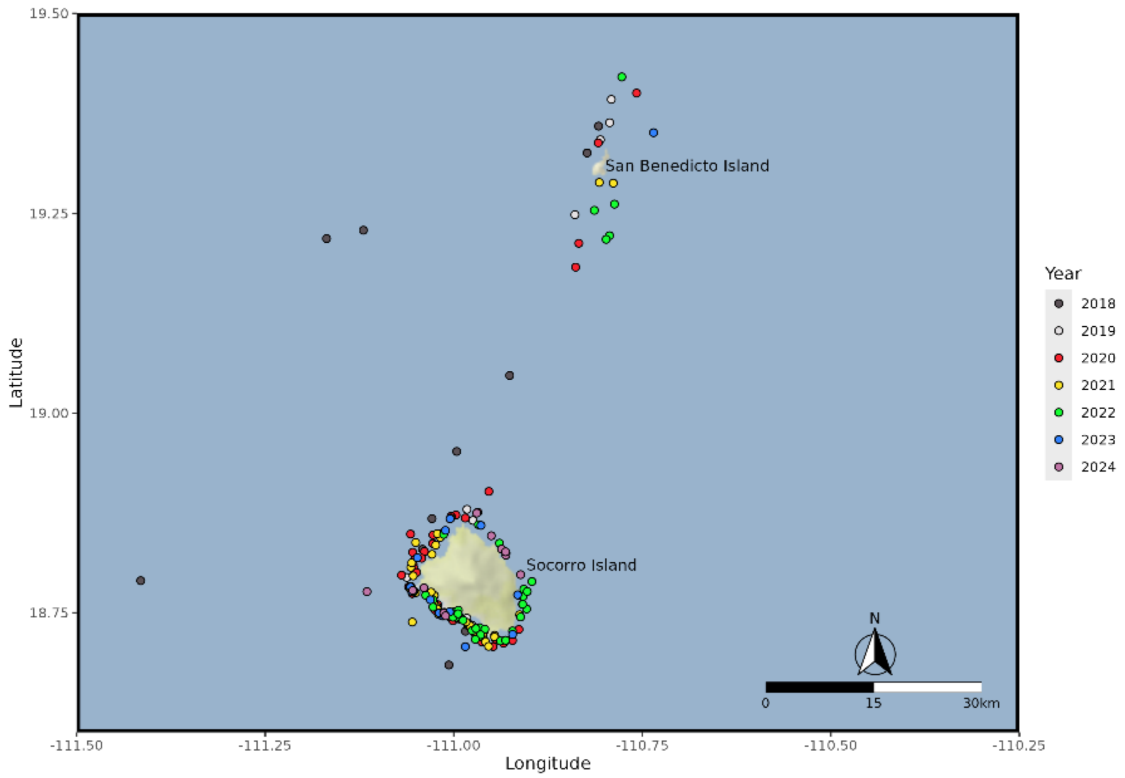
Where, N is the Estimated population size; M is the Number of individuals marked during the first capture; C is the Total number of individuals captured during the second capture and R is the Number of marked individuals recaptured during the second session.

This formula assumes that the proportion of marked individuals in the second capture (R/C) represents the proportion of marked individuals in the entire population (M/N).

3. Results

3.1. Distribution

During the six years analyzed (2018-2024), a total of 191 bottlenose dolphin (*Tursiops truncatus*) sightings were recorded, accounting for 8 hours and 38 minutes of fieldwork dedicated to photo-identification and documenting the distribution of sightings (Figure 5). Although it was not possible to obtain photographs for all the sights, every sighting was documented and recorded. Of these, 51 lacked photographic records, while 140 included photographic captures, which were instrumental in the development of this study.



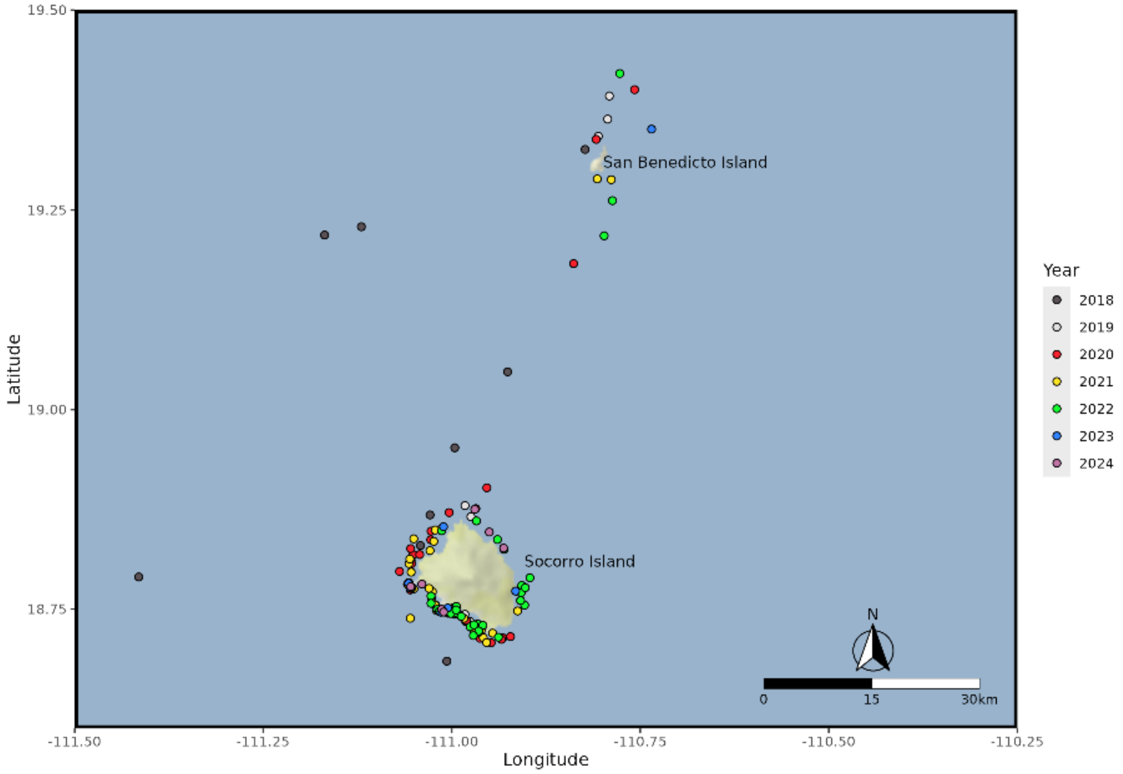


Figure 5. Distribution of sightings of *Ttru* in the REV (2018-2024). The top panel map shows all recorded sightings during the study period, including those without photo-identification. The down panel map displays only sightings where photo-identification was successfully performed.

Most of the documented sightings and photo-identification efforts were conducted around SI (81% of the sightings), the largest island of the REV. This explains why most identified individuals originate from this location. However, individuals were also recorded and identified in other areas, such as SBI, the transit route between SBI and SI, and the transit route between RPI and SI, although in smaller numbers due to less frequent sampling in these zones. A summary table of the number of individuals identified in each study area is presented below (Table 1).

Table 1. Shows the distribution of identified individuals across different zones and years, including areas such as San Benedicto (SBI), Socorro (SI), the route between SBI and SI, and between RPI and SI.

	2018	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
SBI	0	6	12	2	6	0	0	26
SI	22	32	68	72	73	22	20	309
SBI-SI	19	15	0	1	5	0	0	40
RPI-SI	5	0	0	0	0	0	0	5
Total	46	53	80	75	84	22	20	380

Of the 191 documented sightings, dolphins were recorded and classified based on their group size, which ranged from a single individual to a group of 60. The most common group size observed was 1 (solitary), with 41 sightings (21,5% of total sightings), followed by groups of 2 dolphins, representing 17% of sightings (Figure 6). Among the sightings, 166 (86.9%) did not document the presence of calves, while the remaining 25 (13.1% of the total) confirmed calf presence. The highest number of sightings with calves was recorded in 2021, with 12 sightings, 27.27% of that year's sightings, which represented double the average for all years, while 2018, 2019 and 2023 had the fewest, with no sightings of groups including calves (Table 2). 100% of the sightings in which the presence of calves was documented were in waters around SI (Figure 7).

