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**Assessing the Population Size and Range Dynamics of the Atlantic humpback dolphin (*Sousa teuszii*) in the Saloum Delta, Senegal, Based on Two Years of Photo-Identification.**



**Universidade do Algarve**  
Faculdade de Ciências e Tecnologia

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Senegal, Based on Two Years of Photo-Identification.

**Mestrado em Biodiversidade, Pescas e Conservação Marinha**

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### **Dedication to My Son**

I dedicate this work to the love of my life, my sunshine, my endless source of inspiration and motivation, my beloved son Mouhamed Idrissa Deme. Always remember, dear son, that your mom loves you deeply, and never forget that the only limit you'll ever encounter is the one you place upon yourself.

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---

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## **ABSTRACT**

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The Atlantic humpback dolphin (*Sousa teuszii*), is a critically endangered species found along the coast of West and Central Africa, including the Saloum Delta in Senegal. The presence of the Atlantic humpback dolphin has been confirmed in at least 13 countries along the West African coast. For the remaining six countries, it is unknown whether the lack of data is due to the lack of researchers focusing on the Atlantic humpback dolphin, or whether the species is truly absent from those countries. This study aimed to contribute to our understanding of this species by

creating the first long-term photo-identification catalog, Mark-Recapture Analysis, and absolute population abundance estimate in the Saloum Delta, Senegal. The photo identification catalog was established through the collection and analysis of more than 13,000 photographs that captured unique markings and pigmentation patterns on individual dolphins during boat surveys conducted throughout the Saloum Delta in July 2021 and March-April 2022. A total of 164 individual dolphins were identified based on the unique markings on their dorsal fins. Of these 164 (24.4%) were observed on more than one occasion, 9.1% more than two times, and 3.7% more than three times. Mapping of movements of these individuals demonstrated that some ranged widely while others showed high site fidelity. A simple Chapman-modified Petersen mark-recapture estimate generated an abundance estimate of 469 individuals (CV 5733, 95% confidence interval 275 to 801). These preliminary results confirm the results of earlier studies indicating that the Saloum Delta hosts one of the largest known populations of AHD throughout its range and provides additional incentive to conserve the population and its habitat.

**Keywords: Marine mammals; Conservation ecology; Biodiversity; Endangered species; Population estimation.**

## SUMÁRIO

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O golfinho-corcunda-do-atlântico (*Sousa teuszii*) é uma espécie criticamente ameaçada que se encontra ao longo da costa da África Ocidental e Central, incluindo o delta do Saloum no Senegal. A presença do golfinho-corcunda-do-atlântico foi confirmada em pelo menos 13 países ao longo da costa da África Ocidental. Para os restantes seis países, não se sabe se a falta de dados se deve ao facto de não haver investigadores que se dediquem ao golfinho-corcunda-do-atlântico, ou se a espécie está realmente ausente desses países. Este estudo teve como objetivo contribuir para o conhecimento desta espécie através da criação do primeiro catálogo de identificação fotográfica a longo prazo, da análise de captura-recaptura baseada em observações e da estimativa da abundância absoluta da população no Delta do Saloum, Senegal. O catálogo de foto-identificação foi estabelecido através da recolha e análise de mais de 13000 fotografias que capturaram marcas e padrões de pigmentação únicos em golfinhos individuais durante os levantamentos de barco realizados em todo o Delta do Saloum em julho de 2021 e março-abril de 2022. Um total de 164, golfinhos foram identificados com base nas marcas únicas nas suas barbatanas dorsais. Destes 164, 24,39%, foram observados em mais de uma ocasião, 9,14% mais de duas vezes e 3,66% mais de três vezes. O mapeamento dos movimentos destes indivíduos demonstrou que alguns se deslocaram muito, enquanto outros mostraram uma grande fidelidade ao local. Uma estimativa simples de captura-marca de Petersen modificada por Chapman gerou uma estimativa de abundância de 469 indivíduos (CV 5733, intervalo de confiança de 95% 275 a 801). Este estudo tem como objetivo fornecer uma avaliação abrangente do estado da espécie, dinâmica populacional e padrões comportamentais, contribuindo para a sua conservação e gestão na região. Estes resultados preliminares confirmam os resultados de estudos anteriores, que indicam que o Delta do Saloum alberga uma das maiores populações conhecidas de AHD em toda a sua área de distribuição, e constituem um incentivo adicional para a conservação da população e do seu habitat.

Palavras-chave: Mamíferos marinhos; Ecologia da conservação; Biodiversidade; Espécies ameaçadas; Estimativa populacional.

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# 1 INTRODUCTION

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The Atlantic humpback dolphin, *Sousa teuszii*, is a captivating and enigmatic species endemic to the shallow coastal waters of West and Central Africa, covering a vast distribution range spanning roughly 7000 km from Western Sahara to Angola (Van Waerebeek et al., 2004, 2011; Collins et al., 2011; Collins, 2015). Despite its ecological importance and cultural significance to local communities, our understanding of this species remains constrained, necessitating intensified scientific investigation and conservation efforts. Listed in CMS Appendix I, the Atlantic humpback dolphin's critical conservation status underlines its significance. It was initially acknowledged as Insufficiently Known in 1994, deemed Data Deficient in 1996, and later categorized as Vulnerable in 2008 and 2012 according to the IUCN assessments (Collins, 2015). However, in 2017, it was reclassified as Critically Endangered on the IUCN Red List (Collins, 2015; Collins et al., 2017). This transition in status emphasizes the pressing need for comprehensive conservation measures to safeguard this highly endangered species, which has also been listed in Appendix I and Appendix II of the CMS (Diversity 2012, 4, 258-300; doi:10.3390/d4030258) (Archer & Van Waerebeek, 2000). In 2019, it was listed as one of the seven dolphin species most likely to become extinct permanently (Taylor et al.; 2020).

Atlantic humpback dolphins are found on the Atlantic coast of Africa, but their distribution is restricted to a limited geographical area. Within this area, they are found in small, fragmented populations, inhabiting mainly shallow coastal environments. The conservation challenges for Atlantic humpback dolphins include their intrinsic vulnerability to population decline because cetaceans have a slow reproduction rate, exacerbated by threats such as fishing gear bycatch (Van Waerebeek et al., 2004; Weir et al., 2011; Collins, 2015; Brownell et al., 2019).

Bycatch-related mortalities have been documented in multiple countries, including Mauritania, Senegal, Guinea, Guinea-Bissau, Nigeria, Cameroon, and the Republic of the Congo, with suspicions of a broader issue across other nations (Van Waerebeek et al., 2004, 2017; Weir et al., 2021). Inadequate baseline data on the species' occurrence pose a significant challenge, as

confirmation of their presence relies on sparse data from occasional sightings, strandings, or bycatch reports, limiting their confirmed range to 13 out of 19 potential countries (Van Waerebeek et al., 2004; Weir et al., 2011; Collins, 2015). The lack of reliable data on global and national population sizes and abundance trends further hinders conservation efforts (Weir et al., 2021). Additionally, documented incidents of accidental dolphin bycatch in local fisheries and the consumption of marine bushmeat, which includes cetaceans, in various coastal countries across West and Central Africa poses significant threats to the survival of the species (Bamy et al., 2021; Collins et al., 2019; Van Waerebeek et al., 2017).

In Senegal, protecting mammals is all about following a bunch of rules and regulations that have been put together over the years to keep the country's marine and land biodiversity safe. It all kicked off when Senegal signed up for the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) back in 1973. That was like the first step in making sure trade in threatened species was kept in check. Then, in 2008, they passed Law No. 2008-06 on Wildlife Resource Management, which gave a much clearer legal framework for looking after animal populations, including mammals. This law said "nope" to hunting or capturing endangered species, and also put a stop to any shady business involving wildlife products. To back that up, in 2008 they also brought in Decree No. 2008-1486 to spell out exactly how to stick to the wildlife resource management law. It covered stuff like hunting permits, protected areas, and what happens if you break the rules. Fast forward to 2010, and Senegal was all about adopting the National Action Plan for the Conservation of Endangered Wildlife Species (PAN-CEMS). This was like a handbook for saving endangered mammals and fighting off poaching. These laws and plans show that Senegal is totally into keeping its wildlife safe and sound. Alongside these national laws, Senegal is also part of a bunch of regional and international agreements that make sure they're serious about conservation. They signed up to the Convention on the Conservation of Migratory Species of Wild Animals (CMS) in 1992, the Ramsar Convention on Wetlands in 1984, the Bamako Convention in 2000, and the Maputo Convention in 2007. These agreements prove that Senegal is committed to looking after its wildlife and keeping its mammals protected.

The Saloum Delta is reputed to be home to the largest population in its entire range, in 2004, Van Waerebeek conducted research in this region (Van Waerebeek, 2004), and in 2015, Weir

embarked on a three-week survey covering the entire Delta (Weir, 2016). Weir documented 30 separate *S. teuszii* observations and was able to identify 103 individuals using photo identification. However, none of these studies were long-term, and none provided robust population estimates using the mark-recapture method. In addition to our photo-identification efforts, it's important to note that the African Aquatic Conservation Fund (AACF) has recorded seven carcasses since 2018, with one showing evidence of bycatch and two subjected to butchering (AACF unpublished data).

This study uses a scientific approach, specifically using Mark-Recapture Analysis methodology, to estimate the population size of *S. teuszii* in the Saloum Delta region. This rigorous quantitative method allows for insights into population abundance, distribution patterns, and other essential demographic factors while also assessing study reliability through confidence intervals. The overarching scientific inquiry focuses on understanding the Atlantic humpback dolphin's population dynamics and conservation status, given its significant role in coastal ecosystems and cultural importance. To achieve this, a multifaceted approach is employed to gather comprehensive data on the species' ecology, ultimately contributing to effective conservation strategies (Van Waerebeek et al., 2009, 2017). The mark-recapture analysis methodology, using natural markings for individual recognition, provides a robust framework for estimating cetacean population size (Hammond, 1986). Additionally, the photo-identification database created in this research can be used to study movement patterns, enhancing our understanding of population dynamics, social structure, and habitat use over time (Wursig and Jefferson, 1990; Hammond et al., 2021).

This research aims to determine the estimated number of individuals in the Saloum Delta and to identify the various movement corridors and distribution patterns.

