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MASTER THESIS PROJECT

"Image-Based Identification of Blue Sharks in the Mid-Atlantic: Evaluating a Standardized Methodology for Long-Term Monitoring"

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CERTIFIES:

That the research work entitled

"Image-Based Identification of Blue Sharks in the Mid-Atlantic: Evaluating a Standardized Methodology for Long-Term Monitoring"

has been carried out by Andrea Herrera in OKEANOS-UAc under the supervision of Dr. Maite Erauskin-Extramiana from February 1st to August 15th of 2025 in order to achieve 30 ECTS as a part of the MER Master program.

In Azores (Portugal), 15 August 2025

Presenter: Andrea Herrera

Supervisor(s): Maite Erauskin-Extramiana

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SUMMARY

The blue shark (*Prionace glauca*), a widely distributed pelagic-oceanic predator, faces heavy exploitation despite its ecological importance, making its good management and conservation urgent. Diving tourism with blue sharks is rising, with increasing social and economic relevance in the Azores, which allows for an informal and extensive data collection platform. Using this opportunistic data collected by divers and local scientists, this study explores whether a standardized, non-invasive photo-identification (photo-ID) methodology can reliably identify shark individuals over time, both within and across years. Data from 2019–2021 and 2024, focused on the Pedra de Sousa, Condor Seamount, and Princess Alice Bank, were analyzed, using opportunistic images and videos collected by researchers and local divers during scientific and shark diving expeditions. Selected images were analyzed using three different identification metrics: (i) dorsal fin edge morphology, (ii) ampullae of Lorenzini pore pattern, and (iii) complementary traits such as bite marks, fishing gear marks, or other visible features. Besides, the total length of the sharks was measured using laser photogrammetry when possible. The methodology developed in this study identified 34 unique individuals, with resighting of 4 of them across years. This study suggested that the dorsal fin is the most reliable long-term trait among the three metrics analyzed, especially when additional traits are available to confirm the identity of the shark over time. The ampullae of Lorenzini hand pore mapping proved to be the least effective metric to be applied to available media, due to visibility issues, time consumption, and low image quality. However, this trait can be of interest if advanced software and AI machine learning systems are used to map it. The easily recognizable "Scarface" was used to validate the methodology. The developed methodology helped identify another 4 individuals (all juveniles or adult males) who have returned to the study over the years. These resightings suggest potential site fidelity, which is consistent with the previous knowledge on seasonal sexual segregation patterns in the area. The research highlights the value of cross-sector collaboration—among researchers, tourism operators, and citizen scientists—to collectively maximize research efforts, while acknowledging the challenges of using opportunistic data. These limitations hinder the identification of individual sharks and are mainly due to the low image quality in some media, as well as the absence of visible reference metrics in certain frames. This

is often caused by a high number of sharks appearing simultaneously or by suboptimal camera positioning relative to the shark. Recommendations were proposed to improve the quality of the data available for future efforts and long-term monitoring and were summarized into the "Data Collection Best Practices." Ultimately, the study demonstrates that a low-cost, replicable photo-ID method mainly based on the dorsal fin's unique morphology but complemented with other traits can be effectively used to identify blue sharks over time. Integrating other technologies into blue shark monitoring may automate the process and enhance the quality of the results. This study may be used as a tool to advance research concerning site fidelity, animal movement, residency, population structure and abundance, potential nursery areas, as well as the potential impacts of a growing shark diving industry.

RESUMO

O tubarão-azul (*Prionace glauca*), um predador pelágico-oceânico amplamente distribuído, enfrenta forte exploração apesar da sua importância ecológica, tornando urgente a sua boa gestão e conservação. O turismo de mergulho com tubarões-azuis está em ascensão, adquirindo crescente relevância social e económica nos Açores, o que possibilita uma plataforma informal e extensa de recolha de dados. Utilizando estes dados oportunísticos recolhidos por mergulhadores e cientistas locais, este estudo explora se uma metodologia padronizado e não-invasivo de foto-identificação (photo-ID) pode identificar de forma fiável indivíduos de tubarão ao longo do tempo, tanto dentro como entre anos. Foram analisados dados de 2019–2021 e 2024, focados na Pedra de Sousa, no Monte Submarino Condor e no Banco Princesa Alice, recorrendo a imagens e vídeos oportunísticos recolhidos por investigadores e mergulhadores locais durante expedições científicas e de mergulho com tubarões. As imagens selecionadas foram analisadas com base em três métricas de identificação: (i) morfologia da margem da barbatana dorsal, (ii) padrão dos poros das ampolas de Lorenzini e (iii) características complementares como marcas de mordidas, marcas de artes de pesca ou outros traços visíveis. Além disso, o comprimento total dos tubarões foi medido através de fotogrametria a laser sempre que possível. A metodologia desenvolvida neste estudo permitiu identificar 34 indivíduos únicos, tendo 4 deles sido reavistados em anos diferentes. O estudo sugeriu que a barbatana dorsal é o traço mais fiável a longo prazo entre as três métricas analisadas, sobretudo quando características adicionais estão disponíveis para confirmar a identidade do tubarão ao longo do tempo. O mapeamento manual dos poros das ampolas de Lorenzini revelou-se a métrica menos eficaz para ser aplicada ao material disponível, devido a problemas de visibilidade, elevado consumo de tempo e baixa qualidade das imagens. No entanto, esta característica pode ser de interesse se forem utilizados softwares avançados e sistemas de aprendizagem automática (IA) para o seu mapeamento. O facilmente reconhecível “Scarface” foi usado para validar a metodologia.

A metodologia desenvolvida foi útil para identificar mais 4 indivíduos (todos juvenis ou machos adultos) que regressaram à área de estudo ao longo dos anos. Estes reavistamentos sugerem uma potencial fidelidade ao local, consistente com o

conhecimento prévio sobre padrões sazonais de segregação sexual na região. A investigação sublinha o valor da colaboração intersectorial — entre investigadores, operadores turísticos e cientistas cidadãos — para maximizar coletivamente os esforços de investigação, reconhecendo ao mesmo tempo os desafios de utilizar dados oportunísticos. Estas limitações dificultam a identificação de tubarões individuais e devem-se principalmente à baixa qualidade das imagens em alguns registos, bem como à ausência de métricas de referência visíveis em determinados fotogramas. Tal deve-se frequentemente à presença simultânea de um elevado número de tubarões ou a posicionamentos subótimos da câmara em relação ao animal. Foram apresentadas recomendações para melhorar a qualidade dos dados disponíveis para esforços futuros e monitorização a longo prazo, resumidas no documento "Boas Práticas de Recolha de Dados". Em última análise, o estudo demonstra que um método de foto-ID de baixo custo, replicável e baseado principalmente na morfologia única da barbatana dorsal, mas complementado com outros traços, pode ser utilizado de forma eficaz para identificar tubarões-azuis ao longo do tempo. A integração de outras tecnologias na monitorização do tubarão-azul pode automatizar o processo e melhorar a qualidade dos resultados. Este estudo pode ser usado como ferramenta para o avanço da investigação sobre fidelidade ao local, movimentos animais, residência, estrutura e abundância populacional, potenciais áreas de maternidade, bem como os possíveis impactos de uma indústria de mergulho com tubarões em crescimento.

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Andrea Herrera

INTRODUCTION

The blue shark (*Prionace glauca*, Linnaeus, 1758) is the only species of its genus in the *Carcharhinidae* family. It inhabits the water column from the surface to at least 600 m depth in temperate and tropical oceans, allowing its wide distribution. However, it is known that they have dives as depth as 1100m (Andrzejaczek et al., 2022). Their distribution seems to be influenced by seasonal variations in water temperature, reproductive cycle, and availability of food resources (Kohler et al., 2002). It undergoes one of the largest migrations globally, making routinely crossing the Atlantic Ocean (Vandeperre et al., 2014; Fontes et al., 2024). In its migration, the blue shark annually arrives at the Azores (Portugal), the most remote oceanic archipelago located in the middle of the Atlantic Ocean (Afonso et al., 2020). The archipelago lies in oligotrophic waters, within one of the most productive marine regions, the North Atlantic Ocean (Amorin et al., 2017). The area is a seamount-rich ecosystem, recognized for its key role as a transitional habitat for large open-ocean animals (Amorim et al., 2017), making it particularly attractive to marine megafauna (Afonso et al., 2020). These conditions establish the archipelago as a critical habitat and migratory waypoint for species such as the blue shark. Understanding the life cycle of this species, including the region where they seem to return due to the potential site fidelity, is essential for conservation and management initiatives.

Blue sharks, as other shark species, play an important ecological role in marine ecosystems. Sharks, also referred as “apex”, “top predators”, or “great sharks” (Daniela Ceccarelli & Tony Ayling, 2010), are at the top of the food chain and play a significant role in the ecosystem as top-down regulators by hunting weak or sick prey, and controlling the prey abundance and maintaining healthy populations (Das & Afonso, 2017). This is the reason why sharks are considered good indicators of a healthy ocean, which sustains healthy commercial fisheries and ecosystem services derived from marine environments (Motivarash Yagnesh B. et al., 2020). Although sharks’ ecological importance is recognized, many populations are fished as target and bycatch species globally, leading to a strong decline in many populations (Queiroz N. et al., 2019).

The blue shark, with its high abundance and worldwide distribution, has become one of the most exploited shark species in the world, being frequently caught in pelagic longline fisheries targeting tunas (*Thunnus* spp.) and swordfish (*X. gladius*). With the increase in demand for the species for trade, the blue shark is also targeted by commercial oceanic fisheries, and when considering the total catch volume of all fish, the blue shark accounts for 50% and 90% when considering only elasmobranchs (Thaísy E.F. da Silva et al., 2021). In addition, it is the main component of the international shark fin trade (Stevens et al., 2010), with an estimated over 6 million blue sharks killed annually by high-seas fisheries all around the world (Hideki Nakano & John D. Stevens, 2008). These estimates highlight the magnitude of exploitation on this species, which has been classified as Near Threatened in the Atlantic by the IUCN Red List Threatened Species since 2020. However, according to the latest report from ICCAT, the blue shark species is not classified as overfished but is experiencing overfishing. The report advises reducing annual catches to maintain healthy populations and recommends implementing catch quotas for both the North Atlantic and South Atlantic for the first time. Thus, due to the blue shark population status, understanding its migration pattern and habitat use is essential for the species management and bycatch reduction.