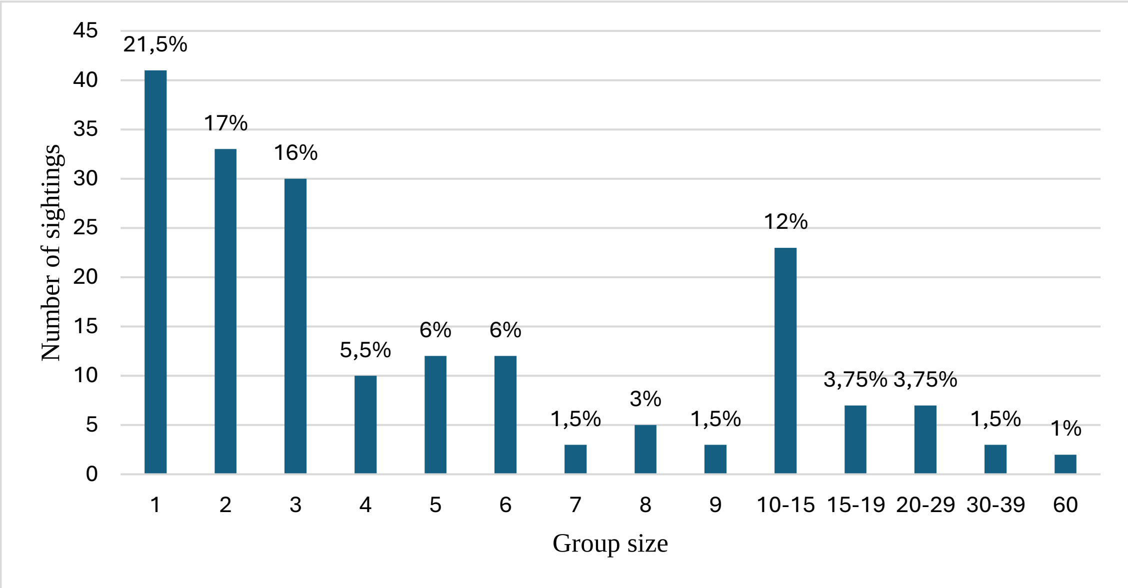


Figure 6. Number of sightings by group size

Table 2. Annual distribution of dolphin sightings categorized by the presence or absence of calves during the study period.

Calf	2018	2019	2020	2021	2022	2023	2024	Total
Yes	0	0	3	12	9	0	1	25
No	14	21	37	32	37	15	10	166
Total	14	21	40	44	46	15	11	191

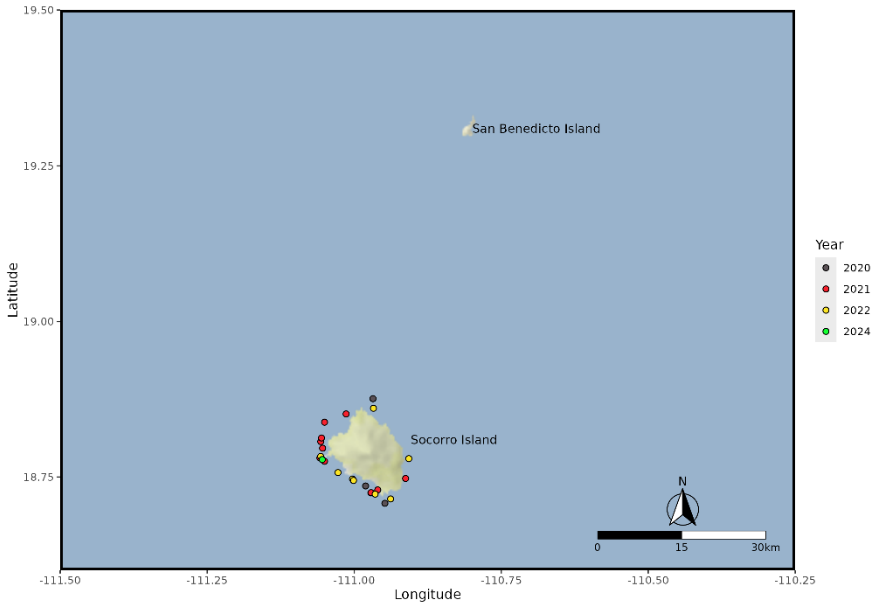


Figure 7. Distribution of *Ttru* sightings where calves were documented for the period 2018-2024.

3.2. Photo Identification

During the photo-identification effort, 5,483 photographs were taken, identifying a total of 380 individuals over the six years analyzed. The year with the highest number of identifications was 2022, with 84 bottlenose dolphins' photo-identified, while 2024 recorded the lowest number, with 20 individuals identified (Table 3). Identifications from 2018 to 2020 are part of an undergraduate thesis currently in progress (Martínez, in press), while those from 2021 to 2024 were carried out during the preparation of the present study. Comparing all identified individuals across years, a total of 331 unique dolphins were identified using Photo-ID, with multiple intra-annual and inter-annual recaptures recorded (Figures 8 and 9).

Table 3. Number of unique *Ttru* individuals identified per year, and total photos collected per year, during each year of the study period (2018-2024).

Year	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**Total**
Total photos	595	829	1034	1366	1319	93	247	5483
Identified individuals	46	53	80	75	84	22	20	380