## **2 METHODS**

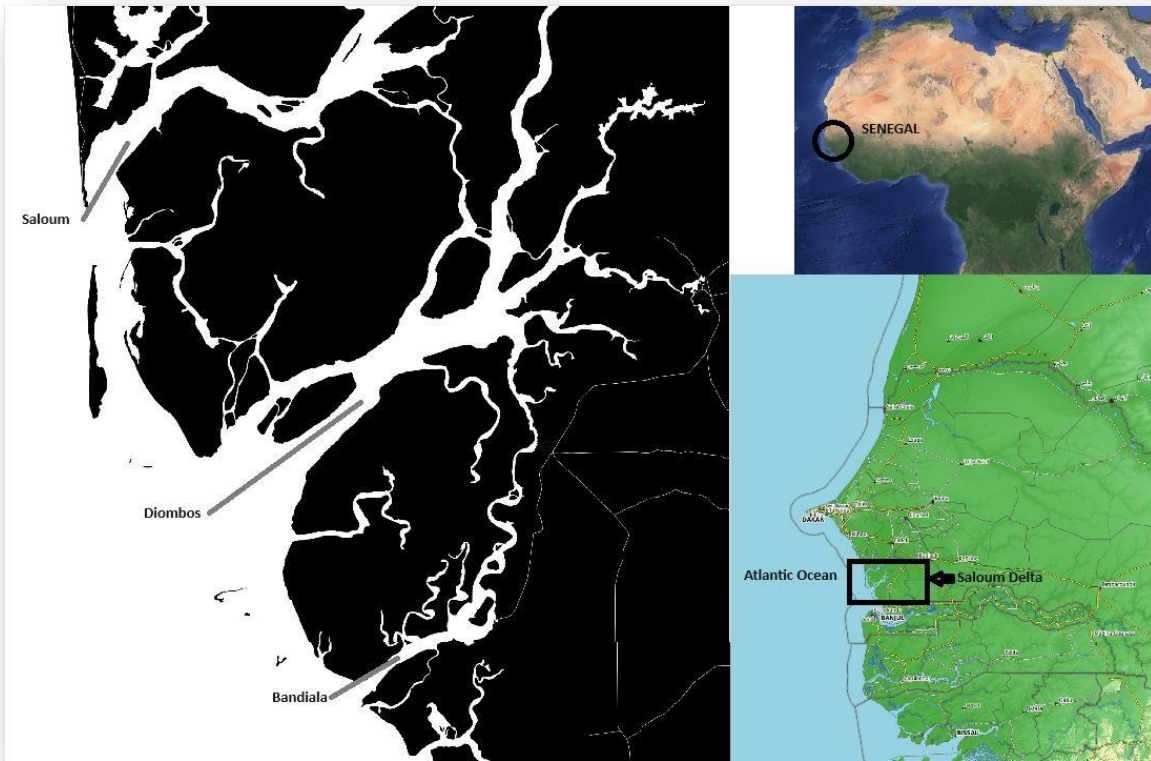
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### **2.1 STUDY AREA**

Covering an area of approximately 73,000 hectares along the central coast of Senegal, the Saloum Delta is of paramount ecological significance. Designated as a Ramsar site since 1984, it

features a complex interplay of islands, mangrove ecosystems, and saltwater channels known as "bolongs" and lagoon configurations (Figure 2.1). The Saloum Delta experiences a prolonged dry season, from November to June, followed by a period of concentrated rainfall from July to October annually. This region is classified as an "inverse estuary", characterized by marked hypersalinity. Water temperatures within the Saloum oscillate between 23 and 30°C, reflecting the influence of both seasonal and geographical variations. These environmental dynamics contribute to the diversity of habitats within the delta, favoring a rich variety of estuarine fish. Stretching some 70 km along the Atlantic coast, the Delta's coastal boundaries extend from around four km south of Joal (latitude 14.13° N) to the border shared with Gambia (latitude 13.59° N). In addition to being classified as a UNESCO World Heritage site, Delta Saloum includes a national park and five marine protected areas (Joal-Fadiouth, Palmarin, Sangomar, Gandoule, and Bamboung). This area is also closely associated with the Niimi National Park in the Gambia, accentuating its ecological importance due to its diverse biodiversity.

Delta Saloum includes three main channels – the Saloum, the Diombos, and Bandiala – which all run longitudinally from north to south. The Saloum River, the longest channel, stretches for over 90 km and hosts the highest concentration of human activity within the delta. It includes such notable features as a shipping route, the Foundiougne bridge across the river, and various fishing villages. The Diombos, which meanders inland for almost 50 km, and the Bandiala, which is characterized by a narrow inlet bordered by marine sandbanks stretching for almost 3 km, also hosts a lower density of fishing settlements and small towns. In addition, a small tributary named Djinack, which borders the Gambia at the southern end of the Delta, features a narrow navigable channel bordered by marine sandbars extending over 2 km from the coast.



*Figure 2 1: The geographical setting of the research site within Senegal's Saloum Delta region.*

## **2.2 SURVEY METHODOLOGY**

The surveys were carried out from 9<sup>th</sup>-18<sup>th</sup> and 28<sup>th</sup>-29<sup>th</sup> July 2021 and from 18<sup>th</sup> March to 6<sup>th</sup> April 2022, a total fieldwork period of 28 days. The same routes and points as the (Weir, 2016) study were used, to allow data comparison. This approach allowed the study to cover the whole Delta, including the Diombos River, the Saloum River, the Bandiala River, and the offshore area. This approach also involved systematic transects of the designated offshore section, as visually depicted in Figure 2.2. For the other parts of the Saloum Delta, the same standards set in Weir's study (2016) were followed but changes were made to accommodate weather and accessibility challenges. The surveys were carried out during daylight hours, to facilitate observations and ensure optimum exposure to the sun for quality photographs. Our tracks are shown in Figure 2.2.

## **2.3 FIELD PROCEDURE**

In general, the Consortium for the Conservation of the Atlantic Humpback Dolphin (CCAHD, 2023) protocol was followed for boat-based cetacean surveys. Two types of boats were used, one made of wood, 6 m long, with a 25 HP motor, and the other made of fiberglass, 7.5 m long, with

a 60 HP or 100 HP motor. During the dedicated search effort, the speed of navigation varied between 11 and 15 km/h, and a minimum of two people and a maximum of five people actively participated in the search effort in addition to the boat driver. One person remained at the front of the boat and scanned an arc from the bow of the boat to 90° on the port (left) side. Another person did the same on the starboard (right) side. Observers rotated and changed positions at regular intervals so as not to get fatigued and lose focus during scanning. Binoculars were also available to ensure the confirmation of the sighting. The GPS was utilized to navigate from one transect point to the next, and to monitor the distance traveled. Stops were made every 5 km to take water samples Tables 7.2 and 7.4, notably for the surface water temperature and the depth using a Hawkeye depth sounder and a refractometer for the salinity. Strong currents hindered the deployment of a Secchi disk, causing lateral displacement within the water column during each descent, which impeded the accurate assessment of depth, and therefore, turbidity.

When a dolphin or a group of dolphins was encountered, the sighting was recorded on the effort datasheet. A second datasheet was used to record all the details of the observation, including the GPS coordinates, observation angle, and comprehensive group information, including, group size, and direction of movement in the presence of adults or juveniles (e.g., Weir 2009). After this stage, the boat approached the dolphins gently, without any sudden movements or changes in speed, so as not to disturb them, always parallel with their direction of movement, while maintaining a safe distance. Depending on weather conditions and dolphin behavior, photos for photo identification were taken following established protocols (e.g., Wursig and Jefferson; 1990). Two Canon EOSD7 cameras equipped with a 100mm-400mm zoom lens and a Canon EOS30D camera equipped with a 100mm-300mm zoom lens were utilized.

## **2.4 DATA ENTRY**

Once field operations have been completed, all the information collected via GPS, including waypoints and tracks Tables 7.1 and 7.3, Figure 2.2, were downloaded using Garmin Basecamp. Simultaneously, the information on effort, water parameters, and sightings data recorded on the survey sheets were inputted into an Excel spreadsheet. Furthermore, a structured methodology was employed for handling field-captured photographs. These images were systematically transferred to a dedicated folder for images, with separate sub-folders for each of the two to three cameras daily.

Photographs were simultaneously renamed in batches using the dedicated software FileRenamer. New file names included the survey date, a project code, the photographer's initials, and the camera model.

## **2.5 DATA ANALYSIS**

### **2.5.1 PHOTO-IDENTIFICATION – DATA ARCHIVING AND PREPARATION**

To undertake photo processing for individual identification, I adhered to the methodologies established by the CCAHD. Firstly, specific folders were created with structured names such as XXX\_XXXX\_XX\_Sousateuszii\_PhotoID, where the variable elements reflect the place of capture, year, and month of processing. This first level of categorization facilitates subsequent data localization. In line with (CCAHD, 2023) Photo-ID guidelines, then a folder structure was developed "\_INDIVIDUALS" that represents each observation.

Within these folders, an additional level of sub-folders was introduced for each dolphin, identified by capital letters in alphabetical order. This hierarchical organization maintains a clear separation between the different sightings and the individuals within each sighting. The crucial step in identifying individual dolphins is a thorough analysis of the photographs, highlighting distinctive features such as scarring and cuts on dorsal fins and other unique markings. Once individuals had been identified, the most representative images of each dolphin were carefully selected, and they were transferred to the corresponding sub-folders. The aim is to preserve the integrity of the original files while organizing the data for easy retrieval. To improve the quality of the dorsal fin images, photo editing software, FastStone Image Viewer, is used to crop and enhance the selected images. Following these adjustments, each file is manually renamed, incorporating specific information such as the group name and individual ID. This processing phase aims to sharpen the images and ensure accurate identification in the future.

### **2.6 PHOTO-IDENTIFICATION: PROCESSING AND MATCHING**

Permanent identification codes were assigned to each dolphin that was identified throughout the study. For example, the first individual was given an ID such as SALOUM21-001, indicating the study site (Delta Saloum, Senegal), the year of first identification (2021), and its sequential position of first capture in the year (001). Original and enhanced versions of the left and right sides of the dorsal fins were copied into a folder for each unique individual, along with additional photographs showing specific features such as sex or distinctive markings and scars.

