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DAILY OCCURRENCE OF WHALE SHARKS (*Rhincodon typus*) AND MIGRATION OF NEW INDIVIDUALS IN THE WATERS OF KWATISORE

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ABSTRACT

The waters of Kwatisore are recognized as a consistent aggregation site for whale sharks (Rhincodon typus) throughout the year, with an increasing number of individuals observed. Understanding individual occurrence patterns is essential for monitoring population dynamics and conservation planning. This study aimed to analyze the daily occurrence of whale sharks based on individual identification and assess the entry of new individuals into the Kwatisore waters. Data collection was conducted from November 2023 to January 2024. A total of 27 male individuals were recorded, with a cumulative 592 sightings. Body lengths ranged from 2.5 to 5 meters, dominated by individuals approximately 3.5 meters in length. Spatial distribution of daily occurrences followed the positioning of anchored lift-net fishing gear (bagan), while temporal distribution showed a higher occurrence during morning hours. In 2023, 13 new individuals were recorded entering the area. The daily appearances were dominated by juvenile-sized individuals, and sighting frequency varied among individuals. Spatial and temporal patterns were strongly influenced by anchovy (Stolephorus spp.) catches from the bagan gear, while the entry of new individuals contributed to the growing aggregation of whale sharks in the Kwatisore waters.

Keywords: *whale sharks, daily occurrence, new individual migration*

INTRODUCTION

The whale shark (*Rhincodon typus*) is a species of fish that generally lives solitarily, but their appearances can form aggregations, making them an attractive subject for ecotourism and generating significant income (Toha *et al*. 2018; Maruanaya 2022). Whale shark aggregations are limited to a few regions worldwide, and countries with these aggregations have developed them into ecotourism attractions, including Australia, the Philippines, Seychelles, Maldives, Belize, and Mexico (Sadili *et al*. 2015). Whale sharks have a pelagic habitat, spending more time on the surface or in the water column (Toha *et al*. 2018). They spend time at various depths but predominantly at a depth of 10 meters over 24 hours. Comparing aggregation and non-aggregation sites, aggregation sites are generally shallower and have steeper slopes (Copping *et al*. 2018).

One factor that attracts whale shark groups to certain waters is the concentration of pelagic fish (Stewart 2014). Whale sharks are often seen near boat life net areas, where zooplankton and small fish, their food sources, are abundant. They tend to dive deep and surface when feeding (Suprapti 2015). Whale sharks generally spend time in shallow waters less than 50 m or near the surface because whale sharks is a plankton-feeding shark and is a filter feeder animal (Ranintyari *et al.* 2018).

Whale shark appearances in Indonesian waters are limited to certain months with very few individuals. In general, the appearance of whale sharks in Indonesian waters occurs at

certain times. According to Bajo fishermen, whale sharks appear in Bajo waters only in the eastern season (August) to the beginning of the western season (November or December), while whale sharks appear regularly every year only in the waters of Cenderawasih Bay (Papua), Talisayan (East Kalimantan), Probolinggo (East Java), and Botubarani (Gorontalo) (Rombe *et al*. 2022). The appearance of whale sharks in Indonesian waters occurs in certain months, such as in Anambas waters in July, South Coast, West Sumatera in April, Pangandaran in September, Kendal in February, Jepara in December, Surabaya in October, Banggai in May, Probolinggo in January, Botubarani in June, and Labuhan Jambu, Teluk Saleh appeared throughout the year with 42 individuals (Djunaidi *et al*. 2020). The occurrence of whale sharks in the waters of Botubarani Gorontalo during March to June 2021 was 47 individuals and only 20 individuals were identified (Rombe *et al*. 2022). Whale shark exploitation is still occurring in Indonesia, as in Bali and East Lombok in August 2005 (White and Cavanagh 2007).

Cenderawasih Bay is a strategic and important location for whale sharks (Toha *et al*. 2019). Kwatisore waters as part of Cenderawasih Bay is the only location where whale sharks occur regularly throughout the year (Toha *et al*. 2018; Djunaidi *et al*. 2020; Maruanaya *et al*. 2021; Maruanaya and Pattinaja 2023). The permanent appearance of whale sharks is an important potential that needs to be managed in an integrated manner by relevant parties so as not to interfere with the survival of whale sharks. Culturally, indigenous people in Kwatisore/Akudiomi Village believe that whale sharks are considered hiniotaniv're (local language), which means king of the sea or guardian troops (Maruanaya 2022). Indigenous people's belief in whale sharks is a force to maintain the survival of whale sharks as a form of conservative protection (Maruanaya 2022; Maruanaya and Pattinaja 2023). Studies on whale sharks in Kwatisore waters have not yet contributed to regional governance, both the ideal number of boat life net and the economic improvement of the indigenous people of Akudiomi/Kwatiore Village who have customary marine rights to the occurrence of whale sharks (Maruanaya 2022).

Studying the occurrence of whale sharks and the migration of new individuals into Kwatisore waters every year is important information for the Nabire Regency Government so that it can determine strategic steps in management, especially whale shark ecotourism based on indigenous peoples so as to provide added economic value for indigenous peoples and income for the Nabire Regency Government. The development of whale shark ecotourism based on indigenous peoples, indigenous peoples play an active role in protecting the location of whale shark emergence. Recording the influx of new whale shark individuals that increase every time in Kwatisore waters becomes a database of how many individuals migrate, settle or surface. Whale shark in-migration provides an indication that Kwatisore waters are a major feeding ground and habitat throughout the year (Tania and Noor 2014; Enita *et al*. 2017; Maruanaya 2022). The year-round presence and occurrence of whale sharks in Kwatisore waters and their daily aggregations involving many individuals are unique characteristics and opportunities for ecotourism development (Zuzy and Saputra 2017; Ranintyari *et al*. 2018; Saroy and Saiful 2018; Maruanaya 2022; Maruanaya and Pattinaja 2023; Maruanaya and Sumaryono 2023). This study aims to examine the daily occurrence of whale sharks and record the migration of new individuals, providing data on the daily appearance of each individual and the total number of individuals in Kwatisore waters.

METHODS

The study to observe the daily occurrence of whale sharks in the waters of Kwatisore was conducted from November 6, 2023, to January 28, 2024. The data on the influx of new individuals were collected by the National Park Management Division, Region I Nabire, throughout 2023. The research location was focused solely on the waters of Kwatisore. Kwatisore waters are located entirely in the southern part of Cenderawasih Bay. Based on government administration, Kwatisore waters are within the Yaur District, Nabire Regency, Central Papua Province, due to the higher concentration of daily whale shark appearances around the boat life net deployed in these waters (Figure 1).