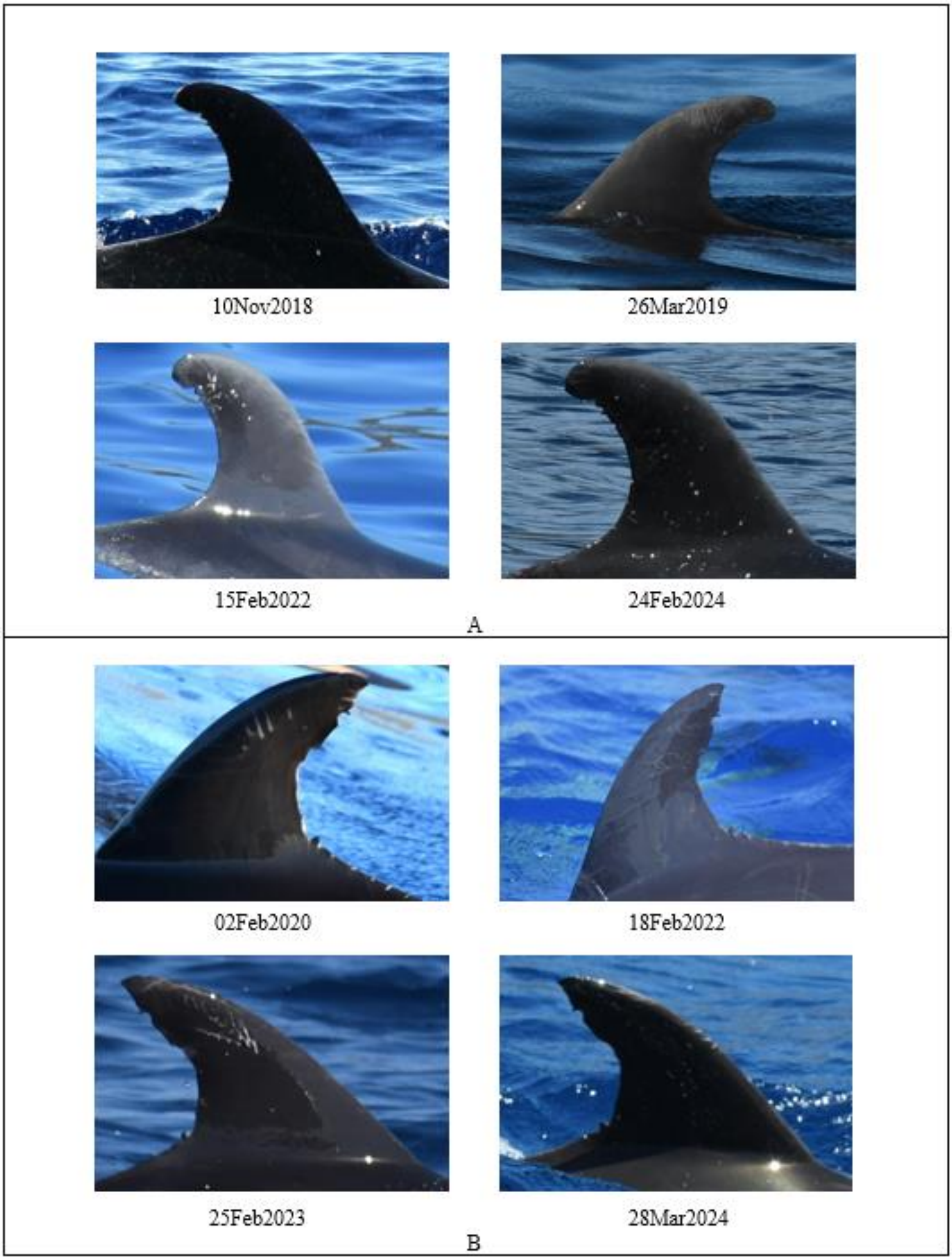


Figure 8. Examples of *Ttru* recaptured in different years by photo-identification analysis during the study period (2018–2024); A) Ttru_008 and B) Ttru_145. Data source: MMAPE.

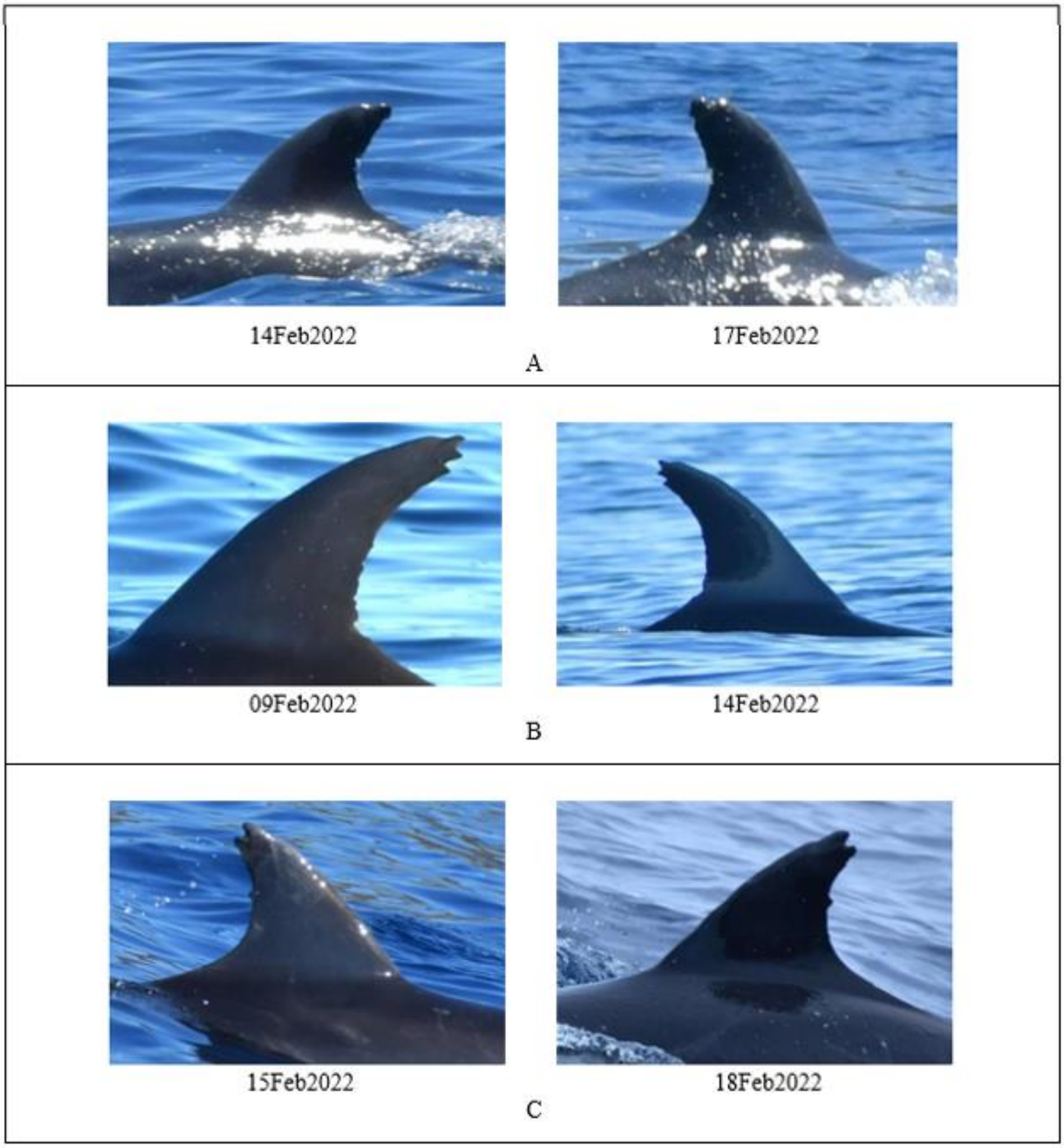


Figure 9. Examples of *Ttru* recaptured in the same year by photo-identification analysis during the study period (2018–2024); A) Ttru_015, B) Ttru_150, and C) Ttru_192. Data source: MMAPE.

3.3. Philopatry

The philopatry analysis showed that of the 324 identified individuals, 80% (n=259) were observed only once (initial capture), while 20% (n=65) were observed more than once, including intra-annual, inter-annual, or both types of recaptures. Of those 65 individuals, 16 (5% of the total photo-identified dolphins) had intra-annual recaptures in 2019, 2020, and 2022. Additionally, 49 individuals (15%) had inter-annual recaptures, meaning they were observed in different years. Among these, 27 dolphins were seen in two different years, 15 in three years, 5 in four years, and 2 in five different years (Figure 10).