The Excel template provided for the CCAHD was used: *S. teuszii* photo-identification catalog. The best photograph of each side of the dolphins' dorsal fin within the encounter was selected and observation dates were added, alongside latitude and longitude for mapping and range analysis. Finally, scores for the quality of photos of the right and left sides of the dorsal fin were assigned, following the definitions shown in Table 2.1.

*Table 2.1: Description of quality scores assigned to dorsal fin photographs (CCAHD Photo-ID guidelines).*

<b>Quality Level</b>	<b>Description</b>
0	No photo, poor or blurred quality
1	Minimal resolution and insufficient quality
2	Adequate resolution, with limitations. Distinctive features like scars are somewhat identifiable.
3	Optimal angle, resolution, and lighting. Perpendicular photo angle.
4	Excellent quality. Impeccable sharpness, lighting, and angle.

The distinctiveness of marks on the dorsal fin was also assessed, assigning them a score separate from photo quality, while following objective definitions. The rating system for dorsal fin characteristics Table 2.2.

*Table 2.2: Description of the distinctiveness score of the photographs (CCAHD Photo-ID guidelines)*

<b>Level</b>	<b>Description</b>	<b>Effect on Silhouette</b>	<b>Visibility in Photos</b>
0	Total absence of distinctive features	None	N/A
1	Superficial scars, with no impact on silhouette, may fade or not be detected in low-quality photos	None	Can be used for ID
2	Deeply engraved or raised marks, potentially permanent, no effect on edge shape	None	Visible on Photos



the proportion of individuals with a distinctiveness rating of 3 or higher per encounter will unveil unique traits within this captivating population. This data is presented in Figures 3.3, 3.4, 3.5, and 3.6.

### **2.6.1 MARK-RECAPTURE ANALYSIS**

A data set listing all the permanent IDs of each identified individual was created, along with the dates of encounters with the dolphins. Then, two tabs were created within the Excel file: one called "Capture All," which included all encounters, regardless of the quality of the photo obtained of the individual in question during the encounter, and another called "Capture 3," which only included encounters with individuals that resulted in a photo of photo quality 3 or higher. For each tab of the Excel sheet, dolphin 'presence' (successful 'capture') is marked by 1, and absence is marked by 0.

### **2.6.2 CAPTURE-RECAPTURE ANALYSIS**

These data, listed in the Excel file, were used to construct a discovery curve and a recapture rate curve. It was also used to analyze the recaptures, calculate the proportion of marked animals, and estimate the population size using the Chapman-modified Petersen estimator (Chapman, 1951 cited in Seber, 1982) and (Bailey, 1951 cited in Seber, 1982) adapted Petersen two-sample estimate models were employed for yearly data aggregates. The equations used were as follows:

$$N = \frac{(n_1 + 1)(n_2 + 1)}{m_2 + 1} - 1$$

where N represents the computed population estimation, with n1 referring to the count of animals photographed during the initial sample, n2 denoting the count of animals photographed during the subsequent sample, and m2 indicating the count of animals within n2 that were also captured in n1. If animals are captured multiple times in the second sampling instance, they are accounted for only once in n2. Consequently, such animals are treated as "eliminated" and are not reintroduced into the population after their capture during the second sampling event.

N corrected was calculated using the proportion calculated based on individuals with a distinctiveness of 3 or more (Minton et al., 2013), Fig. 3.4. The average proportion of distinct individuals (Score 3 or 4) out of all individuals, both distinct and non-distinct (scores 1 - 4), was computed for each sighting and then aggregated across all sightings to derive the mean proportion, denoted as p. This mean proportion, p, was subsequently employed as a correction factor for mark-recapture estimates (N mark-recapture), which included only the observation histories of separate individuals.

$$N_{\text{corrected}} = N_{\text{(mark-recapture)}} / p$$

The computation of the variance of N (V) is performed using the subsequent formula:

$$\text{Var} = CV N_{\text{mark-recapture}} = \frac{(n_1 + 1)(n_2 + 1)(n_1 - m_2)(n_2 - m_2)}{(m_2 + 1)^2 (m_2 + 2)}$$

The Standard Error of the estimate was calculated using the following formula:

$$SE = \sqrt{\text{Var}}$$

The coefficient of variation for the correction factor was determined through the following formula:

$$CV = SE / N_{\text{mark recapture}}$$

Ninety-five percent confidence intervals were computed by assuming a log-normal distribution for the estimates, establishing the lower and upper 95% confidence bounds as  $N_{\text{corrected}} / c$  and  $N_{\text{corrected}} \times c$ , respectively.

This approach isolated in  $C = e^{1.96 \sqrt{\ln \frac{1+CV^2 N_{\text{corrected}}}{N_{\text{mark recapture}}}}}$

$$c = \exp(1.96 * \sqrt{\ln(1 + (CV)^2)}) \text{ Lower95\%}$$

$$\text{limit} = N_{\text{mark recapture}} / C$$

$$\text{Upper95\% limit} = C * N_{\text{mark recapture}}$$

The same was done for the  $N_{\text{corrected}}$

Lower95% limit =  $N_{\text{corrected}} / C$  Upper95%

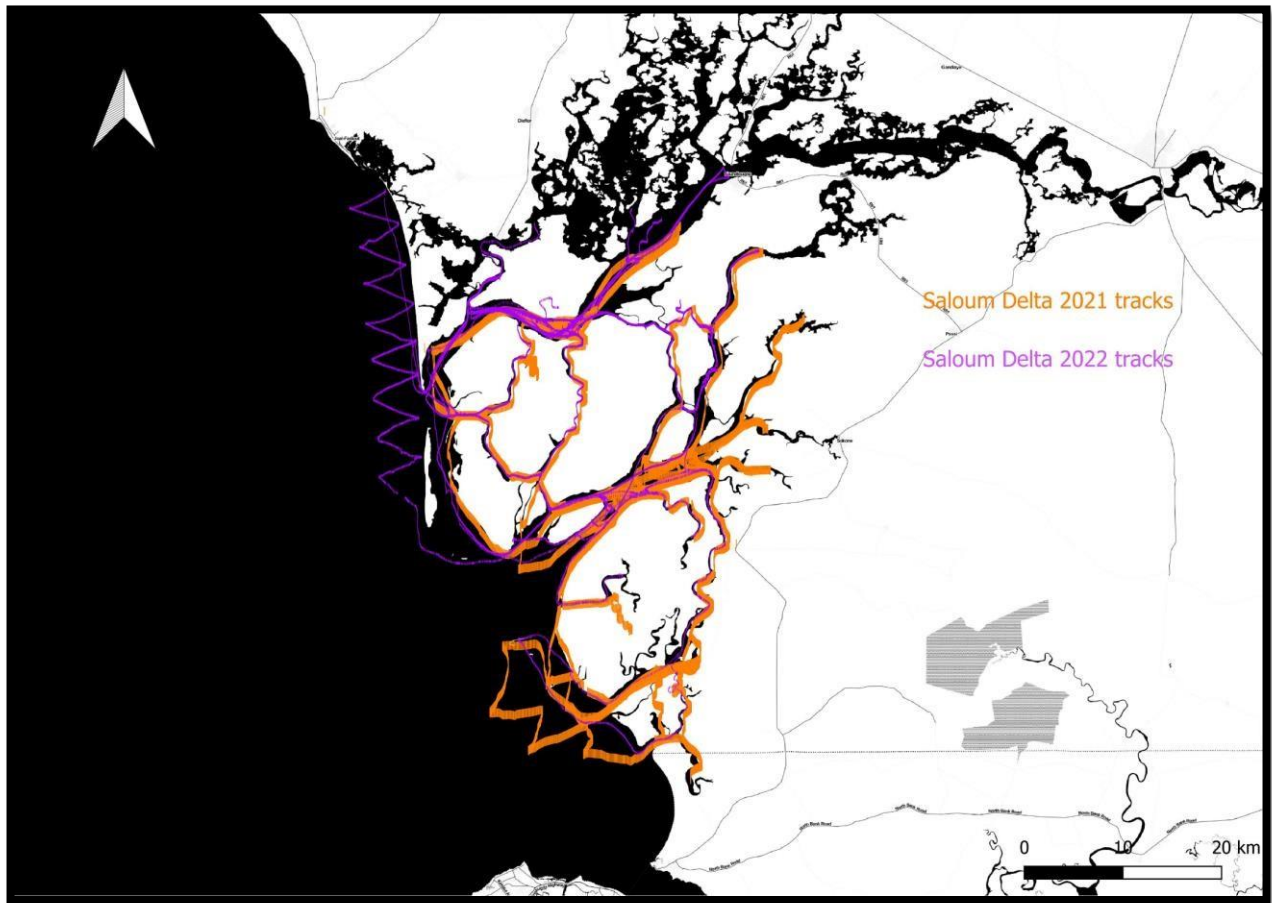
limit =  $C * N_{\text{corrected}}$

## **3 RESULTS**

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### **3.1 ABUNDANCE ASSESSMENT USING PHOTO-IDENTIFICATION AND MARK-RACAPTURE ANALYSIS.**

Over a period spanning two survey years, from July 11 to 29, 2021, and from March 9 to April 5, 2022, a total of 28 survey days were carried out. These surveys encompassed a total distance of over 2,000 kilometers, of which over 1,300 kilometers were spent on effort. The cumulative time spent on the boat was around 198 hours, of which around 113 hours comprised search effort, indicating that most of our time (57%) was spent scanning for dolphins. Throughout this study period, a total of at least 13,000 photographs were captured, enabling the precise identification of 164 distinct individuals (Table 3.2). Four of them are shown in Figure 3.2. These identifications led to the establishment of the first-ever multi-year photo identification catalog for the Atlantic humpback dolphin.