Data on the daily occurrence of whale sharks were collected using a census method on each boat life net unit deployed in the waters of Kwatisore. Each daily appearance of whale sharks was recorded through photo identification (photo ID) of individual sharks using an underwater camera to identify their ID numbers. The number of individuals, estimated length, and time of appearance (morning, after-

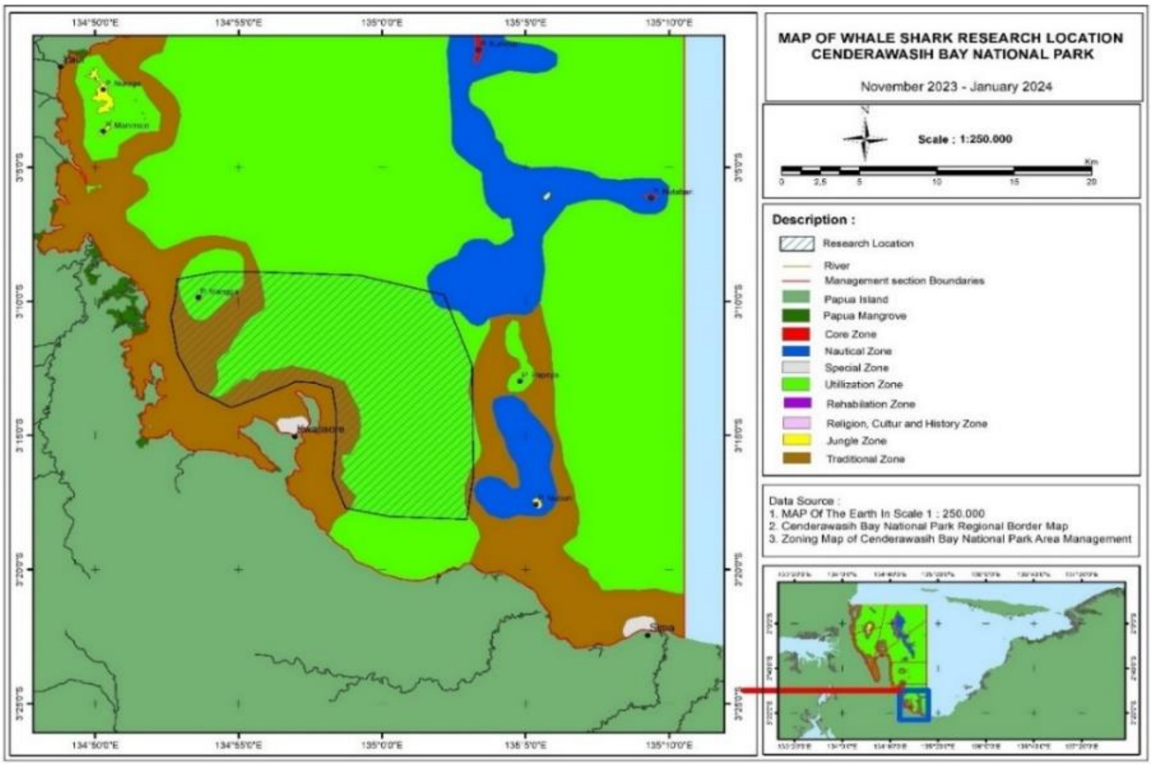


Figure 1 Research Location for the Daily Occurrence of Whale Sharks

noon, evening) were also documented. The photo ID technique for whale sharks involved photographing the left side from the last gill (fifth gill) to the tip of the pectoral fin, and similarly, the right side from the last gill to the tip of the pectoral fin. The sex of each whale shark was determined through visual observation of their anatomical structures: male whale sharks have two elongated claspers near the anal fin, while female whale sharks do not have claspers.

The daily occurrence of whale sharks followed the positions of the boat life net, and their locations were determined using GPS. This helped to establish the spatial and temporal distribution of each individual whale shark. The body length of the whale sharks was estimated by swimming parallel to them and comparing the swimmer's length to the length of the whale shark (Tania and Noor 2014; Himawan *et al*. 2015; Jentewo *et al*. 2021; Maruanaya 2022; Maruanaya and Sumaryono 2023).

Identification of each individual whale shark was based on field photo IDs and analyzed using the "Interactive Individual Identification System Version 2.0" (I3Sv2) software. The I3Sv2 identification technique involved marking at least 16 white spots within a yellow box (Figure 2). The I3Sv2 software then read the individual and cross-referenced it with the existing database. If the database did not show a corresponding individual number, the individual was considered a new individual.

The distribution of the identified whale shark lengths was calculated using the equation according to Tania and Noor (2014); Sadili *et al*. (2015); and Maruanaya (2022), which is:

$$\%\,\mathrm{N} = \frac{\mathrm{ni}}{\mathrm{N}}\ x\ 100 \quad (1)$$

With:

- %N is the percentage of whale sharks with a length of i meters,
- ni is the number of whale sharks with a length of i meters,
- N is the total number of identified whale sharks.

To assess the percentage of male and female whale sharks, the following formulas were used according to Tania and Noor (2014); Sadili *et al*. (2015); and Maruanaya (2022):

$$\%\,\mathrm{J} = \frac{\mathrm{nj}}{\mathrm{N}}\ x\ 100 \quad (2)$$

$$\%\,\mathrm{B} = \frac{\mathrm{nb}}{\mathrm{N}}\ x\ 100 \quad (3)$$

With:

- %J is the percentage of male whale sharks,
- nj is the number of male whale sharks,
- %B is the percentage of female whale sharks,