In recent years, shark-diving tourism has increased exponentially worldwide, as part of the ecosystem services provided to humans. Shark diving is a relatively new marine wildlife tourism activity in the Azores. It began in 2011, with the number of visitors increasing every year. This activity has generated over USD 2 million by 2014 in revenue for the regional economy, with a forecast for further growth (Torres et al., 2017; Ressureição et al., 2022; Gonzáles-Matillas et al., 2022). Local diving operators encounter various shark species during expeditions, mainly blue sharks, followed by shortfin makos (*Isurus oxyrinchus*) and, occasionally, whale sharks (*Rhincodon typus*) (Bentz et al., 2014). To ensure the sustainability and ethical conduct of these activities, all shark-diving operators adhere to a voluntary "Code of Conduct for Pelagic Sharks and Rays Diving in the Azores," which outlines a set of rules aimed at respecting the animals and their habitat during shark diving activities. This code was developed in 2012 through collaboration between two regional secretaries (Tourism and Sea), four tourism operators, and the University of the Azores (Bentz et al., 2014). As shark-diving tourism grows—bringing notable socioeconomic benefits—it also increases public familiarity and awareness of sharks. This heightened exposure can help foster a more positive perception of these animals, supporting better species management and encouraging responsible shark-related activities. Additionally, collaboration between sectors and tourism operators, the use of photo-identification methods, and the inclusion of citizen science in research initiatives can enhance our understanding of species occurrences in the archipelago.

Photo-identification studies demonstrate the advantages of using both opportunistic and targeted recorded media for identifying various shark species. This method offers a non-invasive and low-cost alternative to other conventional identification methodologies. Some photo-ID applications include tracking changes in abundance, seasonal migrations, and inter-site movements; the ecology and biology of species by studying the growth, reproductive behavior, threats like fishing injuries, or the impact of human-animal interactions in the water (tourism) (Buray et al, 2009; Marshall et al., 2012; Barone et al., 2022; Black, 2023; Fontes et al., 2024). This approach not only allows the research community to study shark species but also enables the inclusion of citizen-science, raising awareness and improving human-animal interactions (Marshall & Pierce, 2012).

STUDY OBJECTIVES AND HYPOTHESES

In this context, the development of a standardized methodology for shark visual identification will enhance the understanding of this keystone species, encourage cross-sector collaboration, and act as a complementary method to existing identification techniques like mark-recapture.

This study has two objectives: (i) to test a reliable and cost-effective standardized methodology for photo-identification of blue sharks in the Azores archipelago, using dorsal fin morphology as the main trait, and (ii) to assess the feasibility of resighting the same individual within the study area by applying the specified methodology. To reach both objectives, data were collected during the summer months (July to September) over 4 years (2019-2021 and 2024). The development of this standardized methodology could facilitate the identification of blue sharks in the Azores, making it available to other research groups, tourism operators, and divers, and aims to be replicable in other areas. At the time this study was conducted, no other research was published on blue shark identification, showing the necessity for advancing research in this field.

MATERIALS & METHODS

Data and Study Area

The Azores archipelago, composed of a group of nine volcanic islands and several seamounts, represents a sub-area of Portugal's Economic Exclusive Zone (EEZ) covering around 1 million km², one of the largest in the European Union (Afonso et al., 2020). This region is characterized by its unique climatological-oceanographic properties, acting as an ecotone, an area where two ecosystems coincide. The area is influenced by the north Atlantic subtropical gyre via the southeastern branch of the Gulf Stream, known as the Azores current, with its eddies that flow through the southern part of the region (Caldeira & Reis, 2017; Afonso et al., 2020). These oceanographic and hydrodynamic characteristics contribute to the Azores functioning as an "oceanic seamount ecosystem area," attracting rich biodiversity and megafauna, such as the blue shark. The region, located at depths above 1,500 meters, showcases the unique geological genesis linked to the mid-Atlantic Ridge elevation (Das & Afonso, 2017).

This study focuses on three specific sites: (i) Pedra de Sousa, on the north edge slope of the Faial-Pico Channel, (ii) Condor Seamount, and (iii) Princess Alice Bank (Figure 1), which are also known for being popular shark-diving sites. These areas are rich in biodiversity and are referred to as "hotspot" zones by the scientific community, anglers, and local tourism operators (Morato et al., 2008; Bentz et al., 2014; Afonso et al., 2020; Gonzáles-Matilla et al., 2022). One reason for this designation is the aggregation of blue sharks, especially during the summer months, due to their interannual migrations in the archipelago (Vandeperre et al., 2014). Pedra de Sousa is an area with a depth close to 400 m (Fontes et al., 2024) located on the north slope edge of the Faial-Pico Channel, an elongated passage that separates the islands of Faial and Pico. This channel is characterized by steep depths reaching 800 m, and the Regional Government of the Azores has expressed intentions to classify the area as a "Marine Park" (Rodríguez & Pham, 2017). The Condor is an elongated seamount about 10 nautical miles southwest of Faial Island. It has two peaks and an east-to-west main direction. This seamount rises more than 1 km above the surrounding seafloor, and it is about 35 km long and 2–6 km wide with a shallower summit of about 185 m deep (Tempera et al., 2012). Princess Alice Bank is located roughly 90 km southwest of Faial Island, rising steeply from the surrounding seabed of approximately 2,500 m (De Girolamo et at., 2011). It reaches a minimum depth of 33 m in its western zone, with a mean summit depth shallower than 250 m (Solleliet-Ferreira et al, 2020; Santos et al., 2021). The Condor Plateau's physical structure and oligotrophic conditions favor benthic-pelagic coupling, attracting commercial fisheries, as over 60% of demersal and deep-water fish fisheries in the Azores happen on seamounts, leading conservation initiatives for the protection of this area (Tempera et al., 2012).

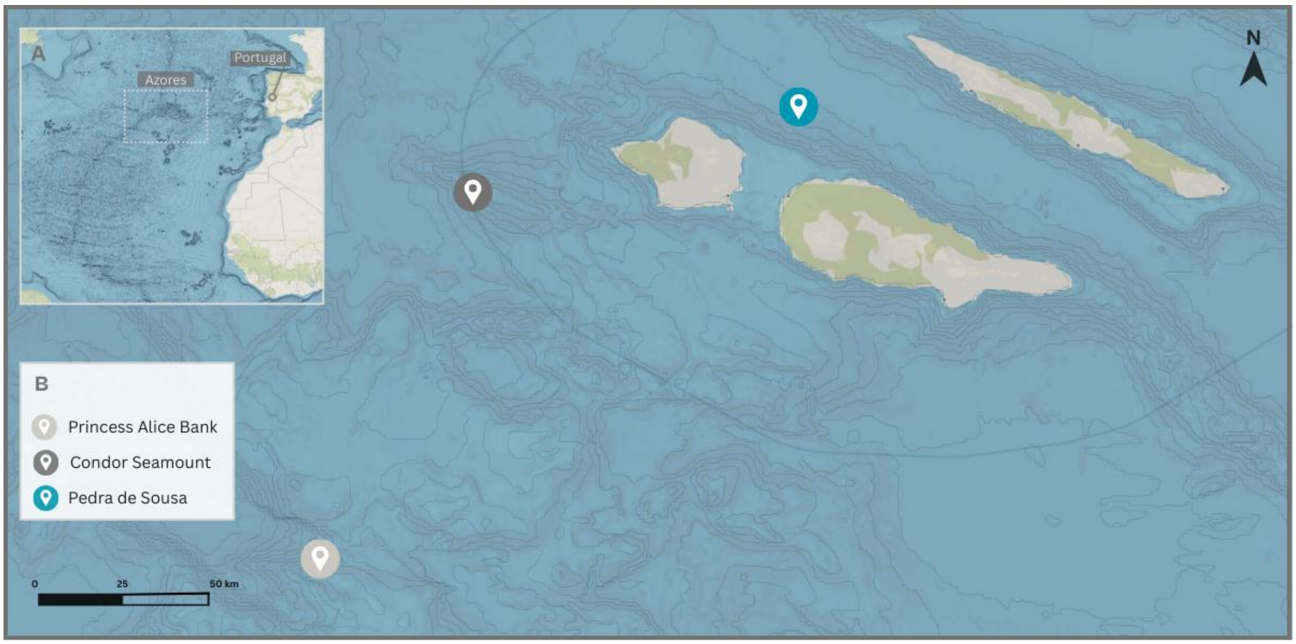


Figure 1 Map with: A) the geographic location of the Azores archipelago (36°0–40' N, 24° W–32' W) in the North Atlantic Ocean and B) the geographic location of the study area and the three diving sites.

Surveys: Citizen-Science and Opportunistic Data Collection

Blue shark's seasonal opportunistic sighting data from 2019 to 2021 and 2024 were collected during the summer season (June to September). After the dataset cleaning, a total of 573 videos and 1,920 pictures were used in the analysis. Data on blue shark sightings were collected by the EcoDivePWN research group, which includes students and researchers from Okeanos-UAc, as well as citizen scientists, divers, and freedivers who collaborated with the study. It's important to note that, during these scientific expeditions, the research group was also collecting photogrammetry data as part of a long-term monitoring protocol. To observe sharks swimming near the vessel, chum—a bait mixture made from pieces of various fish species—was used to attract them. However, on several occasions, blue sharks were already swimming at the surface even before chumming began. Images and videos of blue sharks were captured during shark-diving or scientific surveys, typically conducted between the surface and ten meters in depth. For the analysis, only videos and pictures in which the camera was perpendicular to the animal and at a distance of one to three meters from the shark were selected. This media allows for the observation of features along the shark's body. The action cameras used for video recordings included GoPro Hero models: five, seven, and nine, which had sufficient quality. They were set to wide-angle by default, needing lens correction to a linear view prior to image processing.

The technical camera settings applied by the scientific group included action cameras in wide-angle, with a 4K resolution, MP4 video format, and libx264 codec. For digital still images, RAW resolution, ISO-200, set to f/8, 1/250. A handheld laser photogrammetry system was used to measure the total length (TL) of sharks. The device featured two lasers positioned 25 cm apart, providing fixed reference points that do not refract at the observation distance. This setup enabled accurate identification of two specific points on the shark's body. As a low-cost and effective technique, it allows for measuring free-swimming sharks without physical contact, minimizing stress or impact. Measurements were taken only when both laser points were clearly visible, and the shark was perpendicular to the camera. Additionally, video footage from the research team and other divers using action cameras was included in the analysis.