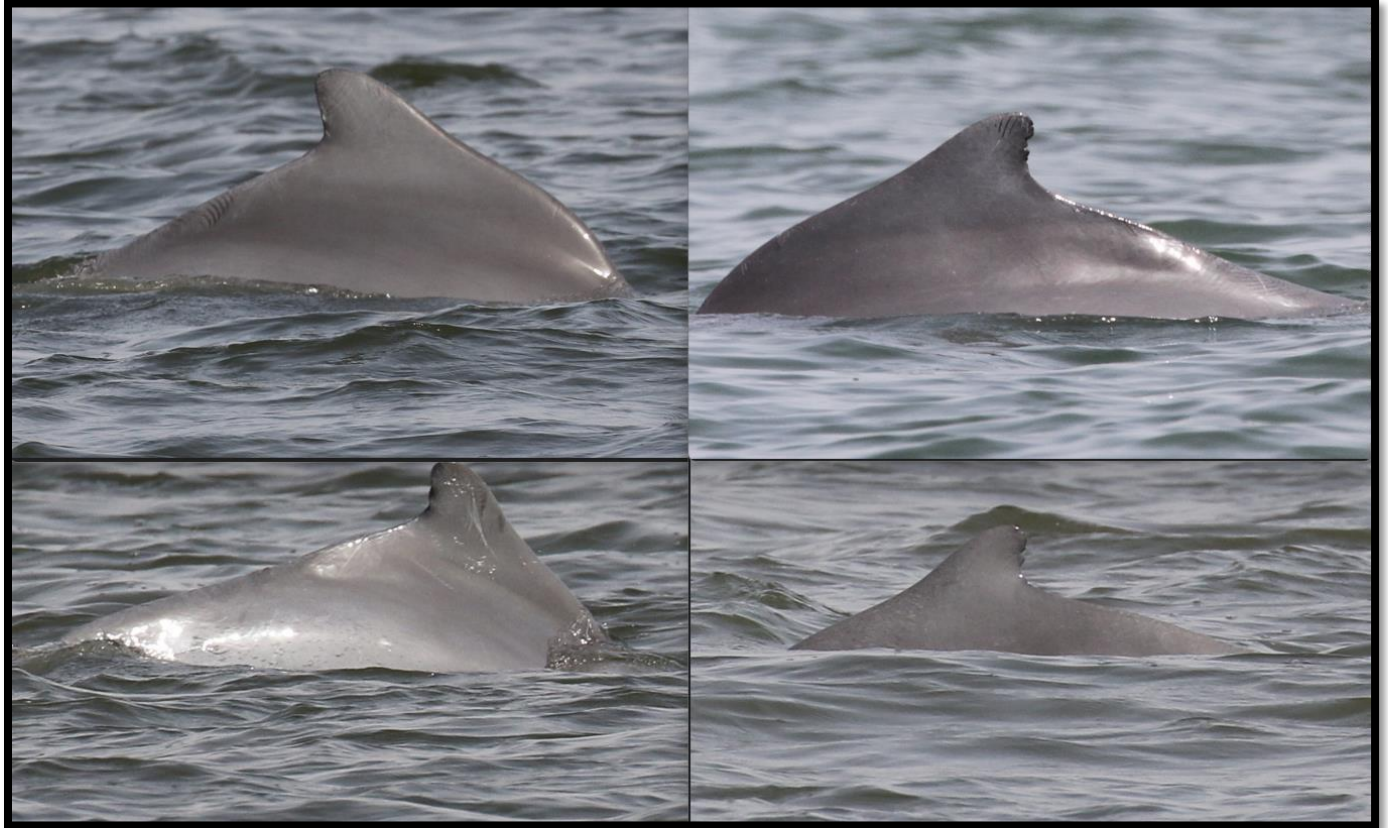


*Figure 3.1: Tracks of 2021 and 2022 boat surveys in the Saloum Delta. 2021 tracks in orange, and 2022 tracks in purple. Zigzags show offshore transects.*

Of the individuals identified, 32 were identified in 2021 (by Gianna Minton before the work represented in this thesis), and 132 in 2022. Among the individuals observed in 2021, six were also photographed in 2022, and 3.7% were sighted more than four times. The results of the identification of dolphins during encounters are summarized in Figure 3.2. To assess the proportion of individuals showing a distinction of 3 or more, as a function of the number of individuals photographed per encounter, an analysis was carried out, revealing a P value equal to 0.58.

n1	20
n2	90
m2	6
p	0.58

Using the Chapman and Bailey method, the total population was estimated, obtaining a result of 272 individuals. This value was then corrected with the proportion  $P=$ , resulting in a final estimate of 469 individuals. To assess the accuracy of this estimate, a confidence interval calculation was undertaken, resulting in a confidence interval of 95%, where the Lower limit of 95% CI is 275 individuals, and the Upper limit of 95% CI is 801 individuals.



*Figure 3.2: Examples of Atlantic humpback dolphin dorsal fin markings. The individuals shown are: Left above = SALOUM22-39; Right above = SALOUM22-154; Left below = SALOUM2235; Right below = SALOUM21-023*

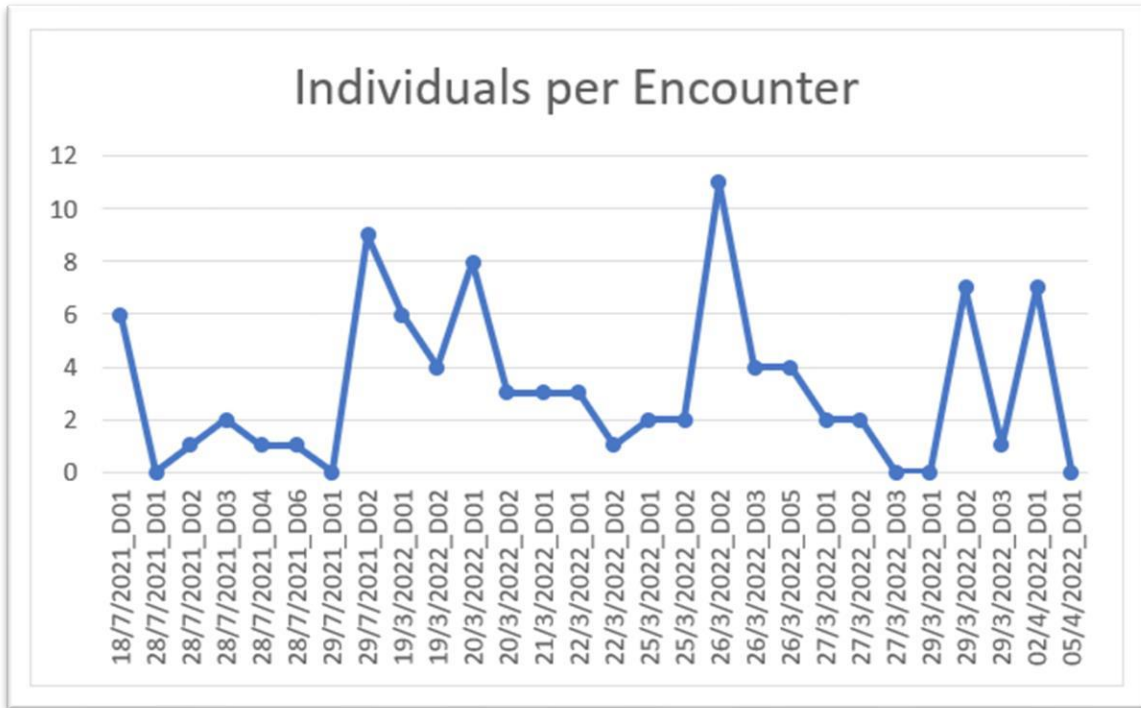


Figure 3.3: Number of identified individual Atlantic humpback dolphins with a quality of 3 or more per encounter, shows the high variability in the number of successful 'captures' during each dolphin encounter.

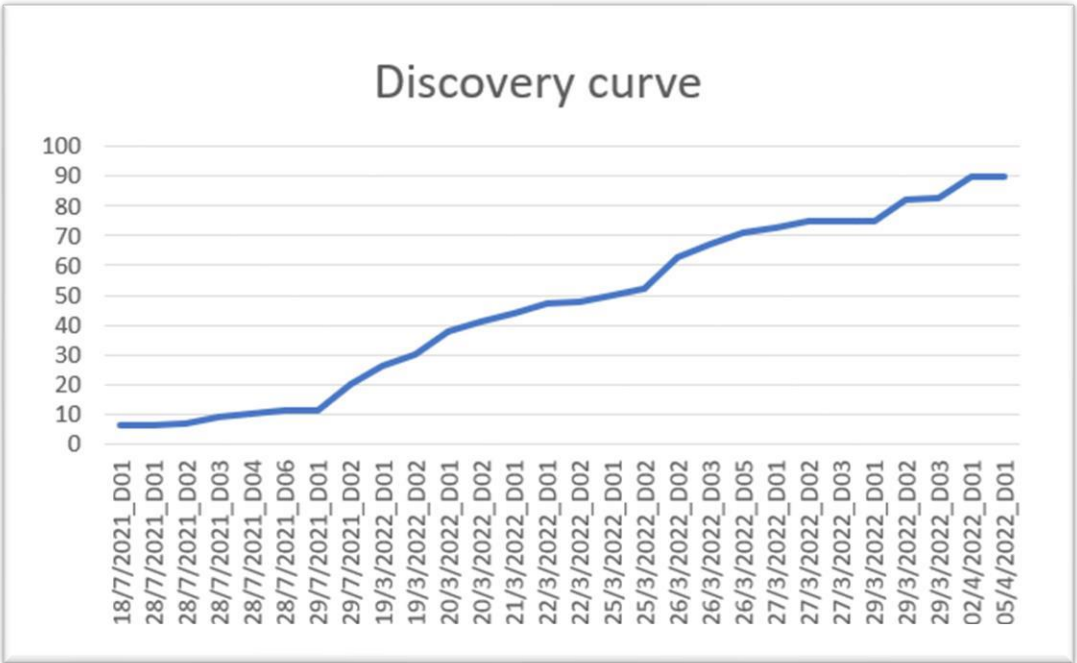


Figure 3.4: Total individual Atlantic humpback dolphins across the study period. The number of identified individuals is increasing throughout the study, however, the curve tends to flatten out towards the end of the surveys.

