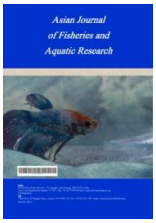

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# Distribution of Blacktip Reef Sharks (*Carcharinus melanopterus*) Based on Habitat Characteristics by the Baited Remote Underwater Video (BRUV) Method in Morotai Waters of North Maluku

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***Authors' contributions***

*This work was carried out in collaboration among all authors. Author WBS designed the study, performed the analysis, wrote the protocol and wrote the first draft of the manuscript. Authors IN, IMA and AMAK managed the analyses of the study. Author WBS managed the literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

Morotai has abundant marine biological resources, sharks being one of them. The blacktip reef shark is one of the dominant types of coral reef sharks in Morotai waters. Worldwide shark are threatened due to the demand for shark fins and over fishing, to protect sharks is important to know their distribution so protected areas can be established. This research aims to examine the distribution of blacktip reef sharks (*Carcharhinus melanopterus*) based on habitat characteristics in the Morotai Waters. Through surveys and observation of coral cover, using the Line Intercept Transect (PIT) method and the Baited Remote Underwater Video (BRUV) to record the blacktip reef sharks who passed by the coral reef. Water quality parameters measured include temperature, salinity, visibility, acidity, current type, tides, and moon phases. Blacktip reef sharks were found in three of the four research stations. Station 4 was the one with the most blacktip reef

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shark appearances, amounting to 91 individuals. This station has the lowest sloping contour and has the smallest live coral cover of only 1%. Station 4 is dominated by sand covering 40%. All water quality parameters influence blacktip reef shark occurrence. The highest appearance of the blacktip reef shark happens during the new moon phase, when the tides are loose and the currents are quite strong.

*Keywords: BRUV; Carcharhinus melanopterus; distribution; habitat charactaristics; Morotai Island.*

## 1. INTRODUCTION

Indonesian waters have a high diversity of fisheries resources and a high diversity of Elasmobranchi (Sharks and rays) spesies. The shark group is divided into 8 orders and 35 families and at least 109 species belonging to 26 families of sharks can be found in Indonesia [1]. All fish life is interrelated and depends on the existing oceanographic conditions, sharks are classified as predator that can eat from small fish to mammals [2].

Shark fishery resources are one of the fisheries commodities that have been taken into account in recent decades due to the high demand for fins on the international market. Generally, sharks are caught in Indonesian waters as bycatch of various types of fishing gear such as longline fishing, gill nets, ring nets. The utilization of this commodity in Indonesia began to increase since the 1980s. Sharks catch data from 1975 to 2011 in Fahmi and Dharmadi [3] show a significant upward trend. The number of shark catches peaked in 2000 and then began to show a downward trend even though it fluctuated.

One factor that indicates a decline in the shark population can be known from the catch per effort or Catch Per Unit Effort (CPUE) that can describe the actual condition of fisheries resource exploitation. The most susceptible shark catch area in Indonesia is the Indian Ocean. Generally, shark fishing activities take place throughout the year, but there are certain months which are the highest catch season of this resource in Indonesian waters, the shark fishing season in the Indian Ocean and South Java waters take place between June - September [1].

Indonesia is listed as one of the countries with largest shark catch rates in the world, as seen from the annual average report of shark capture from 2000 - 2010 which reached 106,288 tons [4]. According to the Sorong Study Program Introduction to the Environment (PSPL) from October to December 2007 [5], shark fin shipments from Sorong City for *Carcharhinus melanopterus* species reached 36 kg. Based on morphometric measurements, 1 set of *C. melanopterus* fins has an average weight of 140 grams. Converted from weight to number of individuals, it is estimated that there were about 230 blacktip reef sharks caught in the first quarter of 2008. Besides the use of fins, these sharks are also often found for sale in traditional fish markets [5].

The Morotai island is one of the outer is island of Indonesia which makes it difficult to reach and so, there are few studies of water conditions and marine biota made in this geographical region. Especially there is no research on the distribution of Blacktip Reef Sharks in these waters. Indonesia has a well-known marine tourism and shark tourism is a growing industry [6]. Morotai is one area that offers shark tourism in Indonesia. The existence of preliminary studies on the condition of Blacktip Reef Sharks in Morotai Waters can develop tourist areas and can be made a protected area so that Blacktip Reef Sharks in Morotai Waters can be protected. Although the available evidence indicates that the abundance of coral sharks is now much lower than the historical baseline and that a decline is underway, there is still much uncertainty about current population trends due to lack of abundance data and research efforts [7].

## 2. METHODOLOGY

### 2.1 Location and Time of Research

This research was conducted in the Morotai waters of North Maluku, geographically located at coordinates 2°00'00" to 2°40'00" N and 128°15'00" to 128°40'00" E. Retrieval of research data carried out on January 22 - March 5 2019.

The choice of location for data collection is done by selecting the location based on the following criteria:

1. Have different habitat criteria at each station

2. Easy to access
3. Having the specificity of using tourist resources.

Based on these considerations, four data collection locations in the Morotai Waters area have been determined (Fig. 1). The four locations consist of:

1) Station 1: Galo-galo Point 2°9'18,064" N 128°12'25,697" E
2) Station 2: Dodola Point 2°4'47,742" N 128°10'46,49" E
3) Station 3: Pulau Pasir Point 1°59'53,784" N 128°13'0,139" E
4) Station 4: Mitita Point 1°58'9,194" N 128°14'8,969" E.