Image Processing and Selection Criteria: Data Cleaning and Refinement

First, all videos and images were organized by year (2019, 2020, 2021, and 2024) and sampling site, providing specific data parameters such as video ID, year, site, or video type (Table 1). To manage the large collection of videos and images, a selection criteria was established prior to analysis to prevent the repetition of images and to avoid capturing multiple videos from the same dive. This approach facilitated the removal of low-quality media, including frames without sharks. Each media file was labeled with a unique code indicating the year and sampling site, ensuring organized and traceable data management. Frames containing images of interest were extracted from each video.

However, only those of sufficient quality were selected for analysis. This selection included frames that were perpendicular to the camera and clearly displayed distinguishing features. For consistency, the term "images" will be used henceforth to refer to videos, video snapshots, and digital photographs. Additionally, some videos that provided valuable information—such as the presence or absence of fish, the number of divers, and the number of sharks in the water—were retained, even though they were not selected for visual identification. To enhance visual analysis, ShotCut video editor was used to convert videos recorded with a wide-angle lens to a linear frame, allowing adjustments such as lens correction, video rotation, and image sharpening. For measuring the TL of sharks in the laser photogrammetry footage, ImageJ software was employed during the analysis.

Identification Metrics:

Blue shark is characterized by its morphological features, such as an elongated body with long pectoral fins, large eyes with nictitating membrane, dark blue dorsal side, and white coloration on its ventral side (Nakano & Seki, 2003; Nakano & Stevens, 2008). After the unique morphological features of the blue shark were analyzed, three metrics were selected for the development of a standardized methodology for the blue shark photo-identification. This selection process was informed by a thorough literature review of previous studies focused on the individual identification of elasmobranchs. The metrics considered in this study included: i) the dorsal fin, ii) the pore pattern of the ampullae of Lorenzini, and iii) other significant visible features, referred to as "complementary traits" such as mating scars, hooks, fishing scars, or other skin marks or morphological features.

i) Dorsal Fin

The dorsal fin of various shark species has been extensively used as a reliable method to identify individuals within the same species (Buray et al., 2009; Marshall et al., 2011). Visual analysis techniques often combine with machine learning and fully automated visual ID systems, have been developed to enhance the accuracy and efficiency of shark identification (Hughes & Burghardt, 2017; Barone et al., 2022). These technological advancements facilitate the rapid processing of large image datasets, enabling researchers and fisheries to identify sharks more effectively. Additionally, shark fin identification guides have been created and implemented in fisheries to assist in species identification during landing processes. These guides rely on visual traits such as unique markings, pigmentation patterns, and the shape of the trailing edge of the dorsal fin, which are considered reliable indicators for identifying both species and individual sharks (Abercrombie et al., 2013; Marshall et al., 2011). The effectiveness of individual identification methods depends on the presence of distinctive visual features that vary among individuals. This study replicated established approaches based on morphological observations and characteristic patterns. To apply these methodologies to blue sharks, it was first necessary to understand their fin morphology and distinguishing traits.

The blue shark's first dorsal fin is located far back, the midpoint of its base about midway between the inner corners of the pectorals (when these are laid back) and the points of origin of the pelvic fins, away from their snouts (Linnaeus, 1758). A five-year comparison analysis was carried out to test morphological changes on "Scarface", a large male blue shark with the longest resight records in the Azores (Fontes et al., 2024). Selected images of "Scarface" were visually analyzed to assess potential morphological changes in the dorsal fin over time (i.e. regeneration). The analysis focused on specific features such as changes in the trailing edge of the dorsal fin, pigmentation variations, and signs of abrasion or healing from injuries. Detailed analyses were carried out to identify asymmetries and other specific features, which proved to be essential in individual identification. The dorsal fin's morphological traits, along with specific marking features, were cataloged to establish a reliable metric for visual identification. This approach facilitated accurate differentiation between individuals.

ii) Ampullae of Lorenzini

The ampullae of Lorenzini are specialized electroreceptive organs located on the skin of elasmobranchs, including sharks, rays, and skates. These organs are highly sensitive to electric fields and temperature gradients in the environment, enabling sharks to detect prey, navigate through complex habitats, and perform social interactions (Wueringer & Tibbetts, 2008). Previous research has demonstrated that the spatial arrangement of the pores varies significantly among species, often correlating with their ecological niches and hunting strategies (Sebastian et al., 2023; Haueisen & Reis, 2024). Mapping the pore pattern involved identifying their locations on the shark's snout from different angles. This process included capturing images of individual sharks from multiple angles (frontal, left, and right sides) whenever available, to ensure a comprehensive representation of the pore distribution. The unique pattern of pores on blue sharks was hypothesized to serve as a biometric marker for individual identification. This technique was selected based on its demonstrated effectiveness in previous studies for distinguishing individuals and exploring sensory adaptations (Sebastian et al., 2023). In this study, each pore was manually mapped to allow precise comparisons across individuals. By analyzing the distribution of these patterns, the research aimed to enhance identification protocols through the use of distinct pore configurations.

iii) Complementary Traits

In the context of visual identification, the selection of complementary traits plays a crucial role in enhancing the accuracy and reliability of individual recognition. Traits such as deep or soft scars, hyperpigmentation, abrasions, hooks, mating scars, and dots are considered supplementary features that, when combined with primary metrics, provide a more comprehensive profile of an individual. These traits are particularly valuable because they tend to be unique and persistent over time, making them effective markers for identification purposes (Marshall & Pierce, 2012). The integration of various visual traits could significantly improve identification protocols. Given that blue sharks lack specific markings like other elasmobranch species, the addition of complementary traits as metrics can facilitate the identification process. Therefore, in this study, it is tested whether incorporating these complementary traits allows for a more robust identification of blue sharks, acting as a complement to the other metrics selected.

RESULTS

A standardized methodology incorporating three selected metrics enabled the identification of 34 individual blue sharks. Notably, four of these individuals were resighted across multiple years, supporting the dorsal fin hypothesis and demonstrating the reliability of the identification approach. The dorsal fin was validated as the primary identification metric through visual analysis of a large male shark, "Scarface," whose left-side dorsal fin was consistently documented over five years.

Among the metrics evaluated, the ampullae of Lorenzini displayed the least reliable metric for identification based on opportunistic data. In contrast, the dorsal fin with the complementary traits provided robust metrics for differentiating between individual sharks, enhancing the overall identification process. Furthermore, the results from the method comparison shed light on the level of difficulty and time-effort required for the analysis when applied in a long-term database, ultimately concluding that fewer and simpler metrics are better.

Dorsal Fin Morphology and Metrics Validation

The dorsal fin of the blue shark nicknamed "Scarface" (named for a distinctive scar near its mouth) was monitored over a five-year period, during which it was consistently documented at Pedra de Sousa. The dorsal fin was hypothesized to be the primary feature for identifying individual blue sharks through photo-identification. This individual with unique scarring patterns was used to test the stability of the dorsal fin morphology over time by comparing footage across 5 years and testing whether dorsal fin morphology is stable in large blue sharks over time. The best five images of the left side of its dorsal fin were selected for long-term comparison and validation of the stability of the dorsal fin shape and color pigmentation. Data from the right side of the dorsal fin were unavailable; thus, the analysis focused exclusively on the left side.

The comprehensive visual analysis of the dorsal fin over five years revealed no evident changes in the morphology or pigmentation pattern of the dorsal fin of "Scarface". Minor morphological variations were observed, such as a mild abrasion at the apex of the dorsal fin in 2019. In the following year, a soft scar-like cut close to the front margin, and a cut in the lower back margin edge of the fin in 2023 were also observed. Despite minor variations, the overall morphology and pigmentation pattern of the dorsal fin remained consistent over time. In particular, the black pigmentation along the rear margin—from the apex to the tip—showed no changes, maintaining a straight vertical line across all observations. The notches on the dorsal fin also remained stable. These findings support the hypothesis that the dorsal fin is a reliable identification metric, especially in large males. This was exemplified by the individual known as "Scarface," whose distinctive dorsal fin features remained unchanged over a five-year period (Figure 2)

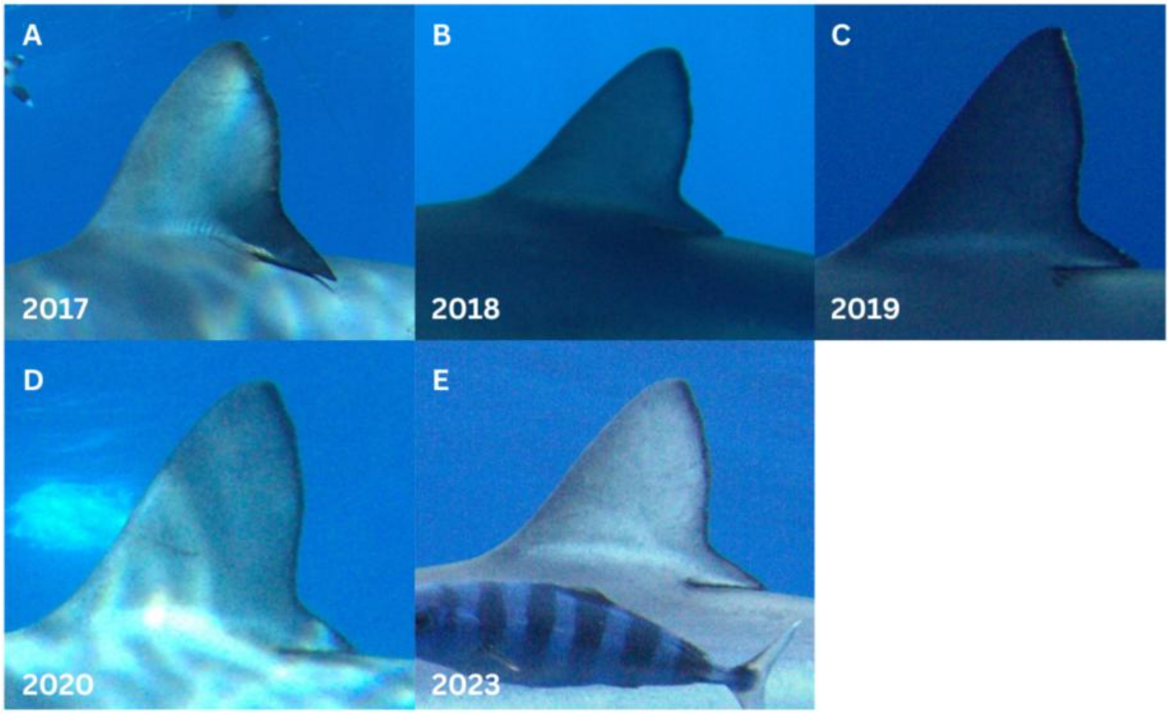


Figure 2 Resighted blue shark (ID: "Scarface") identified through visual analysis of the left-side dorsal fin color counter and shape in (A) 2017, (B) 2018, (C) 2019, (D) 2020, and (E) 2023. Photo credits: (A-E) Martijn Schouten.