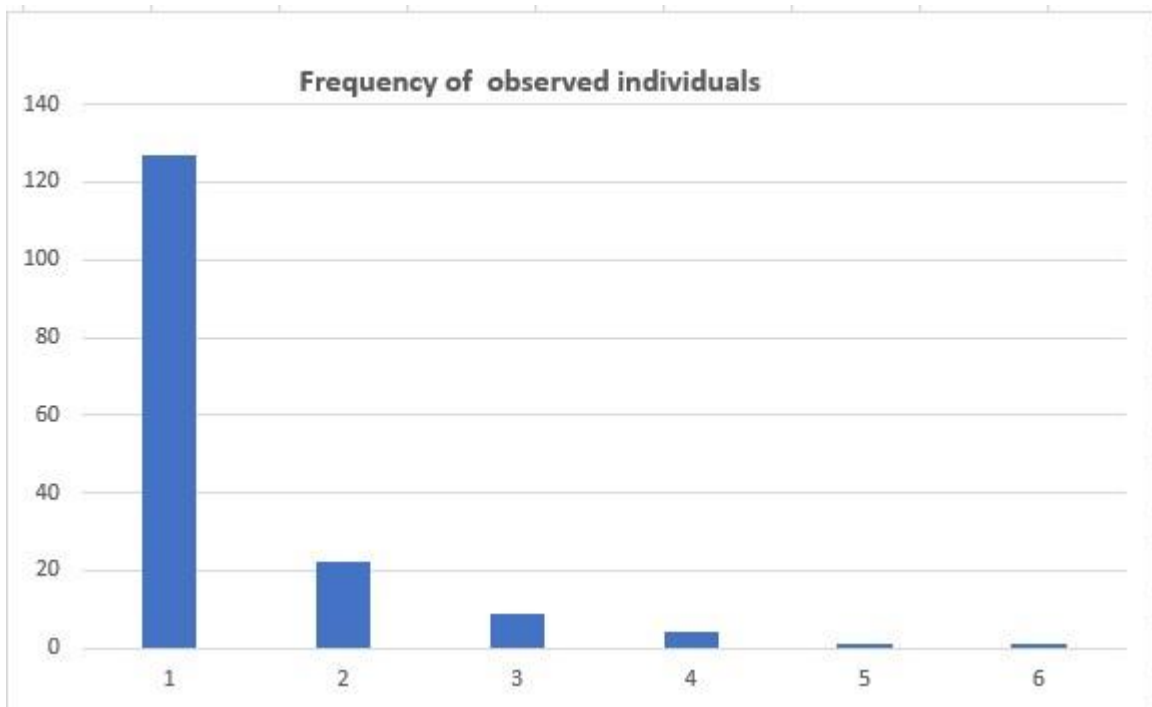


Figure 3.5: Frequency of observed individual Atlantic humpback dolphins. This figure illustrates that the probability of observing the individual multiple times during the study period is highly variable.

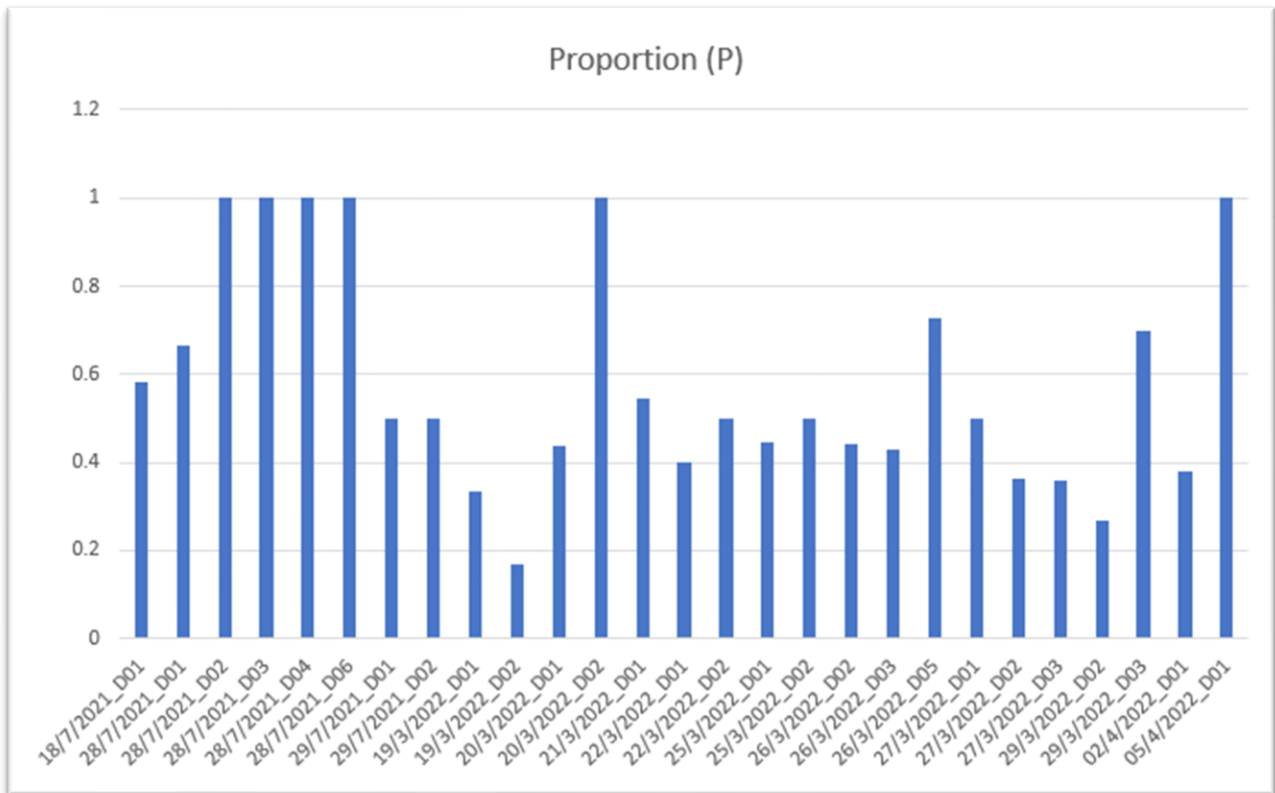
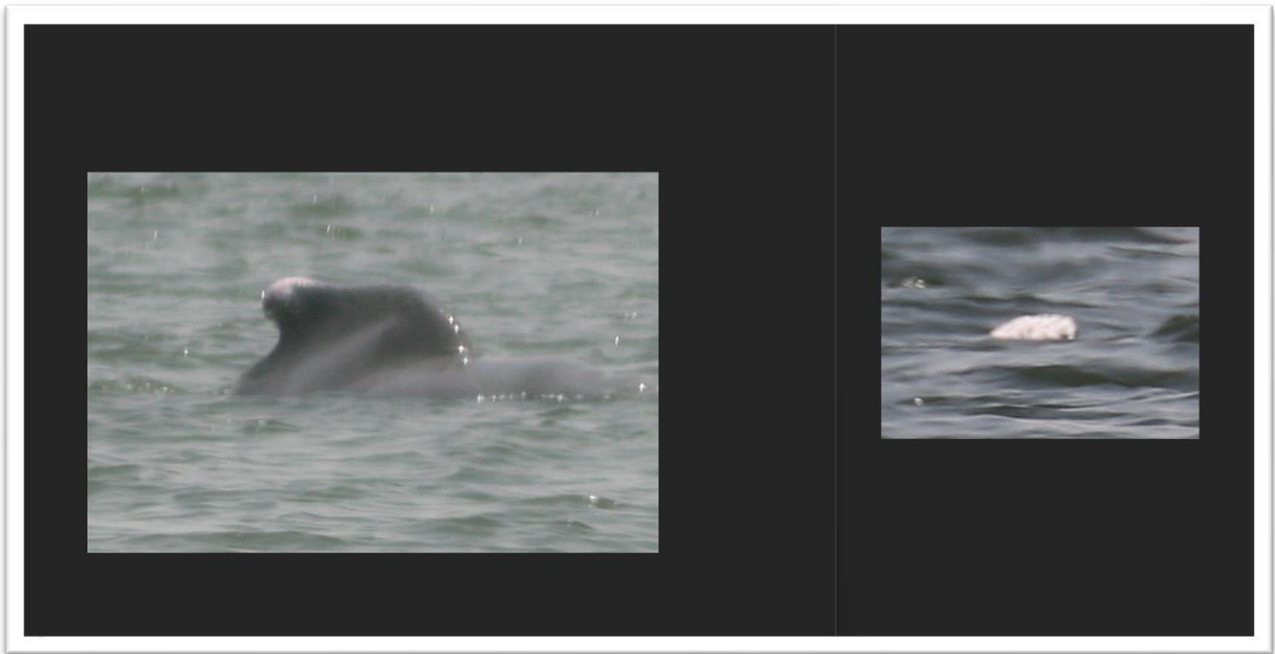


Figure 3.6: Proportion of identified individual Atlantic humpback dolphins with distinctiveness of 3 or more per encounter. This measurement highlights the variability in individual distinctiveness within the population over time and allows us to refine our estimation.