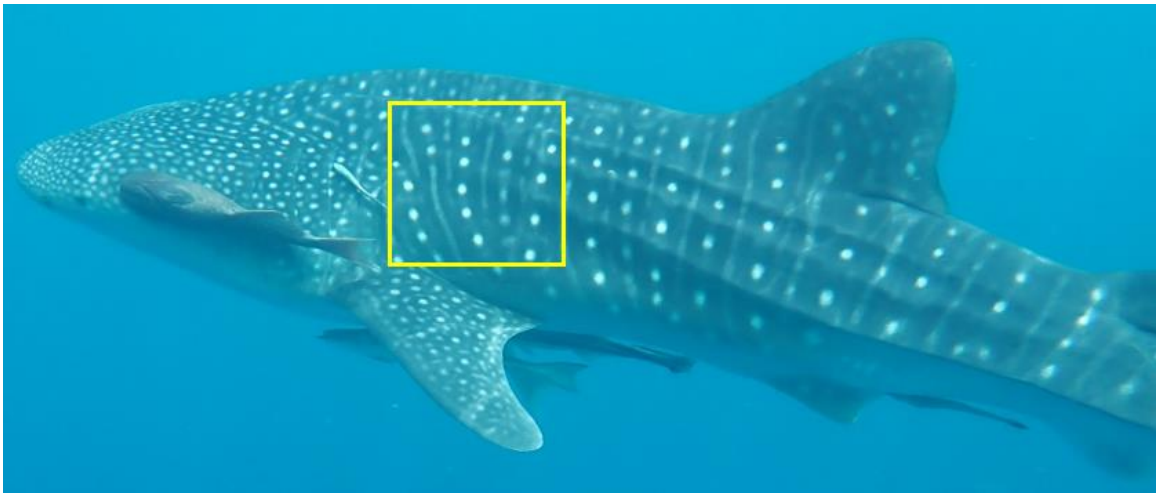


Figure 2 Identification Technique using I3Sv2

- nb is the number of female whale sharks
- N is the total number of identified whale sharks.

RESULTS

Daily Occurrence of Whale Sharks

From November 2023 to January 2024, the daily occurrence of whale sharks in Kwatisore revealed a total of 27 individuals, each with varying frequencies of appearance. These sightings were concentrated around 13 units of boat life net deployed in the Kwatisore waters (Figure 3).

The daily occurrence of whale sharks is closely related to the anchovy catch by each lift net unit. The boat life net plays a crucial role in the daily appearance of whale sharks, as the quantity of anchovy catches influences the timing and frequency of whale shark appearances, with the sharks relying on the lift nets for their daily feeding needs. The appearance of whale sharks is related to the availability of anchovy (*Stolephorus* sp.) in the area, making Kwatisore waters an important feeding area and habitat throughout the year (Enita *et al*. 2017; Maruanaya 2022).

In general, the daily occurrences of whale sharks show fluctuations in both the number of individuals and the total occurrences over November and December 2023, and January 2024. The daily occurrences varied from one to four individuals per lift net unit, indicating a tendency towards aggregation. The presence of multiple individuals at the same time is a characteristic of aggregation (Ranintyari *et al*. 2018).

An analysis based on the number of individual whale sharks during November 2023, December 2023, and January 2024 shows that 27 individuals remained in the waters of Kwatisore. These 27 individuals include the following ID numbers: ID 13; ID 40; ID 43; ID 69; ID 78; ID 112; ID 127; ID 138; ID 140; ID 148; ID 151; ID 160; ID 176; ID 179; ID 180; ID 181; ID 183; ID 186; ID 188; ID 189; ID 190; ID 191 (new individual); ID 192 (new individual); ID 193 (new individual); ID 194 (new individual); ID 195 (new individual); and ID 196 (new individual). Each individual whale shark displayed different patterns of daily occurrence. The ID numbers of each individual are shown in Figure 4.

The daily occurrences of each individual whale shark and their total occurrences in November 2023, December 2023, and January 2024 (Figure 5) show differences among individuals. Some whale sharks that appeared in November 2023 did not appear in December 2023 or January 2024, or vice versa, indicating that these individuals remained in the Kwatisore waters or the Cenderawasih Bay area without migrating out, continuing to appear in Kwatisore over the three months. Notably, five individuals identified several years ago (ID 13, ID 40, ID 43, ID 69, and ID 78) had not been seen in Kwatisore for some time and were presumed to have migrated out of the area, yet they eventually returned to Kwatisore.

Distribution of Whale Shark Lengths and Sex Percentage

Knowing the lengths of whale sharks can serve as an indicator of their purpose for being present or the duration of their stay in Kwatisore waters (Maruanaya 2022). The distribution of whale shark lengths from November 2023 to January 2024 ranged from 2.5 m to 5 m, with the majority being 3.5 m in

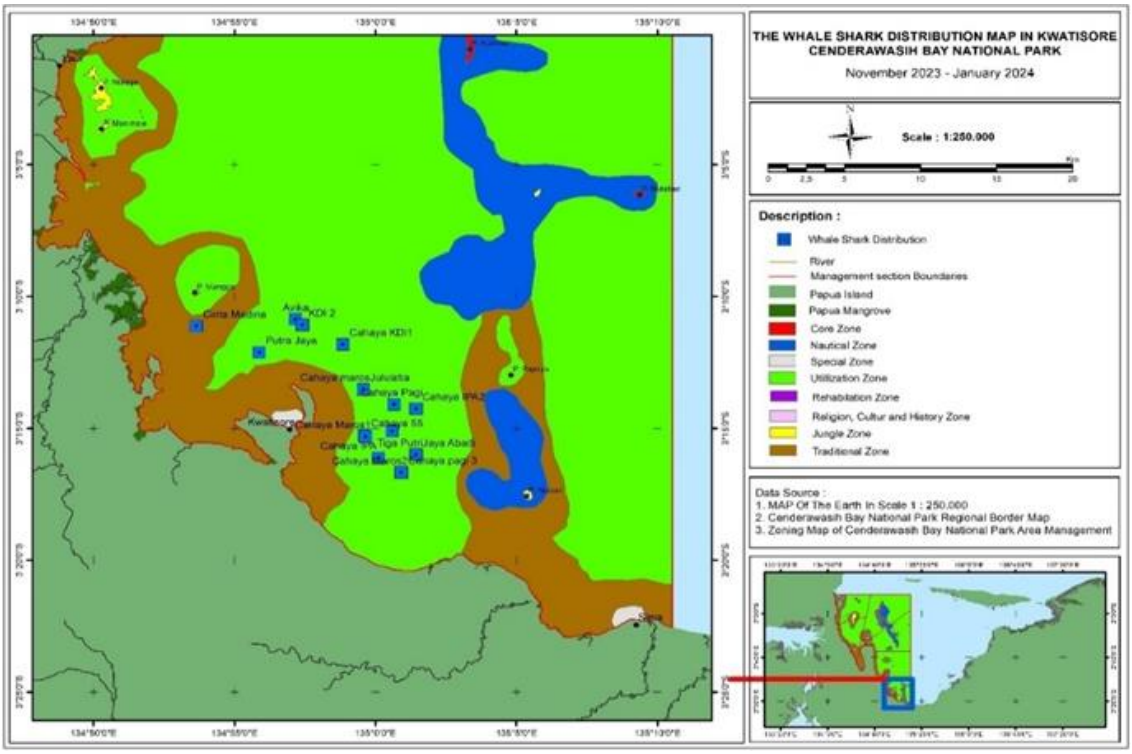


Figure 3 Concentration of daily whale shark occurrences around Boat life net in Kwatisore Waters