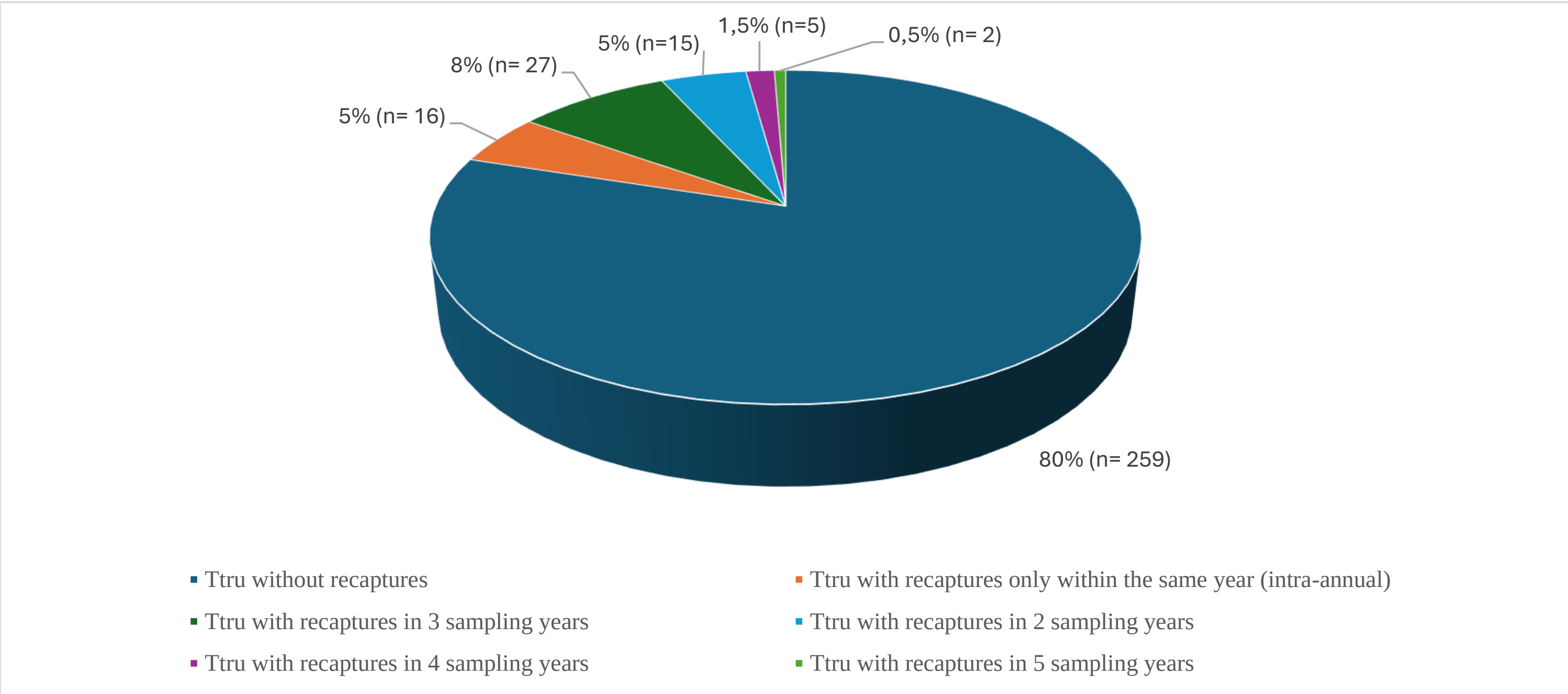


Figure 10. The percentage of bottlenose dolphin individuals (*Ttru*) that exhibited inter- or intra-annual recaptures during the 2018–2024 period in the Revillagigedo Archipelago is shown.

3.4. Discovery curve

The discovery curve of the total number of individuals showed a consistent increase throughout the study period, reflecting the addition of new specimens to the catalog. A notable rise in the number of identified individuals was observed in 2020, 2021, and 2022, highlighting high identification activity during these years. The curve has not yet stabilized, suggesting that more individuals may be identified with increased sampling effort. (Figure 11).

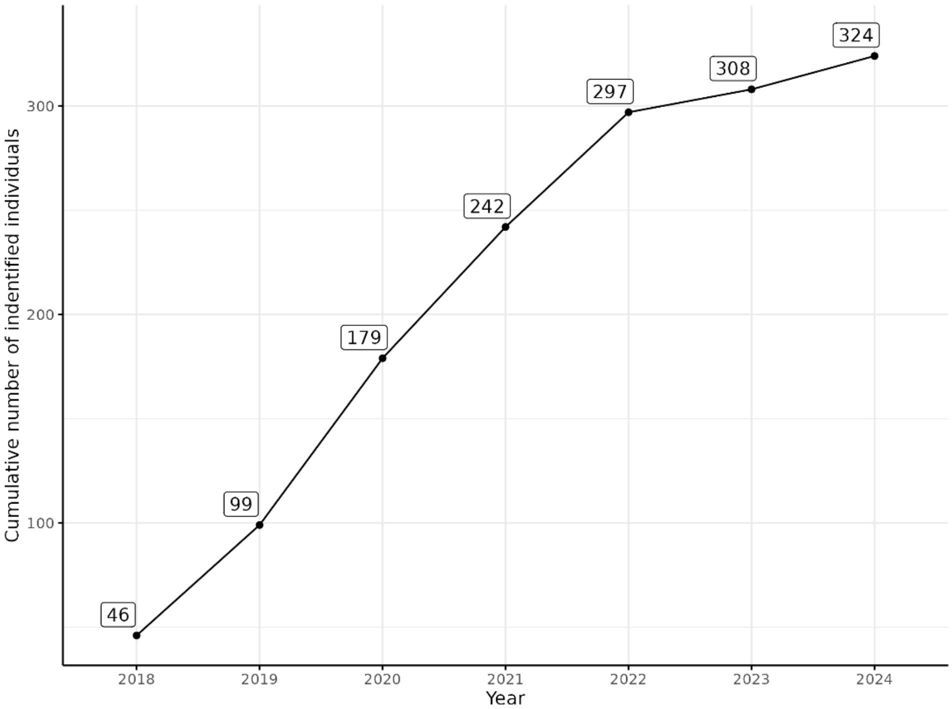


Figure 7. Discovery curve of bottlenose dolphins identified in REV between 2018 and 2024.

3.5. Population estimate

The estimated population size of *Ttru* in the REV, calculated using the Lincoln-Petersen method, was 242 individuals for the study period (2018–2024). Table 4 presents this value along with the standard error (SE), which reflects the variability associated with the estimate. Minimum and maximum possible values for the population estimate, determined from the confidence interval, are also included. These data provide a more comprehensive representation of the inherent uncertainty in the population analysis.

Table 4. Population estimates of *Ttru* using the Lincoln-Petersen method for the period 2018-2024.

	Population	**SE**
2018-24	237	60
Minima	89	18
Maxima	650	195

4. Discussion

This study contributes to the understanding of the bottlenose dolphin in the REV, a place where research on the population dynamics and behavior of cetaceans in general and of the bottlenose dolphins, in particular, is minimal. To date, there is evidence of only one attempt at a catalog of individuals conducted between 2003 and 2006 (Rosales-Nanduca, personal communication), and between 2018-2020 (Martínez-García, in press) and a couple of recent papers documenting some ecological aspects of these dolphins (Carone et al., 2023; Rio et al., 2022). This lack of prior research underscores the importance of the results obtained, offering key insights into the ecological characteristics of the population in this remote marine environment. Furthermore, this scarcity of studies along with the increasing interest in tourism activities to interact with these dolphins, highlights the need for continued research in this region to address knowledge gaps and develop effective conservation strategies.

The spatial analysis of sightings revealed that the highest concentration of records occurred in the waters surrounding SI, the largest and most sheltered of the four islands that make up the archipelago (CONANP, 2018). This concentration seems to be influenced by sampling effort bias, as monitoring activities were primarily conducted during the winter months when northern winds predominate. SI provides sheltered areas from these winds, allowing for effective monitoring. Nonetheless, bottlenose dolphins appear to utilize the entire area surrounding SI, as sightings were recorded on the southern and northern sides as well as on the eastern and western faces (Figure 5).

Since dolphin sightings were recorded concurrently with whale monitoring efforts, the total number of records and their differences across years (Table 1) do not necessarily reflect actual differences in dolphin presence in the area. Additionally, the scarcity of sightings between the islands may be attributed to reduced sampling efforts in these zones. This highlights the need for comprehensive analyses in the REV, taking into account environmental factors and their significance in the distribution and abundance of dolphins (Wells & Scott, 2018).

A notable aspect is that the majority of sightings occurred in relatively nearshore waters, suggesting that dolphin distribution is strongly influenced by proximity to the islands. This type of distribution, with dolphins associated with island environments, has already been described in other regions worldwide (Baird et al., 2009; Kogi et al., 2004; Martien et al., 2012, 2024; Tezanos-Pinto et al., 2013). Additionally, the documentation of sightings in waters connecting SI with SBI, SI with RPI, and RPI with SBI suggests that dolphins are not limited to nearshore waters but also travel between the islands (Baird et al., 2009; Dinis, 2014; Martien et al., 2012, 2024).

Regarding group sizes (Figure 6), 90% of sightings involved solitary individuals or groups of up to 15 dolphins, aligning with the typical group size of dolphins classified as belonging to the coastal ecotype (Carwardine, 2019; Pereira, 2021; Shane et al., 1986; Silva et al., 2008; Wells et al., 1987; Xiao, 2011). Meanwhile, 10% of sightings consisted of groups of 16 or more individuals, including two records of groups with approximately 60 dolphins. These larger group sizes are more consistent with the characteristics of the oceanic ecotype (Silva et al., 2008; XIAO, 2011). The sightings of groups with 60 individuals were recorded along the route connecting SI to RPI and in the northern portion of SI, where the continental shelf narrows significantly (CONANP, 2018). A notable aspect is the high number of sightings of single individuals (Figure 6), which contrasts with the high sociability characteristic of this species (Wells & Scott, 2018). However, this high frequency of sightings with a group size of one animal seems to be related to the prevailing conditions on the island, where there is a lot of swell and sometimes only one animal is recorded when it is observed but the sighting cannot be followed up, but it is recorded to understand the distribution of the species (Rosales Nanduca, personal communication).