Visual Photo-Identification of Individuals: Metric by Metric

i) Dorsal Fin

In this study, a total of unique blue shark individuals were identified using dorsal fin images collected over multiple years: fourteen in 2019, eight in 2020, six in 2021, and six in 2024. Additionally, the TL was recorded whenever possible, revealing that the majority of sharks identified were large male juveniles, typically between 100 cm and 150 cm (Table 2). Overall, the dorsal fin identification method proved to be a consistent and effective tool for monitoring individual sharks, with a total of 34 unique individuals identified and 4 resightings underscoring its robustness and ability to be replicated for long-term studies in other areas. It is important to clarify that these represent distinct individuals, not total sightings. Only four sharks were resighted across different years, highlighting site fidelity and movement patterns (refer to the Resights subsection). This distinction underscores the effectiveness of the identification methodology while emphasizing the value of long-term monitoring.

The identification process relied on the selection of high-quality images of the left and right sides of the dorsal fin, to which each fin was assigned a unique code to facilitate individual recognition across years. Given the variability in image quality and availability, sometimes, individuals lacking images of both sides of the dorsal fin were removed from further analysis. For example, in 2019, a collage of the fourteen identified individuals is shown in Figure 3. Some individuals (S01, S02, and S13) lack images of the left side of the dorsal fin, and others (S03, S04, and S07) lack images of the right side of the dorsal fin. Similarly, in 2020, all eight identified individuals had appropriate images for the left side of the dorsal fin, but in 2021, two individuals (S16 and S20) lacked right side dorsal fin images (Figure 4). Additionally, the TL was recorded whenever possible, revealing that the majority of sharks identified were large male juveniles, typically between 100 cm and 150 cm (Figure 7). Overall, the dorsal fin identification method proved to be a consistent and effective tool for monitoring individual sharks, with a total of 34 unique individuals identified and 4 resightings underscoring its robustness and ability to be replicated for long-term studies in other areas.

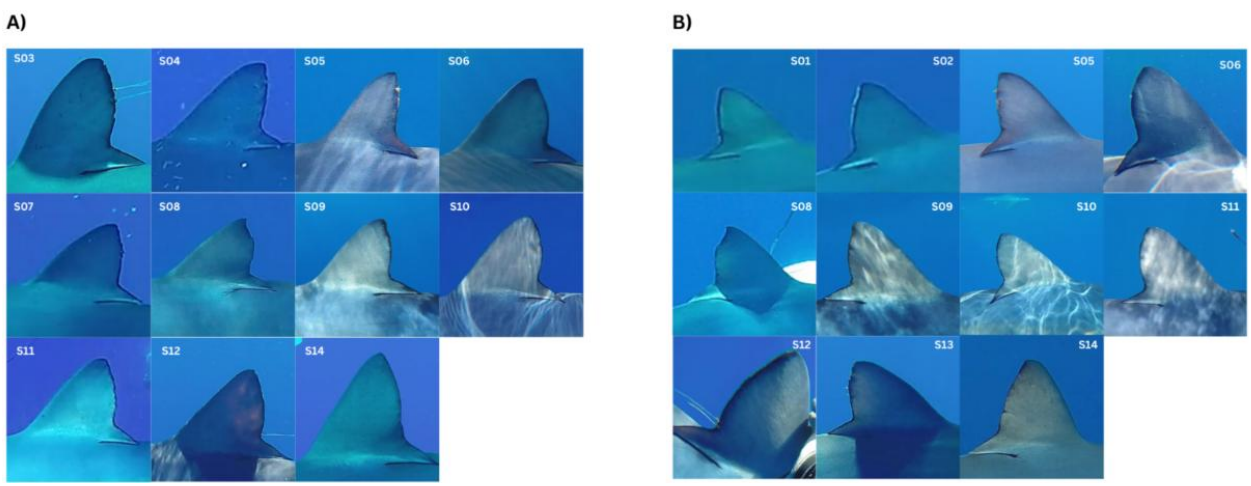


Figure 3 Collage of dorsal fins corresponds to the fourteen identified individuals in 2019, with unique codes for both (A) left and (B) right sides of the dorsal fins.

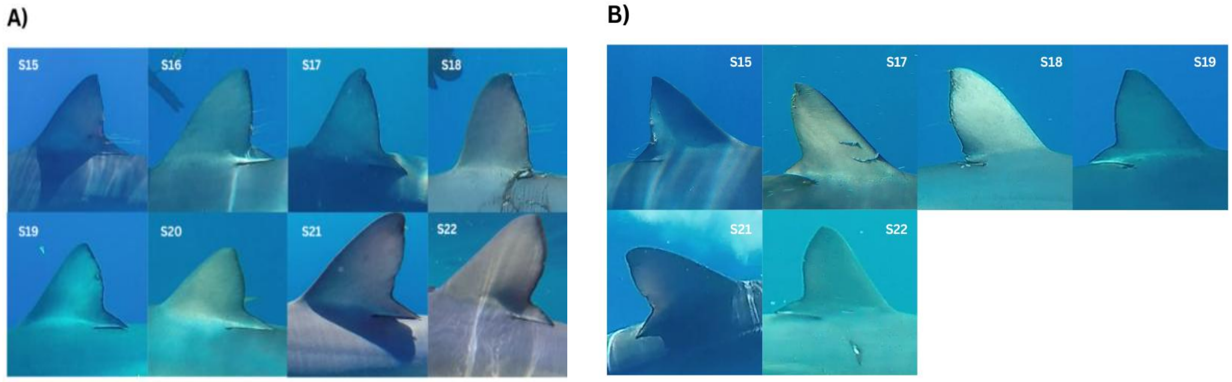


Figure 4 Collage of dorsal fins corresponding to the eight identified individuals in 2020, and name code. (A) Image of the left side of the dorsal fin; (B) Image of the right side of the dorsal fin.

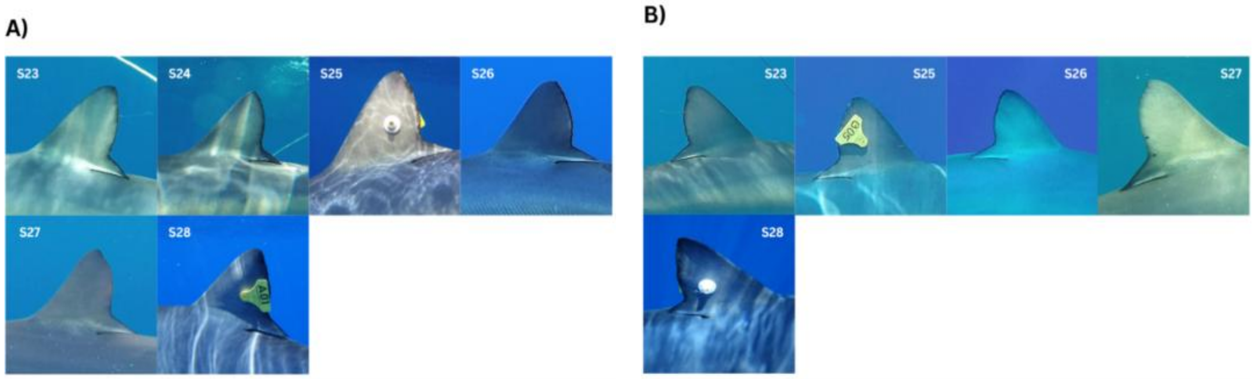
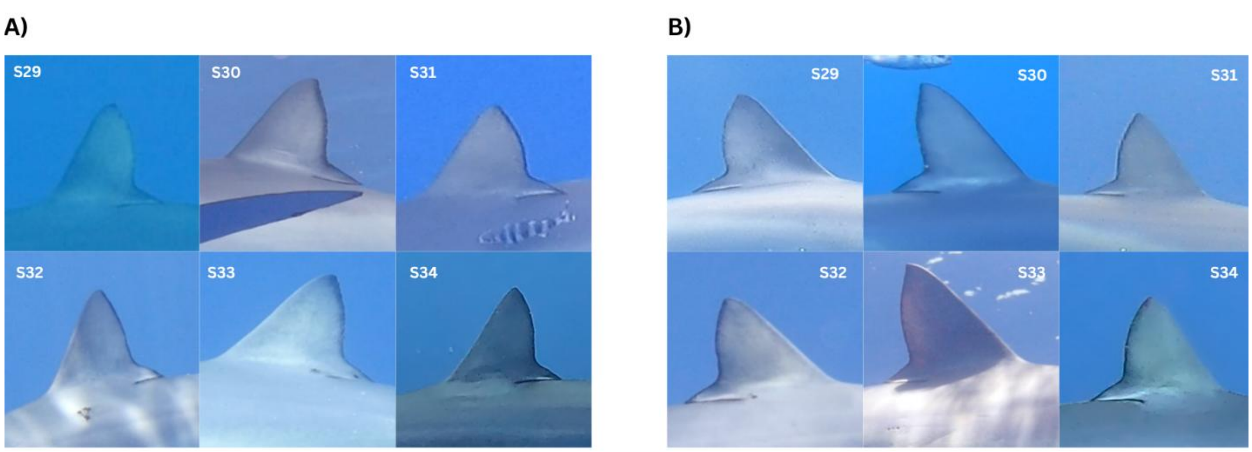


Figure 5 Collage of dorsal fins corresponding to the six identified individuals in 2021, and name code. (A) Left-side image of the dorsal fin; (B) Right-side image of the dorsal fin.



F
igure 6 Collage of dorsal fin corresponding to the 6 identified individuals in 2024 with their unique name code. (A) Left-side image of the dorsal fin; (B) Right-side image of the dorsal fin.