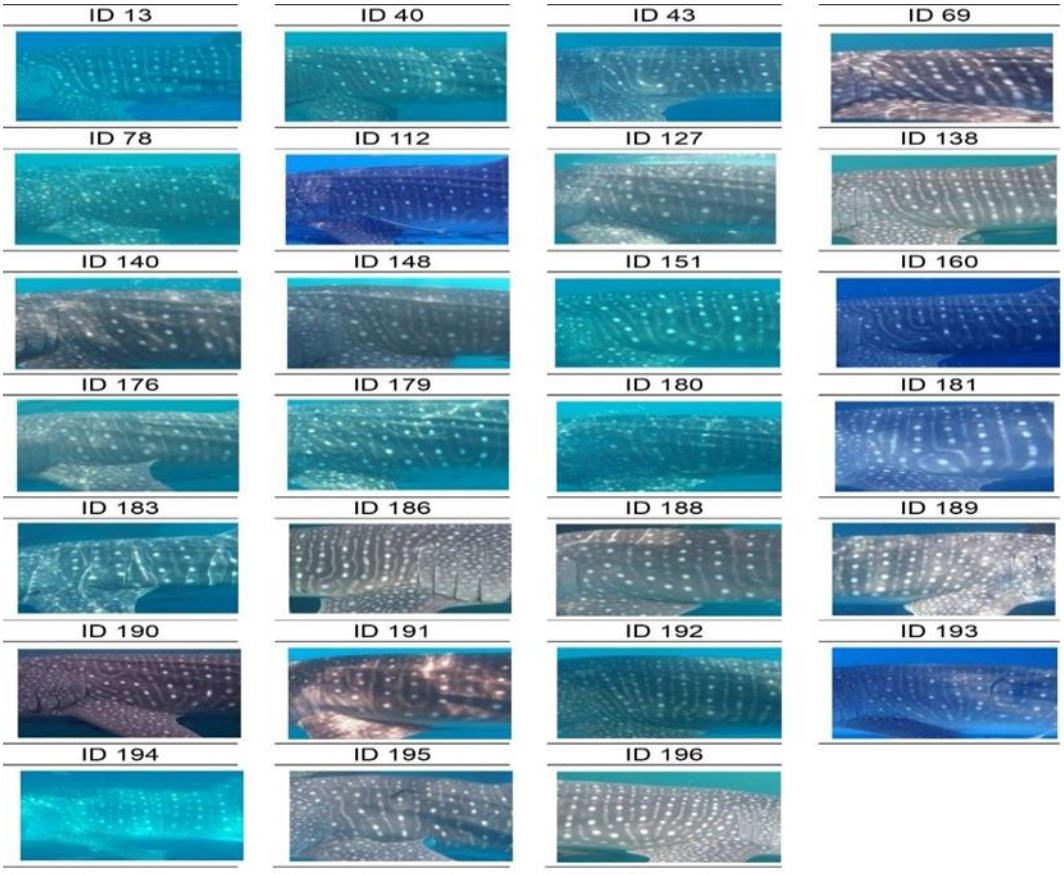
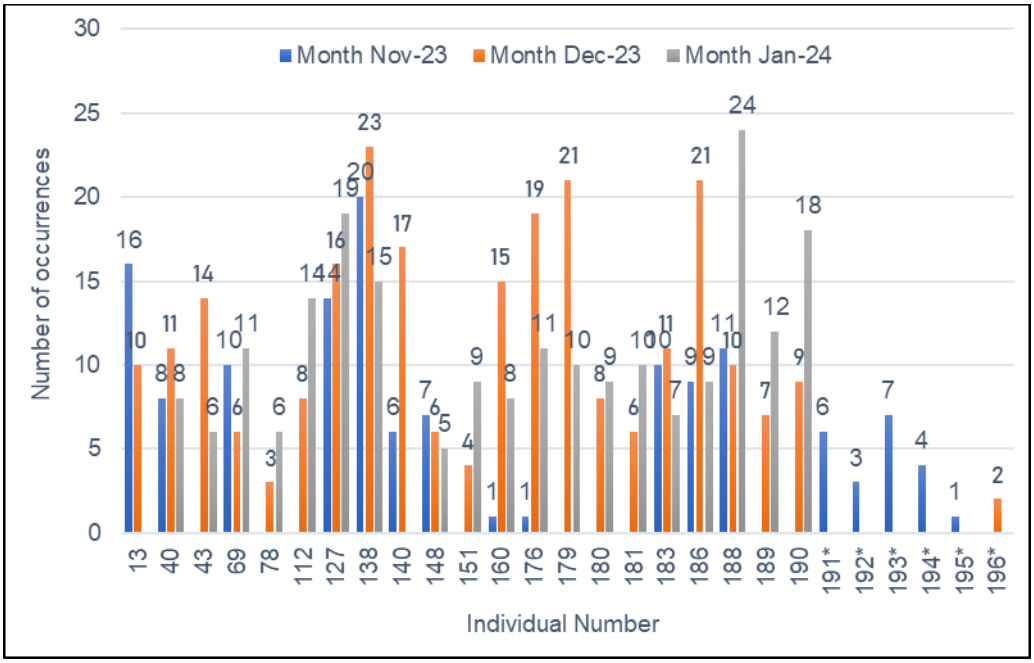


Figure 4 Spot Patterns of Each Individual Whale Shark



*) New Individu

Figure 5 Frequency of Daily Whale Shark Occurrences by Month

length, totaling 11 individuals, while only one individual measured 5 m. Of the 27 whale sharks with lengths ranging from 2.5 m to 5 m male sex:

- Length of 2.5 m: 3 individuals (ID 13, ID 43, ID 191*)
- Length of 3 m: 3 individuals (ID 138, ID 183, ID 189)
- Length of 3.5 m: 11 individuals (ID 69, ID 112, ID 140, ID 186, ID 151, ID 160, ID 179, ID 188, ID 190, ID 194*, ID 195*)
- Length of 4 m: 5 individuals (ID 127, ID 180, ID 192*, ID 193*, ID 196*)
- Length of 4.5 m: 4 individuals (ID 40, ID 148, ID 176, ID 181)
- Length of 5 m: 1 individual (ID 78)

Spatial and Temporal Distribution

The daily spatial distribution of whale sharks in Kwatisore waters follows the direction of the anchored purse seine nets, where the spatial distribution of each individual whale shark is related to the catch of anchovies by each purse seine net unit. The movement of purse seine nets from one location to another within Kwatisore waters determines the spatial distribution of whale sharks. Temporal distribution is related to the daily appearance times of whale sharks in the morning, afternoon, and evening. Overall, whale shark appearances occur more frequently in the morning than in the afternoon and evening.