Calf presence was documented in 13% of the total sightings, exclusively in the nearshore waters of SI (Figure 7). The high frequency of relatively small group sizes (<15 individuals) suggests that similar to their distribution, the group size of dolphins associated with the REV aligns with the group size and behavioral traits typical of the coastal ecotype (Silva et al., 2008; XIAO, 2011).

These observations, along with the documentation of calf presence in most years in nearshore waters, reinforce the hypothesis proposed by Carone et al. (2023), which states that the waters adjacent to the archipelago play a vital role in the rearing activities of these dolphins. The calves observed likely originated in these areas, as young dolphins have limited capacities for long-distance travel due to age-related physiological and locomotive restrictions. These include underdeveloped musculature, reduced aerobic and anaerobic capacity, limited oxygen reserves in their blood, and diminished endurance for prolonged swimming (Noren et al., 2006; Noren & Edwards, 2011). In contrast to what was documented by Carone et al (2023) where the presence of calves in SBI was reported in the two main dive sites (El Boiler and El Cañon), the presence of calves was not documented in any of the 26 sightings in SBI in this study (Table 2, Figure 7). This highlights the need for continuous monitoring that includes spatial analysis and in dive sites where interactions between divers and bottlenose dolphins occur.

Although bottlenose dolphins have been documented to travel distances of up to 1,500 km (Dinis et al., 2021), such movements are characteristic of the oceanic ecotype. Considering the observed group sizes, proximity to the coast, and presence of calves, it is suggested that most of the dolphins recorded in Revillagigedo may belong to a group closely associated with the islands. So, the bottlenose dolphins associated with the waters adjacent to the REV appear to have a complex dynamic in which some individuals are strongly associated with the nearshore and shallow waters adjacent to the islands (high recapture values) (Figure 5), while some bottlenose dolphins appear to be part of an oceanic group that uses the waters adjacent to the islands as part of its distribution. This hypothesis is strengthened by the fact that in the two sightings of up to 60 individuals, none of the individuals that could be identified presented recaptures (Figure 10), as well as the fact that these group sizes coincide with the characteristics of the oceanic ecotype (Pereira, 2021).

The identification and analysis of bottlenose dolphin (*Ttru*) recaptures in REV revealed that 49 individuals had inter-annual recaptures, meaning they were observed in two or more years, while 16 others exhibited intra-annual recaptures, even if they were not sighted across multiple years (Figure 9). Some individuals showed a recurrent association pattern, as they were repeatedly observed alongside the same dolphins, suggesting strong social bonds. This affinity for a specific group of individuals (like a familial clan) warrants further analysis. Similar “strong” associations have been demonstrated in other island-associated dolphin populations (Pereira, 2021). In this context, conducting social structure analyses to explore this ecological attribute of dolphins in REV will be particularly relevant.

The analysis of movements between islands revealed that out of 380 photo-identified individuals (26 in SBI, 309 in SI, and 45 in transit between the three analyzed islands), only two were confirmed to have recaptures across two islands (SBI and SI). One individual was recaptured on three different occasions, initially in SI, then in SBI, and finally again in SI, across different years. Another individual was observed in the transit route between SBI and SI and later in SI. The distance between these two islands (≈50 km) is relatively short given the movement capabilities of these animals, as demonstrated in studies conducted in other regions of the world (Hwang et al., 2014; Keener et al., 2023). Additionally, Martien et al. (2024) described similar movements in dolphins associated with oceanic islands, which have also been documented for bottlenose dolphins in Hawaii, where the inter-island dispersal rate has been estimated at around 1% annually (Baird et al., 2009).

It is not surprising that the general pattern documented here suggests a site fidelity behavior of dolphins to one of the two islands in the REV with the highest monitoring effort. Of the 380 animals photographed for the first time, only two (0.5%) were seen at both islands. Further efforts in photo-identification studies will be needed to confirm whether the documented pattern is not a result of insufficient sampling effort.

Some of the results support the idea that some of the bottlenose dolphins identified in Revillagigedo are closely linked to the islands, displaying characteristics associated with coastal ecotypes while inhabiting a fundamentally oceanic environment, while other bottlenose dolphins seem to be part of a different population unit since they did not have recaptures and were observed in groups of up to 60 animals, which are group sizes characteristic of the oceanic ecotype (Figures 5 and 10). Considering that the coastal and oceanic ecotype of bottlenose dolphins may present sympatric distribution in other areas of the Mexican Pacific (Díaz-Gamboa, 2003; Viloria-Gómora & González, 2015), this supports the idea that dolphins from two population units or ecotypes may be being sampled in the waters adjacent to the Revillagigedo archipelago.

Photographic data collected by the Marine Megafauna and Fisheries Research Group (MMAPE) at the Autonomous University of Baja California Sur (Mexico) on bottlenose dolphins in the REV between 2018 and 2024 indicate that higher photographic effort in specific years resulted in a greater number of identifications (Figure 11). This highlights the necessity of consistent and systematic sampling, which could provide a clearer understanding of population dynamics and social relationships in this region.

While photo-identification is highly effective for studying bottlenose dolphins, the use of natural markings for individual recognition presents inherent challenges. Longevity and mutability of marks are key factors, as long-term population studies require stable markers over time (Würsig & Jefferson, 1990). It has been suggested that dorsal fin tissue in bottlenose dolphins does not regenerate, making nicks and notches relatively permanent (Würsig & Würsig, 1977). However, other marks, such as scratches and scars, tend to fade or disappear over time (Leone et al., 2019), and evidence indicates that even small notches can regenerate, becoming undetectable (Auger-Méthé & Whitehead, 2007). Long-term analyses that consistently consider unique individual characteristics will allow the continued accumulation of knowledge about this species in the REV.

85% of the identified individuals were sighted only once, while the remaining 15% were recaptured on two or more occasions in different years, suggesting philopatry among a significant portion of the cataloged dolphins in the REV. This pattern, where individuals with site fidelity coexist with another segment of migratory and/or transient individuals, has been previously documented in other insular regions, such as Madeira (Dinis et al., 2018) and São Tomé and Príncipe (Pereira, 2012). This combination of site fidelity by a considerable number of identified dolphins and the presence of many individuals observed only once, also suggests the existence of two potentially different population units: one characterized by marked philopatry to the islands and another potentially belonging to a coastal ecotype that moves through the area (Servidio et al., 2019). To definitively identify the presence of distinct population units or if these dolphins are part from a wide-ranging population that uses a wide area, beyond the near-shore areas around the islands, comprehensive analyses will be required.

The fact that the discovery curve has not yet stabilized (Figure 11), despite the fact that the population estimate (237 individuals, ±60 SE), a number lower is lower than the number of individuals identified 324 (see Table 4), supports the hypothesis of a dynamic in which two ecotypes or subpopulations of this species could coexist. This has been documented in other areas of Pacific Mexico, where coastal and oceanic habitats coexist near the coast. This hypothesis needs a thorough analysis. This continuous recruitment may be attributed both to local births, and changes in the natural markings of previously identified individuals. Nevertheless, the constant increase in the number of identified individuals could be related to the presence of migratory and transient dolphins in the area, as documented in other insular populations in Macaronesia (Dinis, 2014; Silva, 2007). Dolphins observed only once can be classified as "behavioral transients". This term describes dolphins that, despite potentially being residents, are not resighted during the study period due to lower capture probabilities, mortality, permanent emigration, or insufficient effort for resighting (Alves et al., 2013; Connor et al., 2000; Servidio et al., 2019).

The estimated population size falls within the range of other populations studied in insular areas. For example, studies in the Hawaiian Islands of Kauai and Niihau reported a population of 184 individuals using the same method based on photo-identification data (Baird et al., 2009). Kendall (1999) noted that closed population models, like those described by Otis et al. (1978), can provide valid estimates even when closure assumptions are violated, such as in cases of random movement in and out of the study area. Therefore, the results obtained in this study are considered a robust and representative estimate of the population size of bottlenose dolphins in the REV. Compared to other insular areas, such as southwest England, where 61 individuals were estimated using similar capture-recapture methods (Brereton et al., 2018), the estimated population in the REV appears to exhibit a more dynamic and heterogeneous structure. This dynamism may be related to the distances between the islands, habitat characteristics, and the geographical isolation of the archipelago, factors that influence both mobility and habitat use by the dolphins. These estimates also emphasize the importance of considering data variability, as the confidence interval in this study reflects a potentially broader population (89 to 650 individuals). This could be due to a mix of residents and transients, a common pattern in open populations such as those described in the Azores (Pereira, 2021; Silva, 2007).