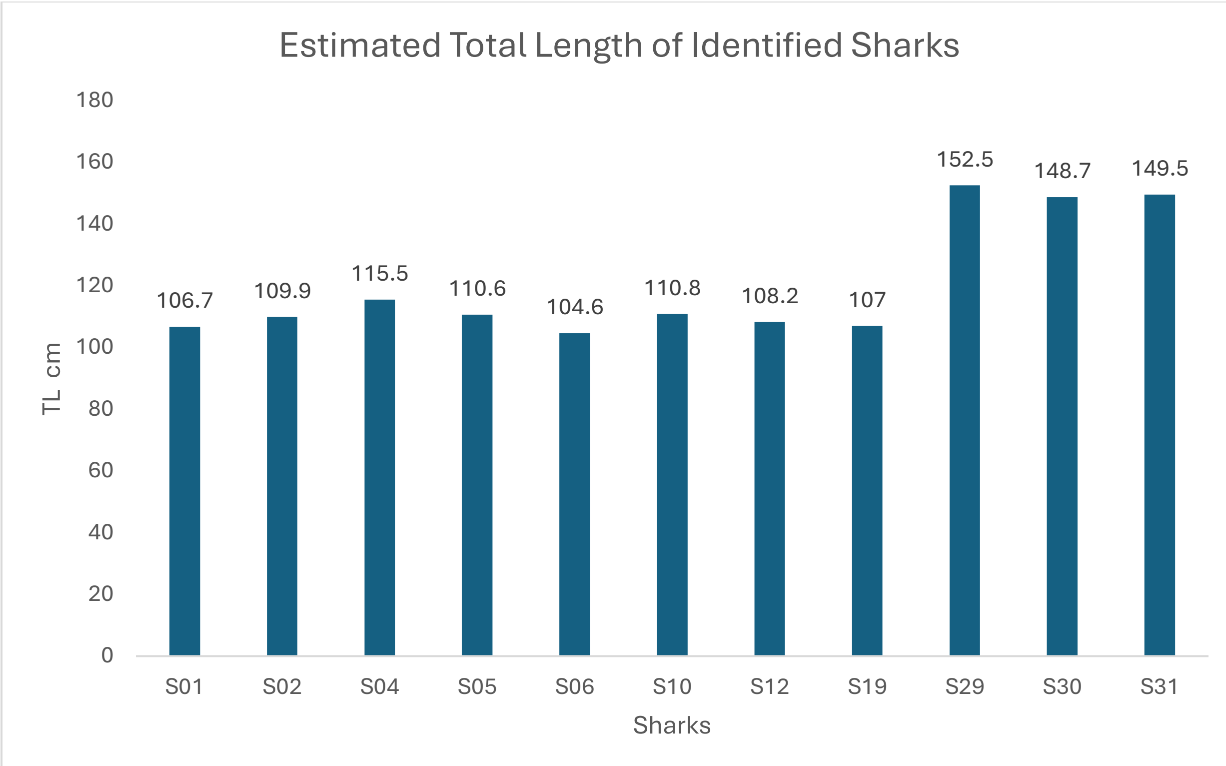


Figure 7 Size distribution of identified shark individuals based on total length using the laser photogrammetry system.

ii) Ampullae of Lorenzini

The mapping of the pore pattern of the ampullae of Lorenzini was manually traced and identified in only 2 individuals out of the 34 successfully identified sharks across all years analyzed. Successful pore-mapping was achieved in just 5.9% of individuals, with the remaining 94.1% lacking the necessary images from the left, front, and right sides of the snout angles. Of the successful cases, individual S12 from year 2019 had a complete left side mapping (Figure 8A), while individual S22 from 2020, both the left and right sides of the snout were successfully mapped (Figure 8B) Mapping duration ranged between 3 and 4.5 minutes per individual, with a variability mainly influenced by image quality, pore visibility, image sharpness, and the location of the pore arrangement around the snout. A before-and-after figure is shown to illustrate the hand-mapping of the pores.

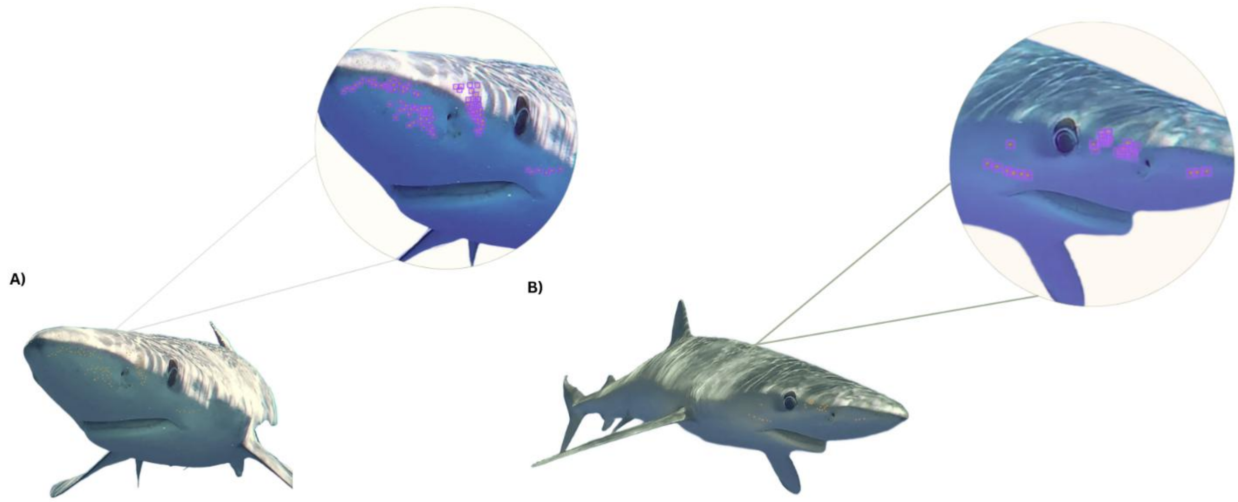


Figure 8 Images of the left-side profile of individual S12 from 2019. with a close-up of the mapped pore pattern; B) the right-side profile of individual S22 from 2020. Left-side profile with a closeup of the mapped pore pattern.

iii) Complementary Traits

Visual identification of blue sharks was significantly enhanced through the analysis of complementary traits, which provided additional insights beyond the morphological features of the dorsal fin, facilitating the identification of 34 different individuals over the period analyzed. These traits could be assessed simultaneously with other metrics during visual analysis, as shown in Figure 9. The case of shark S20 exemplifies how distinctive complementary features can be crucial for individual identification, especially if other identification features are absent (Figure 9C, D).

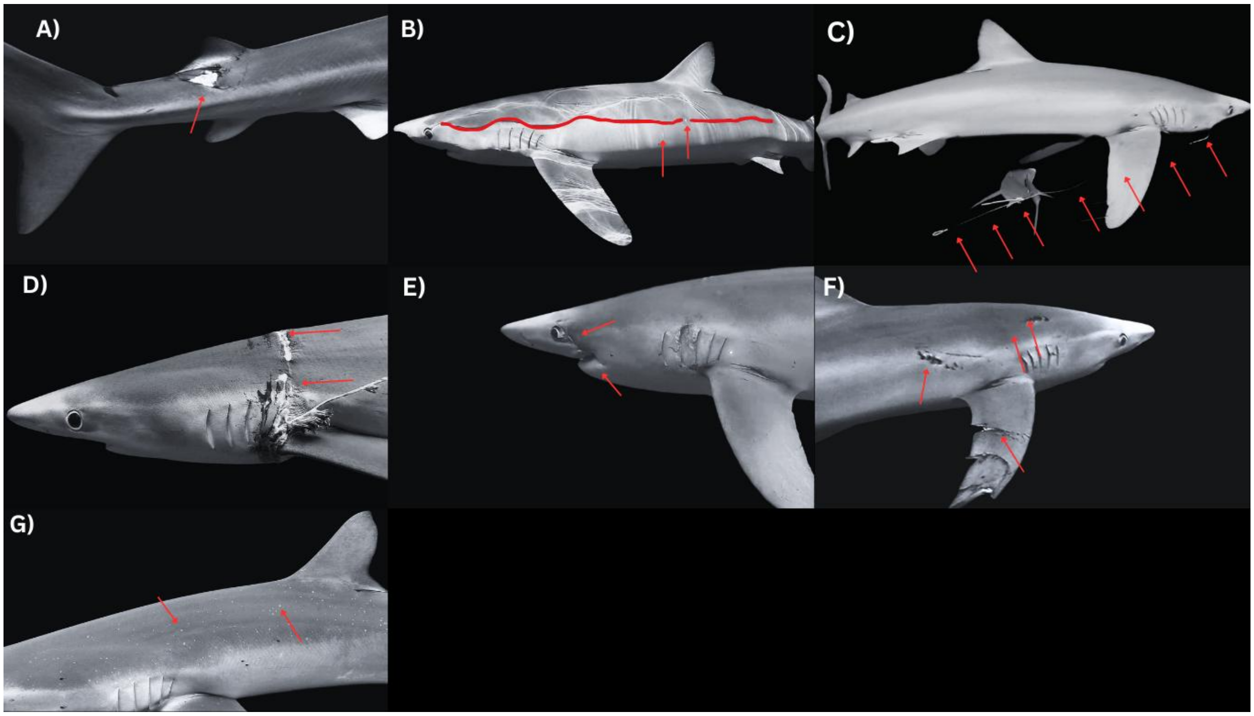


Figure 9 Examples of complementary traits contributing to the third metric: A) Close-up of abrasions on shark S24; B) Tracing of hyperpigmentation pattern along the lateral upper body of shark S06; C) Full-frame image of shark S26 with a hook stuck in its snout; D) Close-up of the left-side profile of shark S20 with remnants of fishing nets and deep abrasions; E) Left-side profile of Scarface, showing deep scars around the eyes and part of the gills; F) Right-side profile of an unidentified shark with deep scars and abrasions along the right lateral area and pectoral fins; H) Close-up of the left-side profile of shark S27, with skin covered in small, birthmark-like spots; Photo credits: A, D, E, F, G by Margaux Le Brun; B by research group.

Resights

Between 2019 and 2021, four of the thirty-four identified sharks were resighted across multiple years, providing valuable insights into site fidelity within the Azores region. These resightings were confirmed through visual comparisons conducted across all years, applying the metrics such as dorsal fin morphology, ampullae of Lorenzini patterns, and complementary traits. Such detailed identification methods are crucial for accurate long-term monitoring of individual sharks.