New Individual Migration

The migration of new individual whale sharks into Kwatisore waters is not yet known, but it is predicted to be related to food availability and physical conditions of the water (Maruanaya 2022). They migrate to other waters but return to Kwatisore waters (Djunaidi *et al*. 2020), and there is also the migration of new individuals into the area (Maruanaya 2022; Punusingon 2023).

In 2023, 13 species of whale sharks were recorded as new individuals migrating into Kwatisore waters. The in-migration of 13 new individuals in Kwatisore waters in 2023 was much more when compared to the influx of new individuals in Botubarani waters of only 6 individuals in 2020 and 2022 (Yasir *et al.* 2024). The migration of new individual whale sharks into Kwatisore waters shows a very limited daily appearance frequency and appearances only in certain months. The appearances of new individuals were recorded only in February, April, July, October, November, and December of 2023 (Figure 6). The IDs of new individuals and the patterns of markings on whale shark bodies are visible in Figure 7.

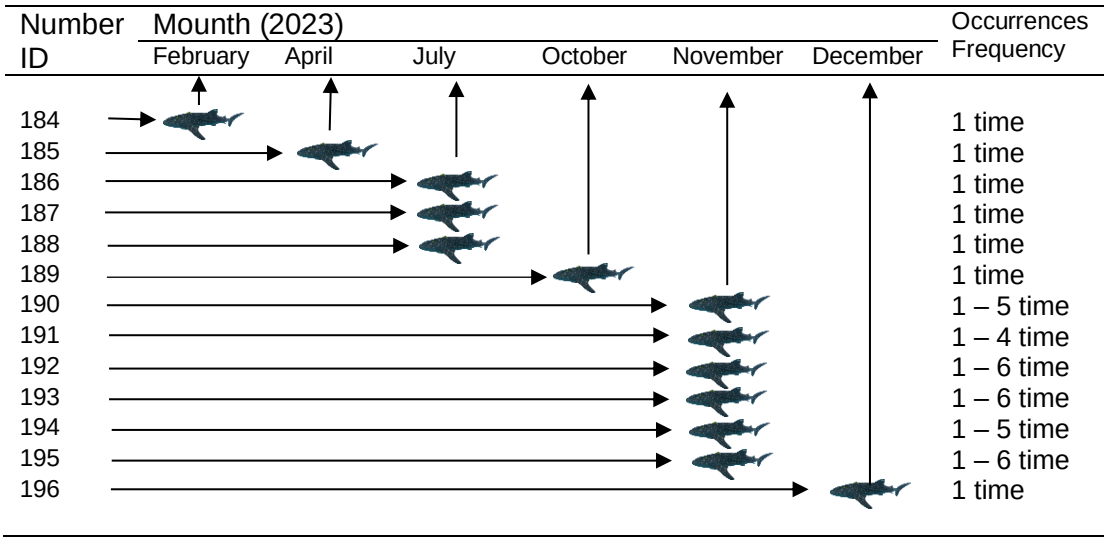


Figure 6 Appearance of new individuals based on individual ID and month of appearance

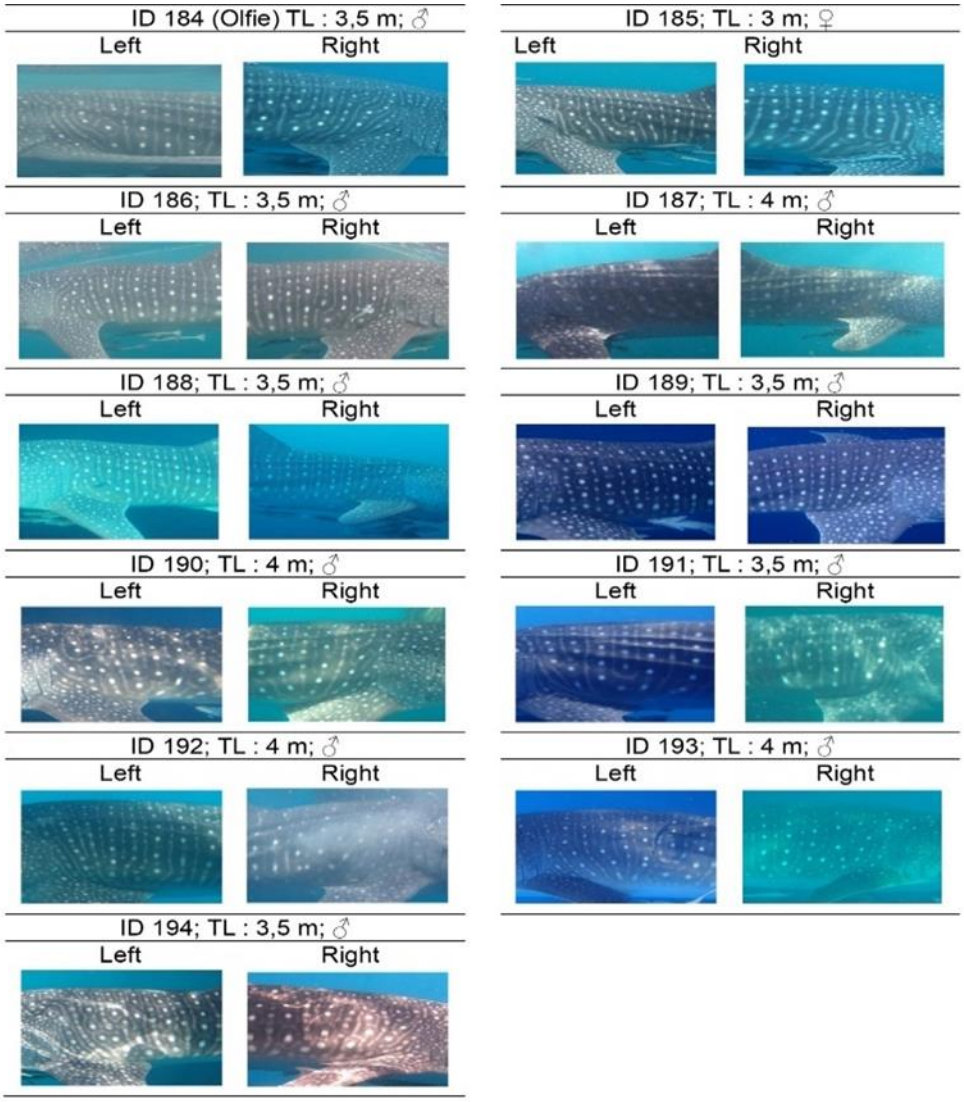


Figure 7 13 New Individuals with their spot patterns

The appearance of new individuals only in certain months in Kwatisore waters, and subsequently these individuals migrate out of Kwatisore waters. The appearance of these