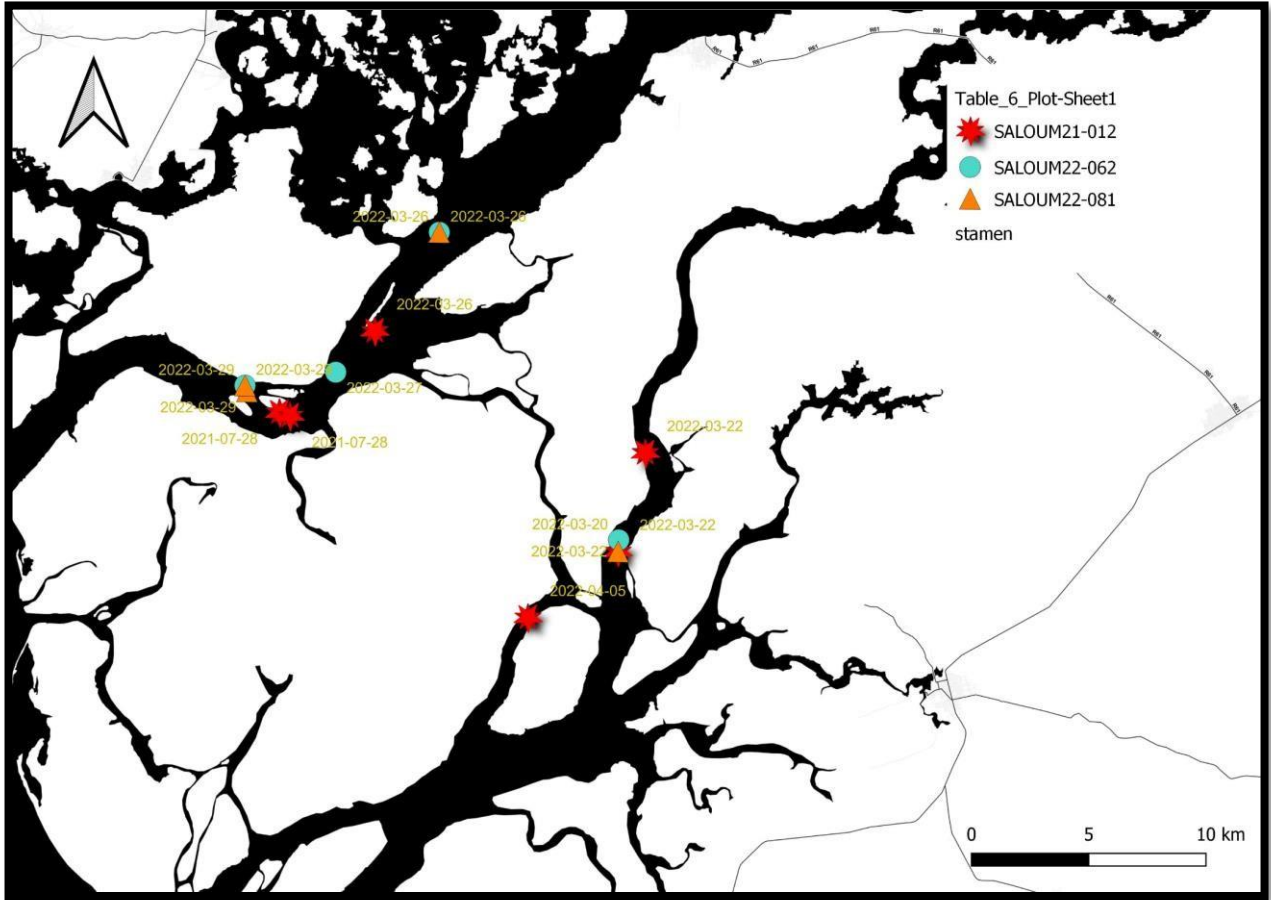
In Figure 3.7, an illustrative example is presented of a low-quality photograph, characterized by blurriness where the distinctiveness of the dolphin SALOUM21-12, known as “Mister Pink” due to the unique pink spot on the dorsal fin, remains unmistakably discernible. This remarkable

individual was observed on six occasions throughout the two-year study period, with two photographic encounters occurring on a single day, March 22, 2022.



*Figure 3.7: Example of a low-quality photograph of an Atlantic humpback dolphin (blurry photo) of the dolphin SALOUM21-12, known as Mister Pink due to its unique pink spot remains unmistakably discernible. This individual was observed on six occasions throughout the two-year study period, with two photographic encounters occurring on a single day, March 22, 2022.*

In the following figures (Figures 3.8, 3.9, and 3.10), key findings from the thesis results are presented. In Figure 3.8, a compelling example of three individuals encountered both in the Saloum River and the Diombos Channel to the north is illustrated, with observations made on different dates. This figure illuminates the dynamic distribution of these individuals. Figure 3.9 is centered on the subset of the study population that stands out: individuals exclusively observed in the Saloum River over the entire two-year study period. Valuable insights into the habitat preferences of these unique dolphins are provided. Lastly, Figure 3.10 offers an overview of all individuals observed more than three times.



*Figure 3.8 Example of three individual Atlantic humpback dolphins encountered in both the Saloum River and the Diombos Channel to the north of the latter. Observations were made on different years for Saloum21-012 and different dates for Saloum22-062 and Saloum22-081.*



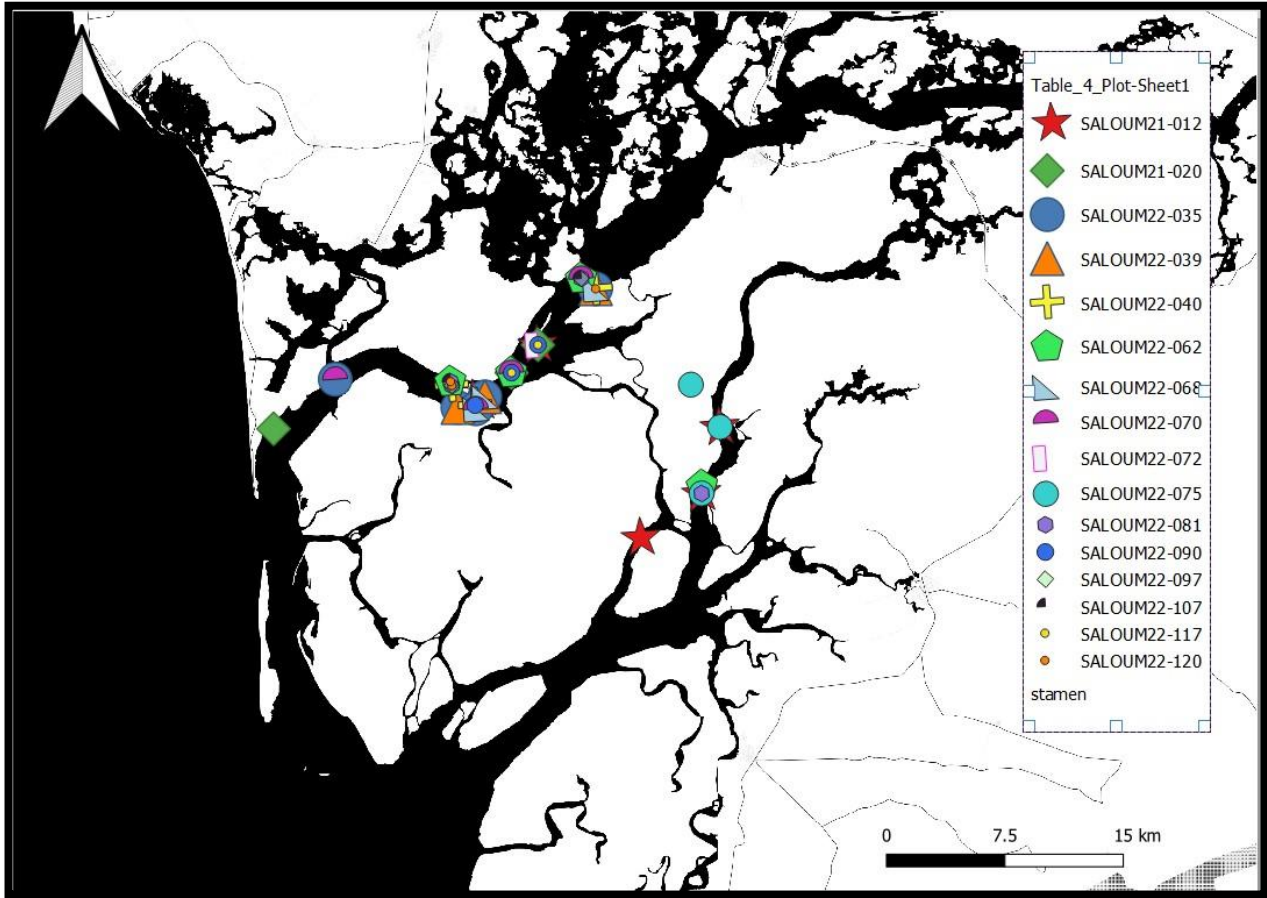


Figure 3.10: This figure shows all individual Atlantic humpback dolphins seen more than three times.

Tables 3.1 and 3.2 provide a detailed overview of our study's key parameters and observations. Table 3.1 summarizes survey periods, distance covered during data collection efforts, hours spent on these efforts, and the total encounter rate over the study period, offering a comprehensive perspective on our data collection process. Meanwhile, Table 3.2 highlights observed dolphin behaviors, including the number of sightings and the corresponding percentages of each behavior relative to the total observations.

Table 3.1: Survey periods, distance navigated on effort, hours spent on effort, and total encounter rate along the study period.

Survey period	Distance covered on effort (km)	Hours covered on effort (hh:min: sec)	Sightings on Effort	Total encounter rate sighting/km

July 11 to 29, 2021	776.24	69:59:00	13	0.0167
March 19 to April 05, 2022	546.63	43:21:00	15	0.0274

*Table 3.2: observed behaviors of dolphins, along with the number of sightings and the corresponding percentages of each behavior relative to the total number of observations.*

**Behavior Type Number of Sightings Percentage (%)**

Unidentified (Unk)	12	28.57%
Likely Feeding	8	19.05%
Feeding	7	16.67%
Traveling	9	21.42%
Socializing	1	2.38%
Milling	4	9.52%
Surface Activity	1	2.38%

The 2022 photos are of higher quality because our team improved our methods, acquired a nicer boat, and conducted more observations. This improvement gives us hope for even better data and results in the future. In short, our systematic approach ensures the orderly and accessible management of photographic identification data. This structured methodology not only facilitates research and analysis processes but also contributes to the creation of impactful visual presentations and the persuasive communication of results.

## **4 DISCUSSION**

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### **4.1 INNOVATIONS AND ADVANCEMENTS IN THIS STUDY**

This study represents a major step forward as it constitutes the first photo-identification catalog for this species that extends beyond a single survey of a few weeks in the same year (Weir; 2015, Weir; 2016, Weir and al.; 2020, Weir and al.; 2021). These results mark an essential first step in

understanding how to manage *S. teuszii* in Senegal and across its entire range. Weir previously conducted photo identification on *S. teuszii* in three countries within their distribution range; however, this study is the first to have been carried out over successive years using the robust Mark-Recapture method for population estimation. It provides an essential baseline for the conservation of the species, enabling a better understanding of dolphin populations and their movements, crucial for developing effective conservation strategies. In addition, the use of the Mark-Recapture method over several years will enable longitudinal monitoring of *S. teuszii* populations, detecting population trends and assessing their stability. The results of this study have a direct impact on conservation planning by identifying areas and movement corridors requiring specific protection.

The observations of various dolphin behaviors in this study highlight the complexity of their habits. The prevalence of 'Unidentified (Unk)' behavior, accounts for 31.57% of observations, this may be due to the fact that either the sighting was too brief, or the dolphins stayed mostly underwater. Additionally, the significance of feeding, representing a substantial 39% of sightings, and the constant movement seen in 'Traveling' behaviors, at 23.68%, suggests that dolphins dedicate a significant portion of their daily lives to foraging and traveling, potentially impacting their search for food, migration patterns, and social interactions. In contrast, less common social behaviors, such as 'Socializing,' imply that social interactions may not be as central to their daily routines as feeding and traveling. However, sightings made by this study were only a brief amount of time in these dolphins' lives, and additional study is needed to truly elucidate their behaviors.