One notable individual, Scarface, was distinguished by its unique deep scar on its snout and dorsal fin, along with unique pigmentation patterns. Scarface was resighted at Pedra de Sousa in both 2019 and 2020, with identification confirmed by its distinctive scar on the left side of the snout and specific dorsal fin shape (Figure 10). Shark S01 was identified in 2019 and 2020 at Pedra de Sousa, with identification supported by features such as the shape of the right side dorsal fin and an external parasite-like mark on its snout, which facilitated recognition across multiple years (Figure 11). In contrast, Shark S09's identification relied on a unique back margin pattern of its dorsal fin. This individual was observed at Condor Seamount in 2019 and later at Pedra de Sousa in 2020, demonstrating the utility of dorsal fin patterning for long-term identification (Figure 12). Additionally, Shark S14 was resighted in 2019 at Condor Seamount and again in 2021 at Pedra de Sousa Channel. Its recognition was based on a distinctive scar along the edge of its dorsal fin, which remained consistent over time. The sighting of S14 in different locations supports the hypothesis of habitat exploration, while the consistent dorsal fin markings indicate ongoing site fidelity (Figure 13).

Overall, these findings highlight the importance of stable morphological features for individual identification and underscore the complex movement patterns of sharks within the Azores. Between 2019 and 2021, four of the thirty-four identified sharks were resighted across multiple years, providing valuable insights into site fidelity within the Azores region. These resightings were confirmed through comprehensive visual comparisons conducted across all years, utilizing key identification metrics such as dorsal fin morphology, ampullae of Lorenzini patterns, and other complementary traits. Such detailed identification methods are crucial for accurate long-term monitoring of individual sharks.

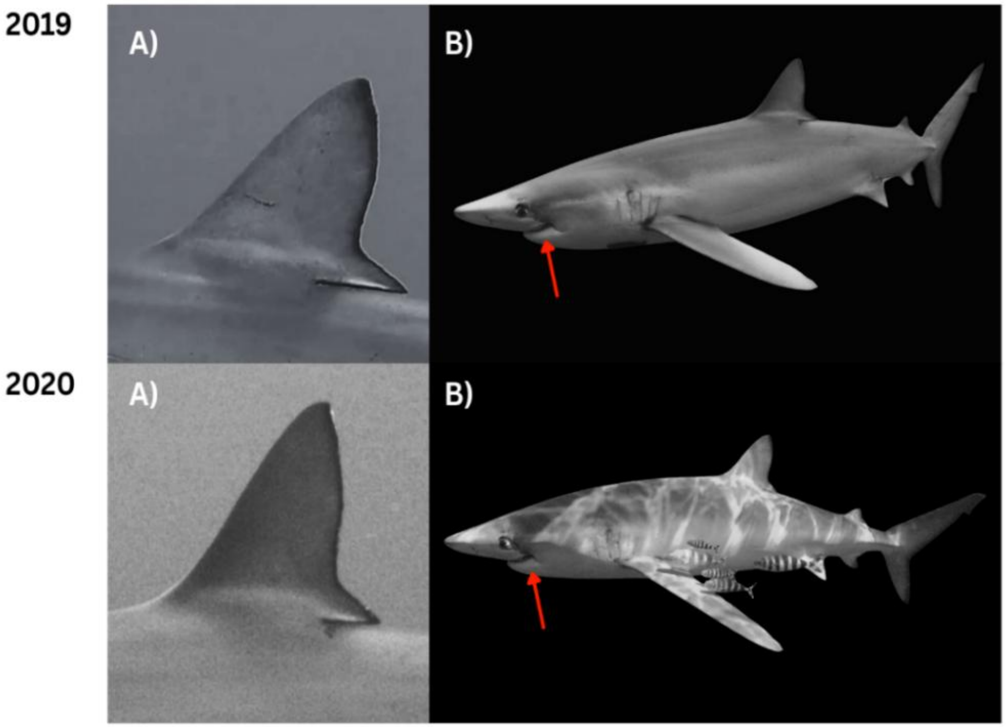


Figure 10 Resightings of Scarface in 2019 and 2021, highlighting key features. In 2019: A) Left dorsal fin; B) Left side of the body, showing a deep scar on the snout (red arrow). In 2020: A) Left dorsal fin; B) Left side, again showing the scar on the snout (red arrow).

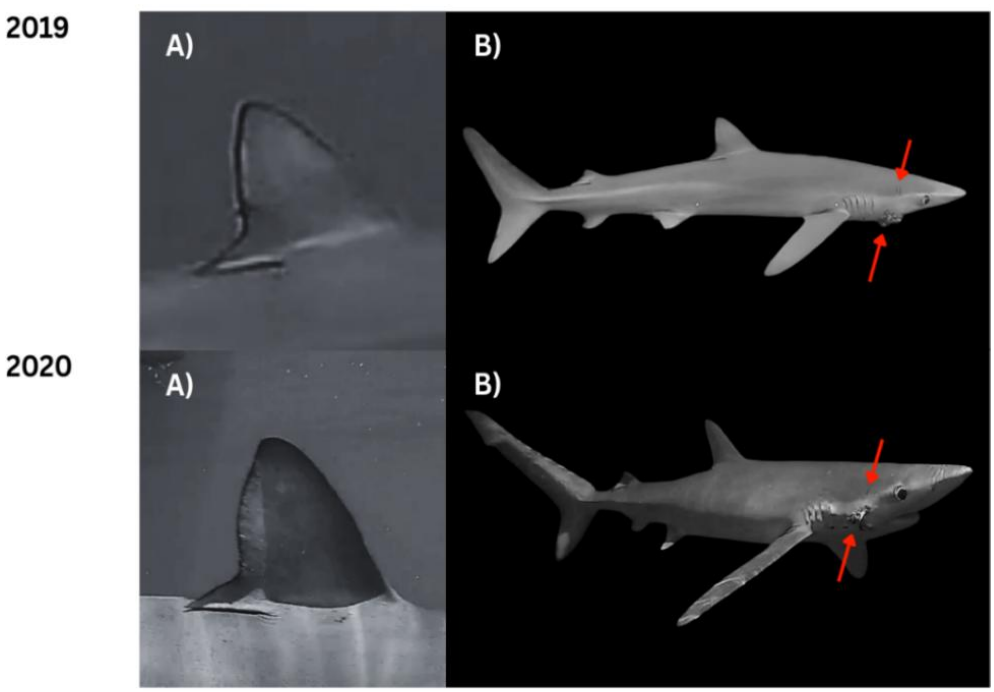


Figure 11 Resighting of Shark S01: A) Dorsal fin (2019); B) Body profile (2019) with complementary traits marked with red arrow; A) Right side dorsal fin (2020); B) Body profile (2020) with complementary traits marked with red arrow.

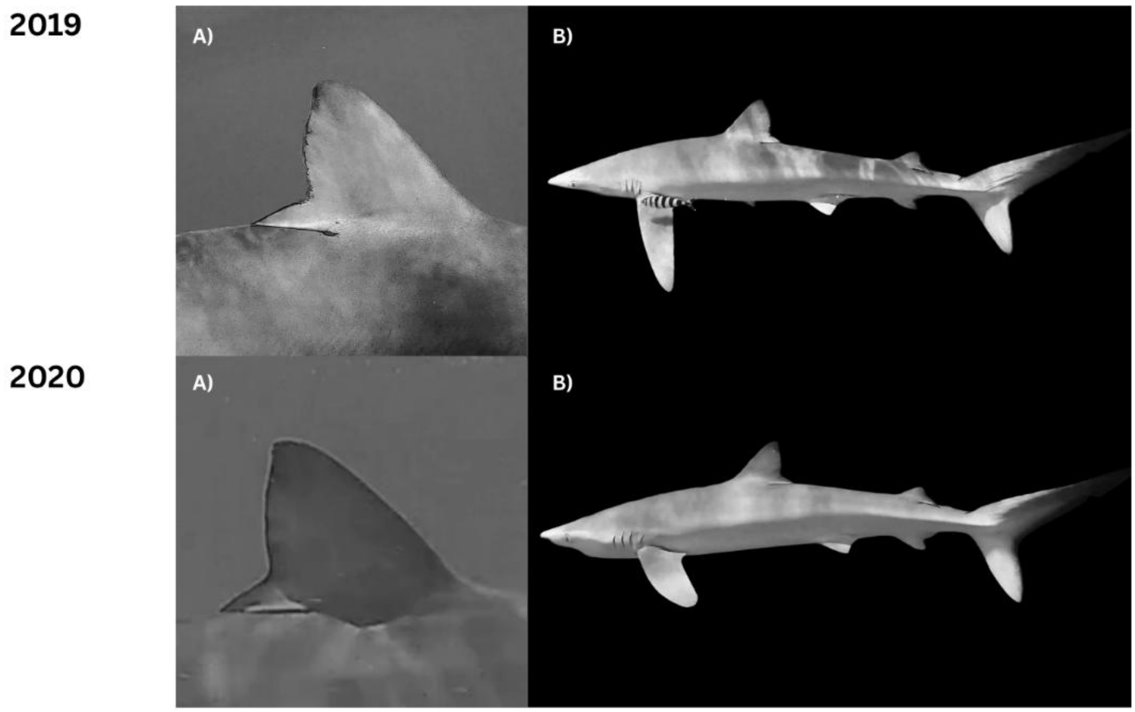


Figure 12 Resighting of shark S09 in 2019 and 2020 following the dorsal fin and complementary metrics. 2019 A) right side of the dorsal fin; 2019 B) left side body profile with complementary features signal with a red arrow; 2020 A) left side of the dorsal fin; 2020 B) right side body profile with complementary features signal with a red arrow.