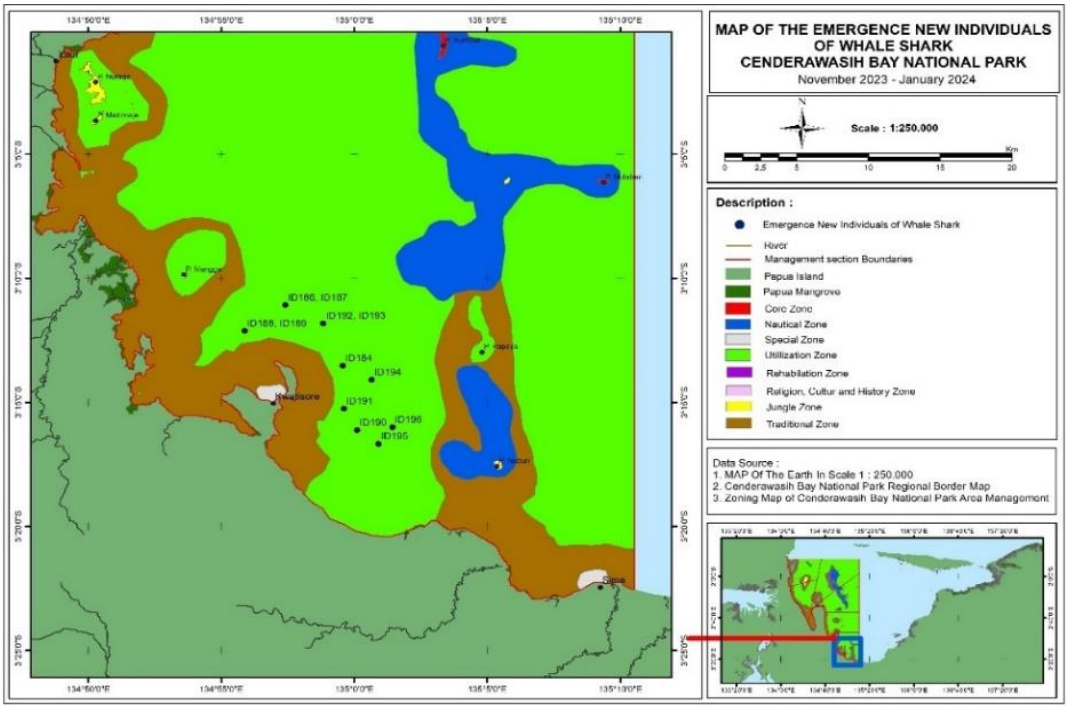


Figure 8 Appearance of new individual whale sharks

new individuals in Kwatisore waters shows two main patterns: 1) a fixed migration pattern, and 2) the presence of inbound migration patterns (Maruanaya 2022).

The appearance of new individual whale sharks during 2023 shows that 12 individuals appeared in Kwatisore waters, namely ID 184, ID 186, ID 187, ID 188, ID 189, ID 190, ID 191, ID 192, ID 193, and ID 194. Meanwhile, 1 individual appeared in Napan Yaur waters, namely ID 185 (Figure 6). Whale shark migration crosses territorial boundaries of a region and ocean waters, where migration is related to reproduction, growth, and food needs. The appearance of new individual whale sharks in 2023 is shown in Figure 8.

DISCUSSION

Daily Occurrence of Whale Sharks

The consistent daily occurrence of whale sharks over time in the waters of Kwatisore reveals unique characteristics. The whale shark sightings are localized to a limited area, specifically concentrated in the Kwatisore waters, with a notably high number of individuals. These appearances are focused within an area of 22,706 hectares (Maruanaya 2022). The Kwatisore waters are characterized by the presence of anchovies, an important food source for whale sharks, which contributes to their year-round presence (Enita *et al*. 2017; Prihadi *et al*. 2017; Maruanaya 2022). Additionally, the topography of the Kwatisore seabed, which includes numerous coral and seagrass areas along the coast, significantly influences the availability of food sufficient to support the whale shark population (Suruan *et al*. 2017).

The substantial anchovy catches by boat life net and the provision of anchovies as food by the lift net fishermen result in whale sharks staying for extended periods around the lift nets. Feeding the whale sharks anchovies creates a passive feeding pattern, meaning that the whale sharks wait for the fishermen to provide the food (Maruanaya 2022). Feeding anchovies by fishermen is easy to condition the behavior or change the nature of whale sharks (Kapinangasih *et al*. 2022). The results of behavioral observations show that 64% of whale sharks appear to be eating (Suruan *et al*. 2024). The increase in anchovy catches in the Kwatisore waters is closely related to the process of water fertilization, indicated by the abundance of chlorophyll-a (Toha *et al*. 2018), wind direction parameters, currents and chlorophyll-a have a significant correlation with the appearance of whale sharks in Cenderawasih Bay because they are thought to be related to food abundance (Ardania *et al*. 2018). The total daily occurrences based on individual numbers during the study period (Table 1) indicate that in December 2023, both the number of individuals and total daily occuren-

Table 1 Total Daily Occurrences of Whale Sharks by Number of Individuals during the Study Period

Total	Month		
	November 2023	December 2023	January 2024
Individual	18	21	19
Occurrences	136	245	211

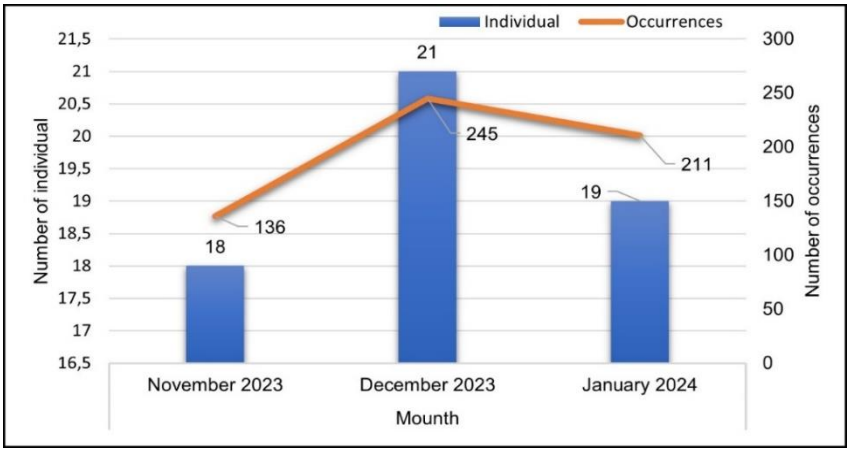


Figure 9 Number of Individuals and Total Daily Occurrences of Whale Sharks

ces were higher compared to January 2024 and November 2023. This increased occurrence in December 2023 is attributed to the higher anchovy catches by the lift net gear.