The 2022 photos are of higher quality because our team improved our methods, acquired a better boat, and conducted more observations. This improvement gives us hope for even better data and results in the future. In short, our systematic approach ensures the orderly and accessible management of photographic identification data. This structured methodology not only facilitates research and analysis processes but also contributes to the creation of impactful visual presentations and the persuasive communication of results that can contribute to raising awareness of this species.

## **4.1 POSSIBLE SOURCES OF BIAS IN THE ESTIMATE**

Assumptions in the mark-recapture method are basic conditions that must be satisfied to accurately apply mark-recapture methods for the estimation of the size of a population of animals. These ideas include that the population does not change, that all animals have the same chance of being captured the first time, that marking does not alter their probability of being captured, that the recapture sample is chosen at random, that marks remain intact, and that all marks are reported correctly (Hammond; 1986). These ideas make the calculation reliable, but they may not always be perfectly true in reality.

### **4.1.1 ASSUMPTION 1: THE POPULATION IS CLOSED**

Although there aren't many long-term studies providing reliable information about the movement and territory of *Sousa teuszii*, some insight into whether the Saloum population might be affected by significant immigration or emigration from nearby populations can be gained by examining other *Sousa* species that have been studied more extensively. Humpback dolphins in the Indian Ocean, *S. plumbea*, generally do not travel long distances, preferring to move locally along the coast between breeding, feeding, and sheltering areas. Some adjust their movements seasonally, moving closer to estuaries during the breeding season or when food is abundant (Jefferson and al.; 2015). They typically exhibit coastal behavior, staying close to the shore and avoiding deep ocean waters. Human interactions, such as fishing and shipping, can also influence their movements (Weir, 2016). If this behavior is extrapolated to *S. teuszii*, the conclusion may be drawn that the population does not stray too far from the Delta. However, in his 2015 scientific paper, Weir also documented interactions between Senegal and Gambian dolphins (Weir, 2016). It was also noted that the number of identified individuals increased throughout the study and that the curve tended to flatten out towards the end of the surveys, suggesting that all animals in the area have been photographed and carrying out further surveys will not identify more individuals (Figure 3.4). The decreasing proportion of new individuals discovered in each survey day indicates that the dolphins appear to have a high level of site fidelity and are likely resident, and thus a 'closed' population (see also Figure 3.9).

### **4.1.2 ASSUMPTION 2: ALL ANIMALS HAVE THE SAME PROBABILITY OF BEING CAUGHT IN THE FIRST SAMPLE; HETEROGENEITY OF CAPTURE PROBABILITY**

In practice, each individual dolphin in a group has a different likelihood of being photographed. Some individuals may be very boat-shy or occupied with feeding or other behaviors.

Consequently, it is challenging to photograph all individuals or obtain high-quality photos of all individuals. On the other hand, there may be curious individuals who frequently approach the boat or surface for observation, resulting in numerous high-quality photos for identification. In some cases, such as "Mister Pink," individuals are so distinct that they can be identified consistently, regardless of various factors like distance or weather conditions. Repeatedly photographing the same individual during the study can potentially bias the results leading to a lower estimate of the population, so these factors must be carefully considered. In studies of cetaceans using photo-identification, the primary challenge to this assumption is that capture probabilities can differ among individuals; differences in how often individuals are encountered can occur because certain places might be preferred by them more (Hammond, 2021). Animals with a high likelihood of being captured will be encountered more frequently than the average, resulting in more recaptures than anticipated and causing a negative bias, as indicated by the equation for the Petersen two-sample estimator mentioned earlier. On the flip side, animals with extremely low capture probabilities might never be observed and therefore won't be counted in the population estimate, also contributing to a negative bias (Hammond, 2021). The study addressed this potential bias by using several cameras and assigning each photographer to a different side of the boat to ensure that all individuals in the group are photographed without bias toward more distinctive individuals or their tendency to approach the boat.

#### **4.1.3 ASSUMPTION 3: MARKING DOES NOT AFFECT THE CATCHABILITY OF THE ANIMAL**

The dolphins were not rewarded for approaching the boat, so there is no reason to believe that they were more likely to be found the next day after being photographed. The boat was handled carefully to avoid disturbing or chasing them, so it appears unlikely that the dolphins were scared or made less willing to be approached by us days or months after our first encounter. Out of 164 individuals, 3.66% (or 4 individuals) were observed at least four times during the entire study period, and all these individuals had a relatively high distinctiveness, making them easily recognizable.

#### **4.1.4 ASSUMPTION 4: THE SECOND SAMPLE IS A SIMPLE RANDOM SAMPLE**

The interval between the two study periods was 10 months, providing ample time for the population to mix well. This is a crucial factor that enhances the reliability of our results, and data sampling in subsequent years has adhered to the same standards.

#### **4.1.5 ASSUMPTION 5: ANIMALS DO NOT LOSE THEIR MARKS**

Marks on the dorsal fin, scars, cuts, etc., function like fingerprints in adult dolphins. Confidence can be placed in the uniqueness of marks in individuals (Hammond et al.; 2021), and the ongoing improvement of the reliability of our data can be expected. For a lasting study based on photo identification, it's essential to have individuals with distinguishing marks that don't disappear over time so that marks are permanent and can't be lost (Hammond et al., 2021). The older Studies of bottlenose dolphins have demonstrated that males are often distinctively marked due to frequent fights for notoriety or females (Wilson et al., 1999; Elwen et al., 2019; Crespo-Picazo et al., 2021). It seems logical to assume that this may be more common among males than females as demonstrated in bottlenose dolphin populations, but this merits further investigation. Juveniles or sub-adults have fewer markings, or sometimes their dorsal fins are completely clean. This is why calves are not often included in the filtered samples for mark-recapture analyses unless they have suffered an accident resulting in a permanent mark on their dorsal fin, which was not encountered during this study period. Even when high-quality pictures of calves, such as those rated 3 or higher for quality, are examined, it is not easy to distinguish them and be certain about their identity (Peter et al., 2012). This challenge arises because they haven't yet accumulated the distinctive scars found in adults. Therefore, confidence can be placed in the uniqueness of marks in individuals (Hammond et al., 2021), and the ongoing improvement of the reliability of our data can be expected.

#### **4.1.6 ASSUMPTION 6: ALL MARKS ARE REPORTED ON RECOVERY**

The reliability of a mark-recapture estimate rests on the assumption that every marked animal is correctly identified and documented (Hammond, 2021). This assumption may be compromised through two scenarios: marks go unrecognized, leading to a situation where an individual previously photographed is given a new ID, resulting in a 'double identity' within the catalog which will generate an overestimate of the population, or two separate animals with similar markings are erroneously considered to be the same individual and are assigned the same ID which will generate an underestimate of the population. The significant number of matches suggests that there might be many cases where individuals were not identified in the dataset

(Figure 3.3). This could occur due to the striking similarity in appearance among some individuals or because their pictures lacked clarity. In the study, we addressed this potential bias by ensuring that only photos of quality 3 or higher were used in our analysis to reduce the chance that marks were not recognized because of lack of resolution or poor angles of photos, as well as reducing the risk of assigning the same ID to two individuals. Filtering capture histories to include only individuals of distinctiveness 3 or higher also ensures that our estimates are not biased by individuals who may appear similar in the population (Peter et al., 2012).

## **4.2 INDIVIDUAL MOVEMENTS WITHIN THE STUDY AREA**

Utilizing the photo-identification technique has allowed us to delve deeply into the intricacies of some individual movement patterns within the study population. Through this method, noteworthy distinctions in the movements of the observed individuals have been discerned. Our observations reveal a twofold division among the population. A subset of individuals exhibits a consistent preference for the Saloum River in the northern portion of the study area as their primary habitat, indicating a strong fidelity to this particular location (Figure 3.8). Conversely, a distinct segment of the population displays a more dynamic pattern of movement, engaging in frequent and regular migrations between the northern Saloum River and the southern Diombos Channel region. This recurring movement between these two locations signifies a more nomadic behavior among this subset (Figure 3.10).

Previous studies, including Weir (2016), highlighted the Diombos region as a notable concentration point for these dolphins, demonstrating their movements between the Saloum, Diombos, and Bandiala regions. The study reaffirms this movement pattern in the Saloum and Diombos Rivers, which is crucial for species management and conservation efforts. On the other hand, no confirmatory sightings of interchange between individuals from the Saloum Delta and those from the Gambia were observed, as documented by van Waerebeek et al. (2004) and Weir (2016), because no comparison study was done between the two countries yet. Even though fishermen claim that dolphins travel between the two countries seasonally, we did not document such movements in the study.

It's important to note that no dolphins were observed in the open sea or around the islands outside the Delta area during the study. However, this does not necessarily imply that the dolphins we studied never leave the Delta. Previous reports, including those by Weir (2016), mentioned dolphin sightings outside the Bandiala region and around the bird island at the entrance to the Diombos River. Additionally, the Marine Protected Area (MPA) staff and local fishermen who accompanied us during our boat surveys have reported seeing dolphins outside the Delta. Nevertheless, it cannot be certain that these sightings involved humpback dolphins.

This study represents a groundbreaking contribution to the understanding of *Sousa teuszii* populations. It comprises the first multi-year photo-identification catalog for this species, offering crucial baseline data for conservation initiatives. Our research sheds light on distinct movement patterns among individuals, revealing both faithful residents of the Saloum River and nomadic dolphins moving between the Saloum River and the Diombos region. These insights underscore the urgency of safeguarding vital areas and migration corridors. While we acknowledge the inherent challenges and assumptions in the mark-recapture method, our commitment to data accuracy and refinement of techniques instills confidence in our results. Moving forward, the combination of photo-identification and the robust Mark-Recapture approach will continue to provide indispensable insights into *Sousa teuszii* population dynamics. Addressing methodological challenges positions us to develop effective conservation strategies, monitor demographic trends, and contribute significantly to the long-term survival of this endangered species.

By employing robust scientific methods and acknowledging the inherent uncertainties through confidence interval calculations, the aim is to provide evidence-based insights that guide effective conservation strategies for the survival of the Atlantic humpback dolphin within the coastal waters of West and Central Africa. The insights gained from this study will not only advance our understanding of this captivating species but also contribute to the broader field of marine conservation.