In summary, these results reinforce the idea that some *Ttru* in Revillagigedo are closely linked to the islands, displaying characteristics associated with coastal ecotypes while inhabiting a fundamentally oceanic environment. However, future studies considering trophic ecology, molecular ecology, movement patterns, and habitat use, among other factors, will help to complete the information presented here.

5. Conclusions

-The findings of this study provide valuable insights into certain aspects of the ecology of *Tursiops truncatus* in the Revillagigedo Archipelago, a region with limited prior research on cetaceans.

-Bottlenose dolphins are distributed around the entire Socorro Island and areas can also be found between the islands.

-The documented movements between islands, group sizes, and philopatry of some individual dolphins, suggest characteristics like those documented in subpopulations linked to oceanic islands.

-The almost non-existent number of recaptures between islands, suggests limited connectivity, albeit the limited number of IDs in San Benedicto Island and Roca Partida, highlights the need to expand sampling efforts to better confirm patterns of residency and mobility.

-All sightings with the presence of calves were concentrated around Socorro Island, which suggests that this island (the biggest island of the archipelago) is important for the breeding of this species.

-The evidence suggests that the dolphins in this area exhibit characteristics of a population segment with certain levels of philopatry and a significant proportion displaying traits of an open oceanic population. This pattern is reflected both in the discovery curve, which shows a constant increase in identified individuals (324), like in the population estimate (237 ±60 SE).

-Long-term analyses and a more systematic sampling design, will be crucial for filling knowledge gaps and designing effective conservation strategies to protect this unique population and its habitat in the archipelago.

-The results of this work are significant not only for advancing knowledge about the dolphin population in the Revillagigedo Archipelago but also for emphasizing the importance of determining with greater precision whether this population consists of residents, migrants, or a combination of both.

6. List of abreviations

REV - Revillagigedo Islands/Archipelago

SST - Sea Surface Temperature

CONANP - Comisión Nacional de Áreas Naturales Protegidas

SI - Socorro Island

SBI - San Benedicto Island

RPI – Roca Partida Island

CI – Clarion Island

Ttru – *Tursiops truncatus* (scientific name for bottlenose dolphin)

RD - Right dorsal (fin)

LD - Left dorsal (fin)

BCS - Baja California Sur

ACDSee - A photo editing software used in photo-identification

GPS - Global Positioning System

MMAPE - Programa de Investigación de Megafauna Marina y Pesquerías

ID - Identification

7. Bibliography

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Descripción detallada de las actividades desarrolladas durante la realización del TFT

El tema y el desarrollo de mi TFT va ligado a las prácticas, es por ello que van a ir en consonancia ya que necesitaba mis prácticas para la realización del TFT. Todo esto empieza en el mes de abril de 2025 y caduca junto con la entrega final del escrito el 12 de diciembre del mismo año.

He de aclarar que este trabajo se divide en dos fases principalmente, el tiempo durante el que realizamos las prácticas y el periodo post-prácticas. Esto hay que destacarlo ya que en este proceso intervienen principalmente dos personas: el Dr. Hiram Rosales (mi tutor del TFT) y la Dra. Esther Jiménez (tutora de prácticas), donde los dos son coordinadores del programa de investigación MMAPE que es con el que realicé ambas tareas.

Todo empieza con las prácticas, donde me reuní con Esther y me explicó lo que iba a necesitar hacer de cara a mi TFT.

Durante las prácticas realizadas en MMAPE, las actividades principales estuvieron enfocadas en la foto-identificación de delfines nariz de botella (*Tursiops truncatus*). Este proceso tenía como objetivo diferenciar y clasificar individuos únicos a partir de las marcas características visibles en sus cuerpos, especialmente en las aletas dorsales. El trabajo comenzó con el acceso a la base de datos de MMAPE, donde se encontraban las carpetas con fotografías y datos de los avistamientos (Figura 1). A partir de estas imágenes, se realizaba un análisis detallado para identificar las marcas distintivas de cada delfín, elaborando pequeños esbozos que facilitaban la comparación entre individuos, tanto dentro del mismo día como en fechas posteriores (Figura 2).

Figura 1: Archivo online de MMAPE.

Una vez identificados los ejemplares, se seleccionaban las mejores fotografías y se registraban en bitácoras, donde se anotaban datos clave como la ubicación GPS, la fecha, la hora y el comportamiento observado durante los avistamientos (Figura 3).

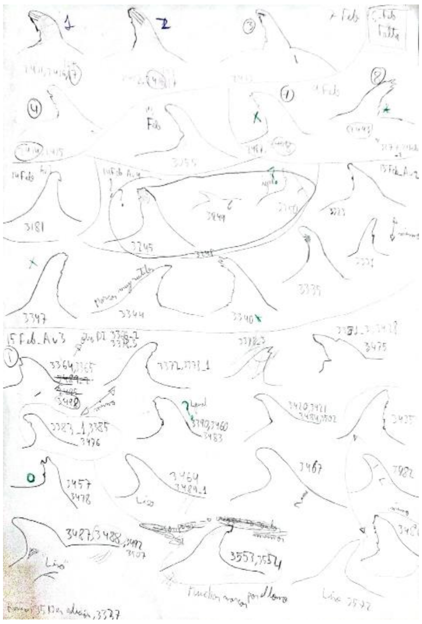

Figura 2: Esbozo de diferentes ejemplares de Tursiops truncatus durante la foto identificación.

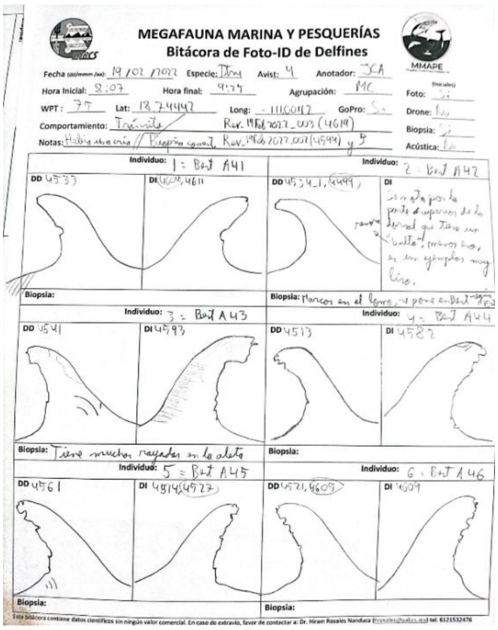

Figura 3: Ejemplo de bitácora de foto identificación de delfines.

Este registro organizado era esencial para la posterior comparación de imágenes. La siguiente etapa implicaba una revisión exhaustiva de los individuos identificados en un mismo año, con el objetivo de detectar posibles recapturas que no se hubieran identificado previamente. Luego, las imágenes se contrastaban con las de años anteriores, abarcando el periodo de 2022 a 2024. Para gestionar y editar las fotografías utilizadas en este análisis, se empleó el software ACDSee Pro 2.5, una herramienta clave para el desarrollo de esta actividad (Figura 4).

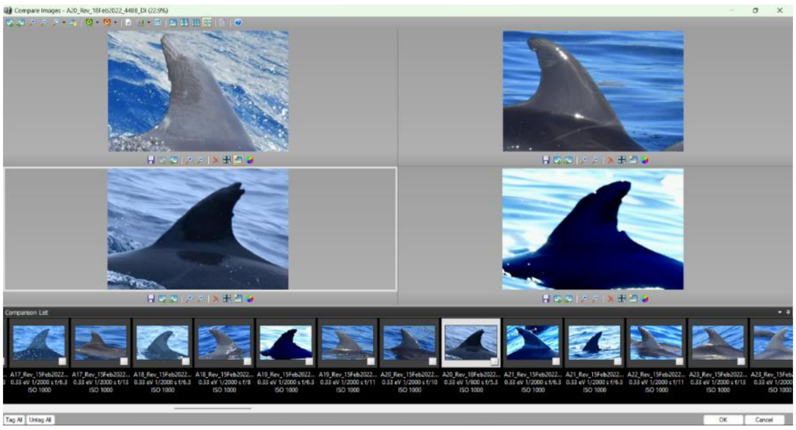

Figura 4: Software ACDSee Pro 2.5 para la gestión y edición de imágenes.