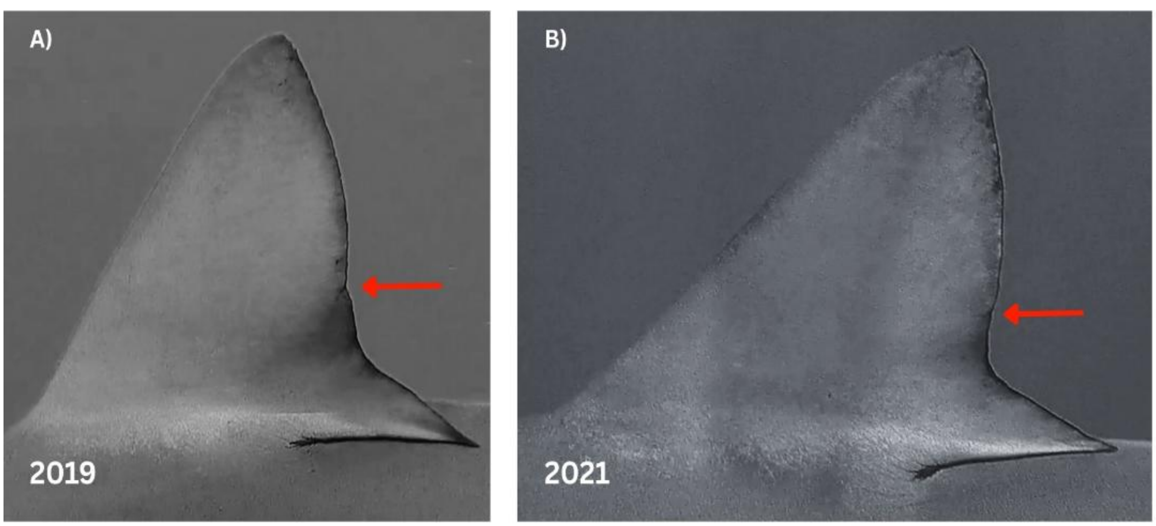


Figure 13 Resighting of shark S14 in 2019 and 2021 following the dorsal fin metric. 2019 A) right side of the dorsal fin in 2019; B) right side of the dorsal fin in 2020. Both pictures signal the fin edge pattern with a red arrow

"Data Collection Best Practices"

To support future efforts for blue shark photo-identification, a set of recommendations includes (i) positioning the camera perpendicular to the shark, (ii) capturing every angle of the snout to carry out the mapping of the pore pattern, and (iii) ensuring clear images with unique features.

To support this study and enable the development of long-term research focused on identifying site fidelity patterns and other life cycle aspects of blue sharks, the following list of best practices has been established. These guidelines are intended for anyone interested in contributing to the project and ensuring the collection of high-quality, usable data:

- The camera should be positioned perpendicular to the animal to ensure optimal framing and clarity.
- When taking videos, avoid recording various sharks at the same time.
- High-quality images, such as 4K and RAW resolution, are preferred for their superior detail and flexibility in post-processing.
- Videos should be set up with a linear angle to maintain consistency and clarity in the footage.
- Images containing one shark per frame are ideal.
- Avoid capturing images with a high density of particles or turbid waters, as these can obscure the subject and reduce image quality.
- For optimal results, it is recommended to focus on capturing images that contain a single shark per frame. When recording videos, it is advisable to avoid filming multiple sharks simultaneously to maintain clarity and focus on individual subjects.

DISCUSSION

The identification of 34 blue shark individuals and four resightings across years using the dorsal fin as the main identification metric demonstrates the effectiveness of the methodology tested in this study. Unlike other shark species, which can often be identified based on unique skin coloration patterns (e.g., Nakachi, 2021; Marshall &

Pierce, 2012; Armstrong et al., 2019; Brooks et al., 2010), blue sharks lack distinctive markings that would facilitate their identification through traditional methods. Given these challenges, the study selected a combination of dorsal fin, ampullae of Lorenzini, and complementary traits for visual identification. This approach is the first attempt focused on blue sharks' photo-identification. The methodology proved advantageous due to the successful identification of individuals by combining the dorsal fin with complementary traits. However, it also exposed limitations in mapping pore patterns when relying solely on opportunistic data. This finding aligns with previous research by Marshall and Pierce (2012), which highlighted the advantages and limitations of using opportunistic data for identification studies. To address these limitations, reinforcing standardized methodologies is essential for improving photo-identification initiatives. By pioneering a photo-identification method for blue sharks—an area that is poorly explored due to the species' lack of unique skin patterns—this research establishes a foundation for future studies underscoring the potential for low-cost methodologies and citizen science to enhance our understanding and conservation efforts for this important species. By showcasing the effectiveness of this approach, the study paves the way for broader applications in marine research and emphasizes the importance of public engagement in scientific initiatives. The recommendations outlined in the "Data Collection Best Practices" are designed to support the collection of high-quality data, helping to address key knowledge gaps about this species.

The summer months in the Azores are an active period due to the suitable oceanographic characteristics, creating the optimal conditions for food availability for different megafauna species, including the blue shark (Vandeperre et al., 2014; Afonso et al., 2020). This allows the presence of different species of sharks, rays, cetaceans, and other pelagic fish that routinely cross the archipelago (Afonso et al., 2020). These characteristics and the high abundance of blue sharks in the area make the Azores an ideal location for developing a photo-identification methodology for this species.

The resighting of Scarface, S01, S09, and S14 served as a baseline for comparing different sharks' morphological metrics and validating them. This recurrent individual resighting, as well as another 3 individuals identified during the study, provides further evidence of the described blue shark seasonal migration in the archipelago (Vandeperre et al., 2014; Fontes et al., 2024). Such areas may serve as key areas to develop their ecological functions, be migration corridors, or cleaning stations. This highlights the need for further research focused on identifying and understanding the life cycle, migration patterns, and habitat use of blue sharks in areas such as the Azores.

The methodology applied has shown a strong reliability for visual photo-identification. However, previous research has shown the ability for some species of elasmobranchs to recover and regenerate their tissue following traumatic injuries, which could imply that scars or injuries used to identify an individual may not be reliable in the following years. This has been previously demonstrated by Black (2023), showcasing the successful dorsal fin tissue regeneration in a male silky shark (*Carcharhinus falciformis*), wound healing in a large whale shark (*Rhincodon typus*), or neonatal blacktip reef sharks (*Carcharhinus melanopterus*) (Womersley et al., 2021; Chin et al., 2015 as cited in Black, 2023). Therefore, the previous validation of "Scarface's" dorsal fin shape morphology suggested that the ability of skin regeneration decreases in larger individuals, with age behaving as a fundamental factor. Nevertheless, further research should be done for long-term monitoring of sharks with unique scar features and further explore the implications in the case of the blue shark species.

The case of "Scarface" suggests that the ease of identifying individual sharks may depend on the size, location, and visibility of injuries, as well as the age of the individual. While prominent marks can aid long-term identification, smaller or less distinct features may not be reliable across multiple seasons. Out of the sharks identified, 30 were males, predominantly juveniles or adults. Additionally, four sharks lacked sex data, and no females were observed during the study period. These results agreed with studies that described a sexual segregation in the area, with males present during summer months (Vandeperre et al., 2014). Furthermore, females or pregnant females only appear later in the year, which could be a sign of nurseries in the archipelago (Vandeperre et al., 2014). The proposed methodology could be extended to other seasons to include females and assess whether site fidelity or specific habitat use during migrations for oceanic-pelagic species of blue sharks is also observed in blue shark females.

Although the developed methodology resulted in the identification of 34 individuals, the lack of consistent and high-quality data probably decreases the number of potential identifications. Among the metrics used in the identification process, the dorsal fin was the most successful and easily applicable, followed by complementary traits, and leaving the ampullae of Lorenzini as the least successful metric tested. The dorsal fin proved to be an effective and consistent tool for identification. This species lacks any unique skin markings; the dorsal fin was reliable and maintained shape and morphology at least in the medium term (5 years).

Regarding the ampullae of Lorenzini, the pore pattern was not visible enough in most of the frames, making hand-mapping difficult. Additionally, this method proved to be highly time-consuming, with low-quality results. To accurately define the pore pattern for one individual, images from both sides of the snout were required, but these were often lacking in most of the identified sharks due to the opportunistic source of data. Studies based on mapping the pore pattern of the ampullae of the Lorenzini of different shark species involved a very low number of individuals (n= <10, as noted by Haueisen & Reis, 2024), which was not the case of this study, where large datasets were analyzed. However, with advancements in Artificial Intelligence software, this process could soon be automated, significantly improving the efficiency and accuracy of identification and enhancing the overall quality of results.

All the data analyzed in this study were opportunistically obtained through collaboration with tourism operators, divers, and local researchers. Given the abundance of media, each metric was thoroughly evaluated. Obtaining such a long-term dataset was only possible through cross-collaboration efforts and data-sharing with different sectors (science community, tourism industry, citizen-science). Shark-diving activities on the rise (Bentz et al., 2014; Gonzáles-Matilla et al., 2022; Ressurreição et al., 2022) presented a valuable opportunity for collaboration. It proved to be an accessible and low-cost tool for developing and applying the identification methodology on the blue shark. The high number of diving expeditions made this a data-rich source, giving the opportunity to develop a long-term study. It also allowed the observation of other megafauna species and animal-human dynamics during expeditions, as well as the estimation of blue shark abundance. For instance, the dorsal fin metric was achieved thanks to the blue shark expeditions, which were often offshore without any cost for researchers, in contrast to the huge budget that would be needed if researchers had to fund these trips independently. By sharing resources, such as boats, with other research groups heading to the same study sites and collaborating with tourism operators on the island of Faial, this research was achievable while also reducing costs and efforts. This study emphasized cross-collaboration and low-cost methods for identifying blue sharks. Overall, the opportunistic data collected served as an excellent resource for blue shark identification, significantly enhancing the limited knowledge currently existing in this area. While opportunistically collected data is abundant, it presents several limitations. Its unstructured nature and high uncertainty—stemming from the absence of standardized methodologies, observer training, and variable data quality—make analysis challenging. Highly trained observers and clearly defined data collection standards are rarely available, and analyzing such data requires significant time and effort to organize and categorize. To illustrate these challenges, a methodology comparison was conducted between this study and an unpublished shark guide developed for citizen science engagement. Although both methodologies emphasize visual identification, the shark guide lacks structure in metric selection, complicating the analysis. Key limitations observed during data processing included: (1) high abundance of shark individuals in the same video, making it difficult to isolate and track individuals across frames; (2) absence of structure and standardized video-photo guidelines, such as attention to lighting and camera angle, which affected image quality and metric visibility—resulting in the exclusion of many videos and (3) insufficient images showing the parts and sides which hindered accurate identification and increased the time and effort required for analysis. These challenges highlight the need for a simpler, more structured methodology, particularly when working with large datasets. Following the guidelines outlined in the "Data Collection Best Practices" section of this study will improve data quality and reduce the limitations associated with opportunistic data collection. These best practices should be shared with the community, ensuring that the following recommendations are followed: (i) position the camera perpendicular to the animal; (ii) capture every angle of the snout; and (iii) ensure clear footage of each fin and unique features. Following these practices can significantly enhance the quality of analysis.