Maruanaya (2022) states that fluctuations in whale shark appearances are highly dependent on two main aspects: 1) the anchovy catches by each lift net, and 2) the provision of anchovies by lift net fishermen as food for the whale sharks. The more abundant the anchovy catches and the more frequently anchovies are provided as food by the fishermen, the quicker the whale sharks appear and the longer they stay around the lift nets. Suruan *et al.* (2024) stated that whale sharks are often seen in Kwatisore waters during sunny weather, compared to cloudy or rainy weather.

This return migration is likely related to feeding activities. Other whale sharks stayed for extended periods in Kwatisore waters. One factor contributing to the variability in whale shark appearances in Kwatisore is the availability of anchovy supplies (Prihadi *et al*. 2017). Increased whale shark sightings correlate with higher anchovy catches by lift net gear (Enita *et al*. 2017; Ihsan *et al*. 2017; Maruanaya *et al*. 2021) and the high abundance of small fishes caught in Kwatisore waters may attract a high number of whale shark occurrences in the area (Himawan *et al*. 2015). Anchovies are the food of whale sharks in Kwatisore waters, presumably due to changes in feeding habits (Ihsan *et al*. 2017) and anchovy abundance in Kwatisore waters is due to water fertility factors and food availability (Ihsan *et al*. 2017). Food factors is strongly suspected to be an attractant for whale sharks to come to the location (Rahman *et al.* 2017).

The influence of whale shark occurrence is due to the factor of anchovy catches, which are food for whale sharks besides plankton (Suruan *et al*. 2017) and most whale sharks forage in shallow coastal areas and are related to productivity and chlorophyll-a concentrations (Guzman *et al.* 2022). Whale sharks are known to dive deep and surface when seeking food (Suprapti 2015). The appearance of whale sharks in Kwatisore waters shows the number of individuals is more than one and as a form of aggregation (Maulida *et al*. 2018). Whale sharks are large opportunistic filter feeders in a mainly oligotrophic environment, where the ability to use novel food sources by modifying their behaviour could be of great advantage (Schleimer *et al*. 2015) and whale sharks actively forage when zooplankton concentrations are at the surface in high densities and feed on them to gain sufficient energy (Rohner *et al*. 2015).

The frequency of daily whale shark occurrences by individual ID indicates that ID

138, ID 127, ID 188, and ID 186 had more frequent appearances compared to other IDs. This suggests that these four individuals remained in Kwatisore waters from November 2023 to January 2024, likely due to the availability of anchovies as food. Whale sharks that have memorized feeding spots tend to return to those locations for feeding activities (McKinney *et al*. 2017). Some whale sharks exhibit site fidelity to a specific location, as demonstrated by individuals with high appearance frequencies (Toha *et al*. 2018). On the other hand, new individuals (ID 191, ID 192, ID 193, ID 194, ID 195, and ID 196) had very few appearances, occurring only in November 2023 and not in December 2023 and January 2024. The absence of new individuals suggests that they may have migrated out of Kwatisore waters. New individuals typically have limited appearances and occur at specific times (Maruanaya 2022) and some individuals a often migrate out of Cenderawasih Bay (Manuhutu *et al*. 2021). The movement patterns of whale sharks in three places in Indonesia, namely in Triton Bay, Saleh Bay, and Cenderawasih Bay, where satellite tags were attached to 53 whale sharks, show that whale sharks in Cenderawasih Bay have a mixed pattern, which is a combination of homing and seasonal patterns. The homing pattern means that most whale sharks in the Cenderawasih Bay area stay throughout the year, while the seasonal pattern means that whale sharks are only in the Cenderawasih Bay area at certain times (Sianipar 2019).

The resighting of whale sharks is associated with their migratory behavior or movement to find food or mates. Tagging of whale sharks in Kwatisore waters showed that some whale sharks traveled out of Kwatisore waters, while others (67%) stayed year-round in Kwatisore waters (Meyers *et al*. 2020). The Cenderawasih Bay waters, being a bay, exhibit characteristic fluctuations in physical-chemical parameters, particularly Sea Surface Temperature (SST) and chlorophyll-a throughout the year. Higher productivity and chlorophyll-a concentrations were associated with whale shark foraging behavior (Guzman *et al*. 2022) and highest average Sea Surface Temperature was about 30.3-31.2 °C, this is very suitable for the presence of whale sharks (Manuhutu *et al.* 2021). The dynamics of these two parameters affect the presence and appearance of whale sharks, which are predominantly observed in Kwatisore waters (Maruanaya 2022). The study by Valsecchi *et al.* (2021) suggests monthly values of SST may play a role in whale shark habitat selection.

The establishment of whale shark subpopulations in Cenderawasih Bay waters is likely linked to food availability and hydrographic conditions conducive to their survival (Nugraha *et al*. 2020). The increasing frequency of whale sharks appearance in Kwatisore waters is due to increased catches of anchovy (Yasmina *et al*. 2017). The occurrence of whale sharks in Probolinggo is not correlated with zooplankton but it is necessary to consider the whale shark zone for the protection of the whale shark (Anggraini *et al.* 2024). The predictable appearance of whale sharks occurs because they are accustomed to a certain range of each environmental parameter, where the appearance of whale sharks is at a water depth of 9-14 m (Syah *et al*. 2018). The appearance of whale sharks throughout the day in Kwatisore waters is an important prospect in the development of ecotourism so that it becomes an added value for improving the economy of the local community.