Como parte del trabajo, se diseñaron plantillas específicas en Excel para organizar las recapturas, lo que permitió determinar con precisión la frecuencia con la que se había avistado cada ejemplar y seleccionar las mejores imágenes para cada individuo (Figura 5).

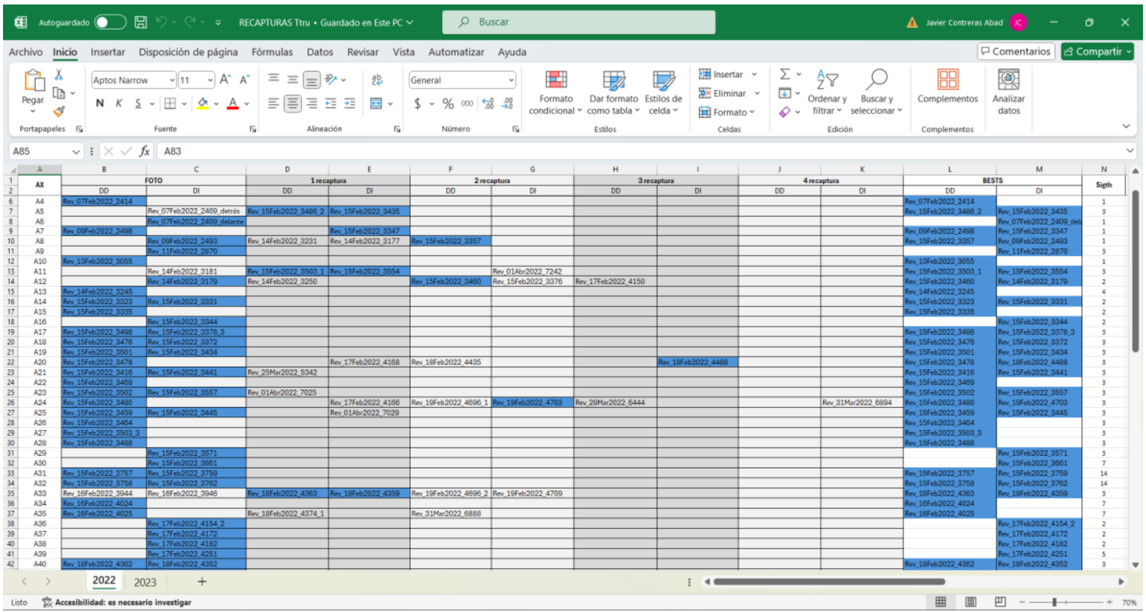

Figura 5: Plantilla utilizada para la recaptura de ejemplares.

Estas imágenes finales, etiquetadas como "BEST", se integraron en un catálogo que agrupaba a los delfines por años y por referencias individuales (Figura 6). Cada carpeta incluía tanto las fotos seleccionadas como las recapturas, organizadas de manera meticulosa (Figura 7).

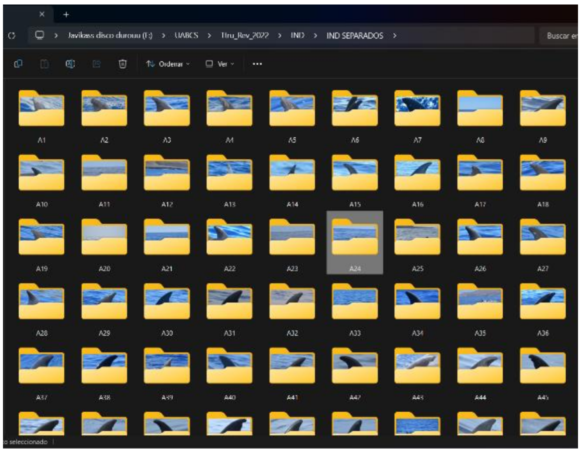

Figura 6: Método de organización para los individuos identificados por año.

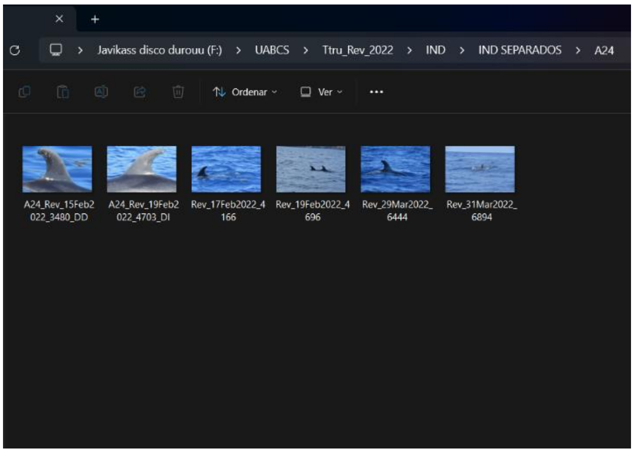

Figura 7: Ejemplo de un individuo de Tursiops truncatus identificado. Dentro de cada carpeta se agrupan sus fotos "BEST" y las fotos de las recapturas.

Las fotos que pude relacionar con individuos ya identificados de años anteriores se nombraron de la misma manera que la primera vez, mientras que las que no pude relacionar recibieron una nueva etiqueta. Mi trabajo consistió en completar la foto identificación de los años 2022, 2023 y 2024, para luego comparar estos resultados con los años anteriores que habían sido realizados por otro voluntario. En mi caso, la primera forma de etiquetado seguía la norma de Lugar_Fecha_Numerodefoto, por ejemplo, Rev_29Mar2022_6444. Las fotos que seleccionaba como 'BESTS' tenían detalles adicionales, como el número de individuo al principio y el perfil de la aleta al final del etiquetado. Por ejemplo, A24_Rev_29Mar2022_6444_DD, donde “A24” indica que es el Adulto número 24 y “DD” indica que es la Dorsal (aleta) Derecha.

El resultado final de estas actividades fue un catálogo completo que reflejaba el número total de individuos únicos identificados. Una vez acabé con lo mandado durante mis prácticas, debía comparar estos resultados que he obtenido con otros resultados pero de los años anteriores, realizados con el mismo procedimiento pero de otro voluntario del grupo de investigación llamado Yilmar Martinez. El se encargó en su momento de hacerlo para los años 2018-2020 y para el 2021 en teoría se encargó una chica de la cual nunca supe el nombre y también se había encargado de hacer el mismo proceso, donde había un documento también con individuos diferenciados, pero sin base, es decir, que estaba el trabajo a medias.

La comparación con estos años anteriores ha sido lo que mas ha retrasado mi trabajo, ya que esto debía ser una tarea que tendría que haber acabado en junio junto con mis prácticas, pero se demoró demasiado porque Yilmar no respondía a WhatsApp ni correos donde le pedía que me pasara toda su base e imágenes para comparar los individuos. Se demoró tanto hasta el nivel que me respondió entorno a finales de septiembre (mas de dos meses) y encima cuando comencé de nuevo con el proceso de comparar y buscar recapturas, me di cuenta de que había mil errores en su catálogo y en la base que me había proporcionado. Esto se lo comenté a Hiram el cual le manifestó mi disgusto y enfado y le metió presión para que me mandara los documentos “buenos”.

Después de tener ya todo en regla y haber buscado coincidencias y demás, entré en detalle con los diferentes objetivos que quería representar en el TFT, como el análisis espacial a partir de las ubicaciones de cada avistamiento, mediante el software R (gracias a la ayuda del profesor Ángelo Santana del Pino, que ha sido muy importante y ha aportado mucha ayuda en este trabajo, formando parte como tutor/colaborador) , la curva de descubrimiento también con R y el análisis de población en Excel mediante el método de Lincoln-Petersen, que era el principal objetivo junto al catálogo.