As we look at the findings from our study on Atlantic humpback dolphins, it's important to recognize both our progress and the study's limitations. We've focused on a specific time and place, which might not give us the whole picture of where these dolphins are and how their populations are doing. To understand them, we might need to expand our study area and keep watching them over a longer time. Our study has got us thinking about some big questions. Like, with the environment changing, how will it affect where these dolphins live and how they behave? Things like warmer seas and habitats getting damaged could shake things up for them. Figuring out how they'll cope with these changes is a big task. We've also been wondering about the pressures people put on these dolphins. What are the main threats they face, and how do these mess with their natural lives? Pollution, fishing, and all kinds of human activities could be making life tough for them. We need to understand this better to protect them. Another thing on our minds is how these dolphins are connected to each other and how diverse their genes are. Are they just hanging out in Senegal, or are they mixing with other dolphin groups nearby? Learning more about their family tree could help us protect them better. And, of course, we need to keep an eye on them in the long term. Setting up ways to watch them for years to come will help us see how they're doing and if our efforts to protect them are working. Getting local communities involved in keeping an eye out for them can make a big difference, too. Putting all this knowledge into action means working together with governments, groups, and locals to protect these dolphins' homes and keep them safe. By continuing to study them, model their environment, and learn about their behavior, we can make sure Atlantic humpback dolphins have a good chance at thriving in Senegal and beyond.

## 5 CONCLUSION AND RECOMMENDATIONS

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Currently, there is a deficiency in reliable estimations of the global population of *Sousa teuszii*. This absence of precise data complicates the implementation of effective conservation measures. It is a significant issue because it restricts our ability to assess the impact of threats on this endangered species. Without knowledge of their numbers, it becomes challenging to determine the severity of the threats they face (Weir et al., 2021). Another crucial challenge lies in our

restricted comprehension of how different *Sousa teuszii* populations, such as those in Senegal and the Gambia, might interact. We lack knowledge regarding their movement patterns and potential genetic exchanges. This gap significantly hampers our ability to develop comprehensive conservation strategies. Understanding this connectivity is vital for protecting these endangered dolphins as it would enable us to better target conservation efforts and preserve their genetic diversity (Van Waerebeek et al., 2009, 2017; Bamy et al., 2021).

In essence, this newfound knowledge not only enriches our understanding of these dolphins but also empowers managers to make informed decisions that support the conservation and sustainable management of this species in the Saloum Delta. In the study, an estimated population of 469 individuals was obtained, along with a reasonably accurate range, as indicated by our 95% confidence interval, which extended from 275 to 801 individuals. For this reason, it is not recommended to publish these results at this time but rather wait for the data from 2023 to be processed. Through the analysis of the 2023 data, which spans 19 days of survey efforts and encompasses a substantial number of 19,148 photos, a notable improvement in photo quality, attributable to the enhanced skills of the team, holds the promise of yielding significantly more precise and dependable results. The potential increase in the count of re-captures for the year 2023 stands to enhance the accuracy of our estimates, resulting in a narrower confidence interval, thus strengthening the reliability of our findings, enhancing insights into the residence patterns of specific individuals within the Saloum River are anticipated, potentially shedding light on whether permanent residency is maintained in this habitat. It should be noted that our data, derived from research covering a wide range, from biodiversity assessment of the Saloum Delta to fishing effort analysis, offers considerable potential for multiple complementary analyses. This additional information is not only invaluable but will also help to fill the scientific gaps faced regarding *S. teuszii*.

The situation for conserving *Sousa teuszii* is very urgent, and we can compare it to the challenge faced by the Vaquita dolphin in Mexico. In the study, we estimated there are around 469 *Sousa teuszii* dolphins in the Saloum Delta and the largest and healthiest population of the species. However, human activities such as using gillnets for fishing in the Saloum Delta are harming these dolphins and causing accidental catches, putting their survival at risk. We can see a similar problem with the Vaquita dolphin. At first, they were declining quickly because there were lots of accidental catches compared to their low population numbers, causing a decline of 47% each

year (Jaramillo-Legorreta et al.; 2017). Later, it was seen directly in visual surveys in 1997 and 2008, where their numbers dropped by 57% in total, which means about 7.6% fewer each year (Gerrodette et al. 2011). In 2018, there were fewer than 20 Vaquita dolphins left in Mexico, and today, there might be only 10. The main reason for the Vaquita's decline is the use of gillnets in fishing (Jaramillo-Legorreta et al. 1999). This shows why it's so important to act quickly to protect *Sousa teuszii* and avoid the same kind of problems these marine animals face due to human activities.

The other point to take from this study is that some individuals in the *Sousa* population appear to be loyal to the Saloum River which is also the scene of human activities, such as the use of gillnets for fishing, which pose a threat to these marine animals. Despite these threats, the Saloum Delta remains an essential and ideal habitat for dolphins. It is therefore imperative to take urgent conservation measures to protect this dolphin population and preserve this unique environment. This study highlights the importance of harmonious coexistence between human activity and marine fauna to ensure the long-term survival of *Sousa teuszii* in the Saloum Delta.

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## 7 APPENDIX

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*Table 7.1: Atlantic humpback dolphin sightings date and locations, best-estimated group size, total kilometers, in 2021*

<b>Date</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Best Estimate</b>	<b>Total Kilometers</b>
7/11/2021	13.8377	-16.5582	4	102
7/11/2021	13.8554	-16.4949	1	102
7/12/2021	13.8470	-16.5319	1	106
7/13/2021	13.8223	-16.6382	4	78.3
7/18/2021	13.8338	-16.5532	12	66
7/28/2021	13.9864	-16.6346	15	65.2
7/28/2021	13.9850	-16.6305	3	65.2
7/28/2021	14.0005	-16.6153	4	65.2
7/28/2021	13.9824	-16.6190	14	65.2
7/28/2021	13.9755	-16.7382	1	65.2
7/28/2021	13.9698	-16.7518	7	65.2
7/29/2021	13.9284	-16.7577	5	81.5
7/29/2021	13.9942	-16.6726	14	81.5
7/29/2021	13.9826	-16.6352	3	81.5

Table 7.2: Atlantic humpback dolphin sightings date and locations, and environmental parameters in 2021

<b>Date</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Depth (M)</b>	<b>Temp (°C)</b>	<b>Salinity</b>
7/11/2021	13.83773	-16.55816	5.4	33	37

7/11/2021	13.85537	-16.49491	4.9	30	40
7/12/2021	13.84696	-16.53188	5.1	28	42
7/13/2021	13.82231	-16.63821	10.3	29.5	35
7/18/2021	13.83380	-16.55324	2.5	31.5	34
2021_07_28	13.98636	-16.63456	8	32	40
2021_07_28	13.98501	-16.63047	8	32	40
2021_07_28	14.00050	-16.61525	9.4	33	35
2021_07_28	13.98237	-16.61897	15	29.5	36
2021_07_28	13.97549	-16.73817	5.9	29	35
2021_07_28	13.96979	-16.75179	5.9	29	35
2021_07_29	13.92836	-16.75772	11.1	26	40
2021_07_29	13.99422	-16.67257	13.5	33	36
2021_07_29	13.98259	-16.63525	NA	NA	NA

*Table 7.3: Atlantic humpback dolphin sightings date and locations, best-estimated group size, total kilometers, in 2022.*

<b>Date</b>	<b>Latitude</b>	<b>Longitude</b>	<b>Best Estimate</b>	<b>Total kilometers</b>
3/19/2022	13.9818	-16.6439	14	74.4

3/19/2022	13.9955	-16.6193	8	74.4
3/20/2022	13.9375	-16.5008	9	112.9
3/20/2022	13.9880	-16.6280	6	112.9
3/21/2022	13.9811	-16.6333	12	87.4
3/22/2022	13.9330	-16.5011	12	105
3/22/2022	13.9708	-16.4903	6	105
3/25/2022	13.9979	-16.7157	10	46.2
3/25/2022	13.9832	-16.6338	6	46.2
3/26/2022	13.9905	-16.6621	Unk	74.2
3/26/2022	14.0552	-16.5716	30	74.2
3/26/2022	14.0493	-16.5632	5	74.2
3/26/2022	14.0268	-16.5898	1	74.2
3/26/2022	14.0175	-16.5970	14	74.2
3/27/2022	13.9871	-16.6300	6	84.4
3/27/2022	13.9949	-16.5074	12	84.4
3/27/2022	14.0017	-16.6124	20	84.4
3/29/2022	13.9913	-16.6270	1	82.3
3/29/2022	13.9943	-16.6474	17	82.3
3/29/2022	13.9966	-16.6482	14	82.3
4/2/2022	13.8186	-16.5907	25	82.6
4/5/2022	13.9078	-16.5366	1	105

*Table 7.4: Atlantic humpback dolphin sightings date and locations, and environmental parameters in 2022*

<b>Date</b>	<b>Latitude 1</b>	<b>Longitude 1</b>	<b>Depth (M)</b>	<b>Temp (°C)</b>	<b>Salinity</b>
3/19/2022	13.9818	-16.6439	11.6	26.5	41
3/19/2022	13.9955	-16.6193	10.5	25	41
3/20/2022	13.9375	-16.5008	9.4	25.5	37

3/20/2022	13.9880	-16.6280	9.7	34	38
3/21/2022	13.9811	-16.6333	13	25.5	38
3/22/2022	13.9330	-16.5011	6.5	26	34
3/22/2022	13.9708	-16.4903	6.9	29	39
3/25/2022	13.9979	-16.7157	14	26	39
3/25/2022	13.9832	-16.6338	10.5	30	37
3/26/2022	13.9905	-16.6621	13	29	43
3/26/2022	14.0552	-16.5716	4.9	28	40
3/26/2022	14.0493	-16.5632	11	29	40
3/26/2022	14.0268	-16.5898	11.3	26.5	42
3/26/2022	14.0175	-16.5970	10.7	27	42
3/27/2022	13.9871	-16.6300	9.5	24.5	43
3/27/2022	13.9949	-16.5074	1.6	28	40
3/27/2022	14.0017	-16.6124	10.3	27.5	41
3/29/2022	13.9913	-16.6270	8.1	28	40
3/29/2022	13.9943	-16.6474	6.5	28	40
3/29/2022	13.9966	-16.6482	2.7	31.5	40
4/2/2022	13.8186	-16.5907	14.9	25	36
4/5/2022	13.9078	-16.5366	5.9	25	40