Distribution of Whale Shark Lengths and Gender Percentage

Whale sharks with lengths ranging from 2.5 m to 5 m in Kwatisore waters are categorized as juveniles. The aggregation of juvenile whale sharks in Kwatisore waters indicates that this area serves as a feeding ground rather than a breeding area (Maruanaya 2022; Maruanaya and Pattinaja 2023). Most aggregations of whale sharks with total lengths of 6-8 m consist mainly of immature males primarily for feeding purposes. Female whale sharks in size of 3.40-7.60 are categorized as females who have not yet entered sexual maturity, while females reach adulthood at a size of about 12 m (Murdani *et al*. 2018). The information about size and sex is needed to determine the condition of the whale shark (Macena and Hazin 2016).

The appearance of 27 whale sharks in Kwatisore waters was predominantly male. This suggests that the whale sharks entering and residing in Kwatisore waters for an extended period are dominated by males, while female whale sharks appear sporadically and unpredictably. The presence of juvenile male whale sharks in Kwatisore waters indicates it as a growth area (Maruanaya 2022), where their appearances are typically found at depths ranging from 29 m to 83 m (Maruanaya and Pattinaja 2023). Whale shark research studies at

Cenderawasih Bay National Park also reported male dominance although some females appeared from time to time (Himawan *et al*. 2015). The research of Tebaiy *et al.* (2023) in Kwatisore waters found 23 whale sharks and all of them were male where the identified individuals consisted of 17 old individuals and 6 new individuals. Female whale shark have a lower growth coefficient than male, where female whale sharks have asymptotical size slower but continues to grow in a long period of time compared to the male (Meekan *et al*. 2020). Whale shark movements in Cenderawasih Bay form horizontal patterns due to responses to abiotic and biotic factors in different waters, including food availability (Meyers *et al*. 2020).

Most aggregations of immature male whale sharks with lengths of 6-8 m are for feeding purposes and immature male whale sharks tend to utilize shallower waters (Hoffmayer *et al*. 2021). Furthermore, whale sharks exhibit three movement patterns: 1) remaining in Cenderawasih Bay; 2) moving out of Cenderawasih Bay but staying in nearby coastal areas; and 3) moving out of Cenderawasih Bay towards deep offshore waters (Meyers *et al*. 2020). In Kwatisore waters, whale sharks exhibit feeding behavior at 64%, playing at 21%, and transiting at 15%, with most of their time spent at depths of 7-10 m (Suruan *et al*. 2017). There are 20 whale shark individuals in Botubarani waters, which appear every day with varying lengths ranging from 4-6.8 m and all are male (Rombe *et al*. 2022) and whale sharks in Mozambique vary in size with a total length of 3-9.5 m and the majority (74%) are males (Peter *et al.* 2015). Marrero *et al.* (2014) stated that Darwin Island is not a whale shark aggregation site but a stopover or migration site for adult individuals for reproductive purposes, which is important information in understanding the reproductive cycle of whale sharks for conservation purposes

Spatial and Temporal Distribution

Whale shark spatial patterns are an important characteristic of community ecology (Ranintyari *et al.* 2018). This indicates that the spatial distribution pattern of whale sharks is closely related to the presence of boat life net. The daily appearance of individual whale sharks at one boat life net unit, and if that unit has only a few anchovy catches so that the boat life net net fishermen do not provide anchovies as food, then the whale shark individuals move to other boat life net units. The daily spatial distribution of whale sharks is highly dependent on the anchovy catch by boat life net units and the provision of anchovies by boat life net fishermen as food. Whale shark presence is not associated with zooplankton distribution (Anggraini *et al.* 2024).

Temporal distribution of whale sharks are more frequent in the morning because they are related to the activity of hauling by boat life net units and the anchovy catch stored in containers, which accelerates the presence of whale sharks due to the scent of anchovies. The daily appearance of whale sharks is more frequent in the morning due to feeding time or hunger and the activity of whale sharks surfacing in boat life net capture areas is a naturally formed biological pattern for the purpose of obtaining food (Maruanaya 2022). The results of Anggraini *et al.* (2024) found that temporal variations in zooplankton composition were significant with the presence of zooplankton. Surface temperature has no linear relationship with temporal whale shark occurrence (Valsecchi *et al.* 2021).

New Individual Migration

The migration of new individual whale sharks into Kwatisore waters indicates that Kwatisore waters have specific characteristics, especially as a region of whale shark migration patterns. Whale sharks are classified as migratory animals with a very wide and far-reaching range and return to their original areas after several years (Sadili *et al*. 2015) and whale sharks migrated under conditions of higher current speed (Guzman *et al*. 2018). Whale shark migration is satisfied in some waters with vessel collisions because there are currently no mandatory management measures in place by countries to protect whale sharks from vessel collisions in their marine areas and it is a highly relevant threat (Womersley *et al*. 2024).

This figure depicts the appearance of new individual whale sharks in Kwatisore waters. Kwatisore serves not only as a feeding and nursery ground for whale sharks but also as an area where new individuals migrate into (Maruanaya 2022). The addition of new individuals to the whale shark population in Kwatisore has increased the total number of identified whale sharks to 196. The migration of new individuals into Kwatisore waters enriches the diversity of marine life in the area and highlights the significance of preserving and managing Kwatisore waters. This phenomenon underscores the importance of conservation efforts to maintain Kwatisore as a habitat for both resident and migrating whale

sharks. Protection of large areas of the high seas, for migratory routes for sharks to feed and breed, it is necessary to plan marine territories and identify critical aggregation areas that could potentially be used for foraging (Guzman *et al*. 2022). The dispersal potential of wahle sahrk supports migratory connectivity linking the eastern and western Pacific basins for transoceanic migrants (Valsecchi *et al.* 2021).

CONCLUSION

The daily appearance of whale sharks from November 2023 to January 2024 amounted to 27 individuals, all of which were males, with the highest daily appearance frequency in December 2023. The total frequency of whale shark appearances during this period was 592 times, with varying daily appearance frequencies among individuals, including 5 returning individuals to the Kwatisore waters. The size distribution of whale sharks ranged from 2.5 m to 5 m, with a dominance of individuals at 3.5 m. The spatial distribution of whale sharks on a daily basis followed the presence of purse seine units deployed in the Kwatisore waters, with spatial distribution occurring more frequently in the morning. The influx of new individuals into the Kwatisore waters during 2023 was limited, with only 13 individuals recorded, and their appearance frequency was very low.

RECOMMENDATION

To understand the daily movement patterns (spatial distribution) of whale sharks, further in-depth studies with longer durations are needed, as well as consideration of the presence or stock of anchovies as an important factor in relation to whale shark appearances.

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