A partir de aquí, ya me centré en el escrito, pero claro, ya iba algo justo de tiempo porque había estado mucho tiempo antes esperando lo comentado. La redacción ha sido difícil debido a la poca información previa sobre la zona, por lo que he tenido que recurrir a artículos de muchas partes del mundo para tratar de entender el comportamiento de los delfines, tanto en regiones insulares (como es el caso) como peninsulares para ver las diferencias que había y ver si eso iba o no a afectar a mis conclusiones.

Durante estos dos últimos meses, he ido teniendo una reunión Hiram cada semana e incluso alguna de las últimas semanas he tenido dos debido ya al poco tiempo que había para entregar y a la necesidad que tenía para que mis avances sean revisados con mas frecuencia. Durante estas semanas, Hiram me ayudaba, revisaba mi trabajo hecho hasta el momento y me marcaba objetivos que tenía que cumplir de cara a la siguiente reunión. A la vez en este proceso, estaba el Dr. José Juan Castro Hernández (mi tutor de la Facultad de Ciencias del Mar), con él el trato ha sido menos y solamente me ha estado revisando el escrito algunas veces después de yo hacer toda la parte con Hiram, en donde Castro se dedicaba a realizar correcciones y comentarios para que yo pudiera verlos y corregir según su criterio conociendo mejor las características que pide la facultad.

El proceso del escrito con dos tutores tan diferentes ha sido complicado, ya que las correcciones de uno con el otro no conectaban debido a que en cada país tienen su forma de redactar un trabajo de esta magnitud, además, en México para ellos lo equivalente a un TFG es lo que le llaman ahí una tesis, generalmente de más de 100 páginas (por los ejemplos que he podido ver) entonces para Hiram también era complicado adaptarse a este formato, y siento que para Castro las formas de expresión que Hiram me pudiera recomendar para el escrito según él, no estaba de acuerdo en algunos casos (esta es mi opinión al ver las correcciones y aportaciones de cada tutor en mi trabajo).

Durante el transcurso del escrito, en el trabajo nos hemos ido dando cuenta (Hiram y yo) que podíamos añadir alguna información más que diera más contexto a todo, como por ejemplo en la distribución, sacar un análisis más específico sobre cada isla (ya que el objetivo principal era solamente mapear los avistamientos pero sin entrar en detalle en ellos, solo para que se viera el esfuerzo y la zona donde se recopilaron los datos) para poder ver los posibles movimientos entre delfines, también se nos ocurrió analizar los avistamientos con crías y por último medio indirectamente, aprovechamos para calcular la filopatría, ya que era un trabajo que con la foto identificación ya lo habíamos hecho sin darnos cuenta y eso nos iba a ayudar a dar mucho contexto en la discusión y el trabajo en general.

Ya en la última semana antes de hacer la entrega, siento que ha sido la que más me ha disgustado, por el hecho de que encima coincidía un puente en Canarias y algún malentendido entre mis tutores y yo no me ha hecho quedarme del todo tranquilo. Justamente 7 días antes de la entrega (jueves 5 de diciembre), mi trabajo está prácticamente acabado, a falta de revisión por mis tutores, a los cuales les explico la situación y les pido que me hagan penúltima revisión antes del fin de semana, una revisión que consistía en revisar toda la redacción excepto las conclusiones y el abstract, ya que estas dos partes no las había hecho todavía porque mi intención era hacerlas a posterior de la revisión que solicité, la idea era que de esta revisión final, yo tener todo el fin de semana y el lunes de la semana que viene para hacer las respectivas correcciones para así el martes entregarlas de nuevo y con la conclusión y abstract listos, para una última revisión final en el que buscaría acabar y dejar todo el escrito listo para el miércoles (1 día antes de la entrega) para así tener este margen por posibles problemas que puedan surgir y también para acabar de pulir el formato de entrega. Pues bien, esto no sucedió así del todo, con Castro hubo un malentendido a la hora de mandar una corrección que me había hecho y me llegó el domingo-lunes y finalmente tanto con Castro como con Hiram nos reunimos el martes (con Castro por la mañana y con Hiram por la tarde). Pese a esto, el trabajo estaba casi acabado y este último día de reuniones acabé el escrito (sobre todo con Hiram en la tarde).

Finalmente, y como en un principio estaba previsto, el miércoles día 11 de diciembre acabe de dar formato al texto final, y procedí a entregar el trabajo para que cada tutor lo firmara.

Formación recibida (cursos, programas informáticos, etc.)

La formación académica recibida durante el desarrollo de este Trabajo de Fin de Grado estuvo centrada en herramientas especializadas, principalmente programas informáticos. A través de una serie de "minicursos," adquirí conocimientos sobre el uso de ACDSee Pro 2.5, un programa destinado a la gestión y edición de imágenes. Este software fue esencial durante el proyecto, ya que se utilizó ampliamente para el análisis de recapturas y la elaboración del catálogo, basado principalmente en técnicas de foto identificación.

Además, durante mi estancia en México, participé en dos salidas de campo para familiarizarme con los métodos empleados en la recopilación de los datos que posteriormente analicé. Estas salidas proporcionaron formación práctica en protocolos de monitoreo de cetáceos, abarcando actividades como la elaboración de bitácoras físicas que luego se digitalizaron y se incorporaron a una base de datos en línea. Asimismo, adquirí experiencia en la obtención de fotografías de características anatómicas clave de los animales, particularmente de sus aletas dorsales, lo que me permitió comprender todo el proceso mediante el cual estas imágenes iniciales se transforman en datos analizables para la identificación individual y la construcción del catálogo.

Nivel de integración e implicación dentro del departamento y relaciones con el personal.

Durante mi estancia en México, la formación recibida no se limitó exclusivamente a las prácticas relacionadas con el desarrollo de mi TFG, sino que también abarcó otros campos vinculados a los proyectos de mis compañeros. Este enfoque interdisciplinario me permitió adquirir conocimientos más amplios, aprender de las experiencias de otros, y enriquecer mi formación académica, aunque la mayor parte de mi tiempo estuvo dedicada a las actividades específicas de mi campo de estudio.

Mi integración con el grupo fue a través de seminarios organizados por el grupo de estudiantes integrados en MMAPE. En estos seminarios, los integrantes presentaban sus proyectos y trabajos realizados dentro del programa, lo que favoreció el intercambio de ideas, el aprendizaje colectivo y una comprensión más amplia de las diferentes líneas de investigación llevadas a cabo en el marco del programa.

Aspectos positivos y negativos más significativos relacionados con el desarrollo del TFT

Sin duda, uno de los aspectos más valiosos que me llevo de esta experiencia es haber aprendido a realizar todo lo relacionado con el desarrollo de mi TFG. Tanto las prácticas como los conocimientos adquiridos de mis tutores y durante mi estancia en México han sido fundamentales. Reconozco que aún me queda mucho por aprender, especialmente en la realización de trabajos de este estilo que, en un futuro, me permitan emprender investigaciones o redactar artículos científicos. No obstante, gracias a todo lo realizado aquí, siento que estoy un paso más cerca de ese objetivo.

En cuanto a las dificultades encontradas, uno de los principales desafíos ha sido la deficiente organización en MMAPE. Las bases de datos y la información proporcionada presentaban numerosos errores, lo que retrasó considerablemente mi progreso. Esto me llevó a cuestionarme en repetidas ocasiones por qué debía corregir errores cometidos por otros, quienes luego se desentendieron de su responsabilidad. Este aspecto resultó particularmente frustrante, ya que incrementó de forma significativa la carga de trabajo inicial que ya era considerable.

Valoración personal del aprendizaje conseguido a lo largo del TFT.

Como ya he dicho, me quedo con lo positivo aprendido durante el desarrollo del TFT, siento que me falta mucha claridad al expresarme, pero gracias a la ayuda de Hiram he podido aprender un poco más sobre este campo. El hecho de que fuera en inglés también ha dificultado todo, pero me voy contento con el trabajo realizado y presentado.