Visual media (including videos and photographs) is generally agreed to be the best method for recording animals over time and identifying some species of elasmobranchs (Marshall & Pierce, 2012). It is recommended to implement filtering and select useful frames. Establishing best practices can enhance the filtering process, allowing researchers to obtain valuable data that contributes to their research objectives, ultimately saving time and effort during analysis. Environmental conditions can impact visibility and, therefore, data quality. Knowing the ocean conditions beforehand can help assess how much post-image correction needs to be done before the analysis. This study emphasizes the positive effects of cross-collaboration, suggesting that establishing best practices is essential when working with different groups, including regular engagement with citizen science. In the Azores, the activities involving blue sharks are on the rise, supported by a vibrant community of underwater enthusiasts and professional photographers. Their involvement could significantly enhance the research efforts. The scientific community can play a crucial role in assessing what practices have been effective and identifying areas for improvement. Making this information available to the research and citizen science community can promote data exchange, encourage cross-sector collaboration, and help avoid redundant efforts that waste time and resources.

This study has highlighted the significance of cross-collaboration and the advantages of using opportunistic data. By analyzing a comprehensive dataset, the pros and cons of this data type were evaluated, and a standardized methodology was developed. Although this methodology is based on visual and manual sorting of data, there is considerable potential for future research to incorporate artificial intelligence technologies for identifying blue sharks, as these technologies are improving exponentially and are becoming increasingly accessible. The development of this methodology allowed exploring, testing, and addressing the primary objectives of this study: to test whether it is feasible to create a standardized identification methodology using opportunistic data and whether the same blue shark individuals return to the Azores annually. Additionally, the study emphasizes the need to advance visual identification methodologies and foster research that collaborates closely with local researchers and communities. Overall, this work provides a simplified, cost-effective, and complementary method to other techniques, such as mark-recapture studies, that can be applied to this species. This study serves as a foundation for future research on machine learning and other techniques that could enhance the identification of blue shark species in the Azores archipelago and beyond, addressing questions related to site fidelity, the impacts of the growing shark tourism, animal movement, along with population site structure and abundance.

CONCLUSIONS

- The study demonstrates the feasibility of identifying individual blue sharks (*Prionace glauca*) using a photo-ID visual identification approach, supported by a standardized methodology and the dorsal fin as the main identification trait.
- Metrics employed in the research successfully identified 34 sharks and enabled the resighting of 4 individuals over a period spanning from 2019-2021 and 2024, indicating the potential for long-term monitoring.
- While the dorsal and complementary traits metrics were effective for visual identification, the ampullae of Lorenzini metric presented challenges when applied. to opportunistic data, highlighting areas for methodological improvement.
- Future research opportunities include studying the ampullae of Lorenzini on live sharks, which could enhance identification techniques.
- The methodology developed provides a baseline for extending identification efforts beyond the Azores archipelago, encouraging broader geographic application.
- The “Data Collection Best Practices” outlined serve as practical recommendations for the scientific community, tourism operators, and citizen-science, promoting standardized data collection practices to improve accuracy and consistency in blue shark identification.
- This structured approach supports long-term monitoring efforts, contributing valuable data for conservation and management strategies for blue sharks.

Table 1

Metadata For Image and Video Categorization and Analysis

Video ID	Video ID: linear_YYYY_No. Code	Used for analysis	Year	Month	Site	Video Type	Resolution	Format	Codec	Remarks
GOPR7053.MP4	linear_2020_7053.mp4	O	2020	6	CANAL	Stereometry Left Cam	1920x1080	MP4	libx264	08/06/2020;4F
GOPR7054.MP4	linear_2020_7054.mp4	X	2020	6	CANAL	Stereometry Left Cam	1920x1080	MP4	libx264	08/06/2020;4F
GP017053.MP4	linear_2020_17053.mp4	O	2020	6	CANAL	Stereometry Left Cam	1920x1080	MP4	libx264	08/06/2020;4F
GOPR7610.MP4	linear_2020_7610.mp4	O	2020	6	CANAL	Stereometry Right Cam	1920x1080	MP4	libx264	08/06/2020;3P
GOPR7611.MP4	linear_2020_7611.mp4	X	2020	6	CANAL	Stereometry Right Cam	1920x1080	MP4	libx264	08/06/2020;3P
GP017610.MP4	linear_2020_17610.mp4	O	2020	6	CANAL	Stereometry Right Cam	1920x1080	MP4	libx264	08/06/2020;3P
GOPR7031.MP4	linear_2020_7031.mp4	O	2020	7	CANAL	Stereometry Left Cam	1920x1080	MP4	libx264	16/07/2020;4F
GOPR7032.MP4	linear_2020_7032.mp4	O	2020	7	CANAL	Stereometry Left Cam	1920x1080	MP4	libx264	16/07/2020;4F; resighted 2019
GOPR7033.MP4	linear_2020_7033.mp4	X	2020	7	CANAL	Stereometry Left Cam	1920x1080	MP4	libx264	16/07/2020;4F
GOPR7034.MP4	linear_2020_7034.mp4	X	2020	7	CANAL	Stereometry Left Cam	1920x1080	MP4	libx264	16/07/2020;4F
GOPR7588.MP4	linear_2020_7588.mp4	O	2020	7	CANAL	Stereometry Right Cam	1920x1080	MP4	libx264	16/07/2020;3P
GOPR7589.MP4	linear_2020_7589.mp4	X	2020	7	CANAL	Stereometry Right Cam	1920x1080	MP4	libx264	16/07/2020;3P

Note. Only a fragment of the table is displayed for reference purposes. Metadata is available upon request. X= not selected for the analysis; O= selected for the analysis.

Table 2

Detailed Characteristics and Information of All 34 Identified Blue Shark Individuals

Frame_Code	Shark_ID	Year	Site	Sex	Size (TL) cm			Metric 1: Dorsal	Fin side	Metric 2: Ampullae	Metric 3: Complementary				
					Mean	Min	Max				Hyperpgmentation	Abrasions	Hooks	Scars / Mating Marks	Dots
linear_2019_0127	S01	2019	CANAL	M	106,7	39	255	NA	RIGHT	NA	NA	YES	NA	NA	
linear_2019_0147_919	S02	2019	CANAL	NA	109,9	49	212	YES	RIGHT	NA	YES	NA	NA	NA	NA
linear_2019_0154_553	S03	2019	CANAL	M	NA	NA	NA	YES	LEFT	NA	NA	YES	NA	NA	NA
linear_2019_0258	S04	2019	CANAL	M	115,5	49	212	YES	LEFT	NA	YES	NA	NA	NA	NA
linear_2019_0258	S05	2019	CANAL	M	110,6	29	250	YES	BOTH	MA	NA	YES	NA	NA	NA
linear_2019_0259	S06	2019	CANAL	M	104,6	13	255	YES	BOTH	NA	NA				NA
linear_2019_0252	S07	2019	CONDOR	M	NA	NA	NA	YES	LEFT	NA	NA	NA	NA	NA	NA
linear_2019_0270	S08	2019	CONDOR	NA	NA	NA	NA	YES	BOTH	NA	NA	NA	NA	NA	NA
linear_2019_0370	S09	2019	CONDOR	M	NA	NA	NA	YES	BOTH	NA	NA	NA	NA	NA	NA
linear_2019_0253	S10	2019	CONDOR	M	110,8	22	249	YES	BOTH	NA	NA	NA	NA	NA	NA

linear_2019_4118	S11	2019	CONDOR	M	NA	NA	NA	YES	BOTH	NA	NA	NA	NA	NA	NA
linear_2019_14119	S12	2019	CONDOR	M	108,2	18	248	YES	BOTH	NA	NA	YES	NA	NA	NA
linear_2019_4119	S13	2019	CONDOR	M	NA	NA	NA	YES	RIGHT	NA	NA	YES	NA	NA	NA
linear_2019_4139	S14	2019	CONDOR	M	NA	NA	NA	YES	BOTH	NA	YES	NA	NA	NA	NA
linear_2020_7053	S15	2020	CANAL	M	NA	NA	NA	YES	BOTH	NA	NA	YES	NA	YES	NA
linear_2020_7043	S16	2020	CANAL	M	NA	NA	NA	YES	LEFT	NA	NA	YES	NA	NA	NA
linear_2020_7051	S17	2020	CANAL	M	NA	NA	NA	YES	BOTH	NA	NA	YES	NA	NA	NA
linear_2020_7672	S18	2020	CANAL	M	NA	NA	NA	YES	BOTH	NA	NA	YES	NA	YES	NA
linear_2020_7672	S19	2020	CANAL	M	107	43	236	YES	BOTH	NA	NA	YES	NA	NA	NA
linear_2020_7541	S20	2020	CANAL	M	NA	NA	NA	YES	LEFT	NA	NA	YES	NA	YES	NA
linear_2020_7087	S21	2020	CANAL	M	NA	NA	NA	YES	BOTH	NA	NA	YES	NA	NA	NA
linear_2020_7562	S22	2020	CANAL	M	NA	NA	NA	YES	BOTH	YES	NA	YES	NA	NA	NA
linear_2021_7943	S23	2021	CANAL	M	NA	NA	NA	YES	BOTH	NA	NA	NA	NA	NA	NA
linear_2021_7955	S24	2021	CANAL	M	NA	NA	NA	YES	LEFT	NA	NA	YES	NA	NA	NA
linear_2021_7981	S25	2021	CANAL	M	NA	NA	NA	YES	BOTH	NA	NA	YES	NA	NA	NA
linear_2021_8058	S26	2021	CANAL	M	NA	NA	NA	YES	BOTH	NA	NA	YES	YES	YES	NA

linear_2021_8070	S27	2021	CANAL	M	NA	NA	NA	YES	BOTH	NA	NA	NA	NA	NA	YES
DSC00468	S28	2021	CANAL	M	NA	NA	NA	YES	BOTH	NA	NA	YES	NA	NA	NA
2024C3	29	2024	CONDOR	M	152,5	62	250	YES	BOTH	NA	NA	YES (CAUDAL)	NA	NA	YES (CAUDAL)
2024C11	30	2024	CONDOR	M	148,7	85	2,435	YES	BOTH	NA	YES	NA	NA	NA	YES (EYE)
2024C24	31	2024	CONDOR	M	149,5	76	250	YES	BOTH	NA	YES	YES	YES	NA	NA
2024P1	32	2024	CANAL	NA	NA	NA	NA	YES	BOTH	NA	NA	YES	NA	NA	YES
2024P7	33	2024	CANAL	M	NA	NA	NA	YES	BOTH	NA	NA	YES	NA	YES	YES
2024P30	34	2024	CANAL	NA	NA	NA	NA	YES	BOTH	NA	NA	YES	NA	NA	NA

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