## 2.2 Data Collection Methods

A survey was used to obtain data on the appearance of Blacktip Reef Shark *(Carcharhinus melanopterus*). Coral reef condition and physical-chemical parameters were obtained through direct observation and measurement consisting of 4 planned stations. Observation of the appearance of *C. melanopterus* was done by direct observation through the Baited Remote Underwater Video (BRUV) method. BRUV records greater species richness in shallow and mesophotic depths, making it most appropriate for recording all components of fish communities [8].

At the time of field data collection, it is not uncommon for rain to occur and the amount of freshwater entering the waters results in a decrease in the value of salinity in the Morotai Waters. This can occur because the season at the time of data collection takes place is the west season which causes frequent rainfall in Morotai Waters. In a study conducted in Halmahera waters [9], it was found that the horizontal distribution of salinity at the surface (1 m) was obtained between 32 - 34 ppt, where the salinity of the Halmahera Strait and the Seram Sea was higher than the salinity of the Banda Sea or East Seram waters.

The visibility intended in this research is the distance that can be seen and observed in the water. Visibility measurements are carried out at each observation station, measured by stretching a roll meter between buddies and carried out during BRUV observation. Underwater visibility will vary across locations and seasons which are strongly affected by subsequent rainfall and runoff, oceanographic processes such as storm and tidal events, and phytoplankton blooms and as a general rule, BRUV surveys should not be carried out unless there is at least 3 m of underwater visibility [10].

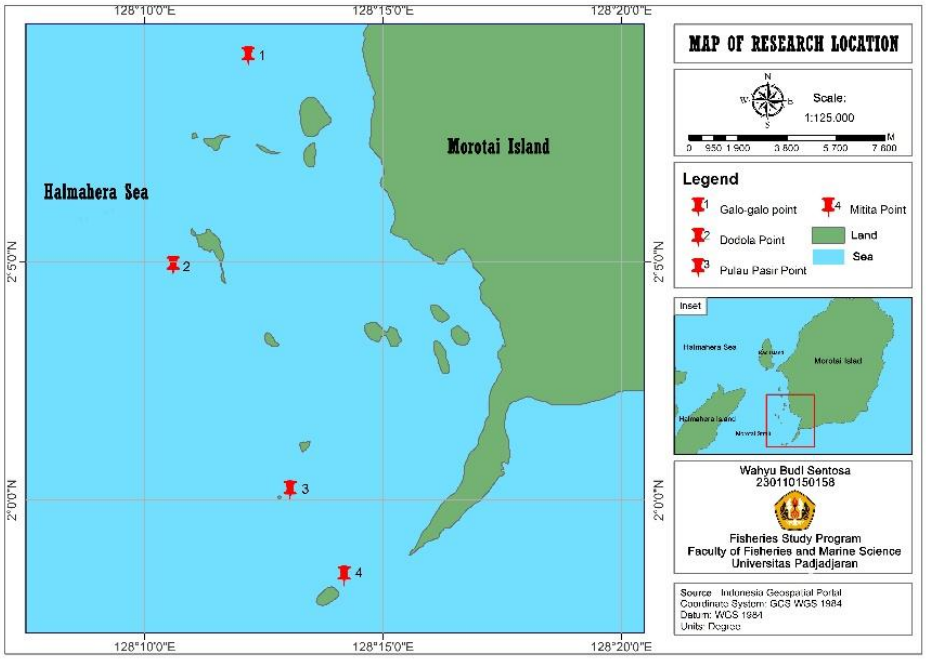



**Fig. 1. Location of the research station**

The sample used for the measurement of the pH value of the waters was obtained during observation. Researchers used empty bottles that were brought into the waters which were then used to take water samples around the BRUV series. Samples were measured for their acidity after researchers returned to the ship. Measurements were made using a digital pH meter.

### 2.2.1 Observation of blacktip reef shark

The BRUV method is used to get shark appearance data at each station. This device attracts the shark's attention by using fresh tuna fish to a point that is the BRUV series. In the BRUV series, two cameras are installed that will record the appearance of sharks that are drawn to the front of the circuit and then record it in the analysis.

The camera used in this research is the GoPro Hero4 series camera which has an ultra-wide 120° lens opening and 12 megapixel camera resolution with quality settings for 1080 pixel video recording and 30 frames per second (fps). In this study, the model used is the VBUV (Vertical Baited Underwater Video) [11]. The VBUV circuit model (Fig. 2) has a vertical view of the camera with a framework located on the seabed.

The VBUV circuit is made of 8 mm diameter iron screw welded as in (Fig. 2) and then painted with oil paint to prevent corrosion in the circuit. In the series paired two GoPro heroes 4 cameras that had previously been fitted housing so that the camera becomes waterproof. At the bottom of the circuit tied with a 5 mm pe rope 4 inch diameter pipe and 30 cm long that has been perforated as a place of bait.

The camera is mounted on the BRUV circuit in a vertical position. The lower camera (Fig. 2) is faced up slightly and the top camera (Fig. 2) is faced up slightly.

Observation of the appearance of Blacktip reef sharks is performed a maximum of 3 (three) times a day, morning, afternoon, and evening. Each data retrieval appears the camera in the BRUV circuit will record for ± 30 minutes. The BRUV series was placed for 50 minutes at two depth limits, 5 meters (shallow) and 30 - 55 meters (mesophotic) [8]. The BRUV series is distributed for 40 minutes, Blacktip reef sharks need 20 minutes to reach the field of view of the camera to be recorded [11]. At each observation, the BRUV series is positioned by divers on a flat contour so that the series can stand upright and the series is facing back against the contour of the coral reef so that the angle of shooting becomes wider.

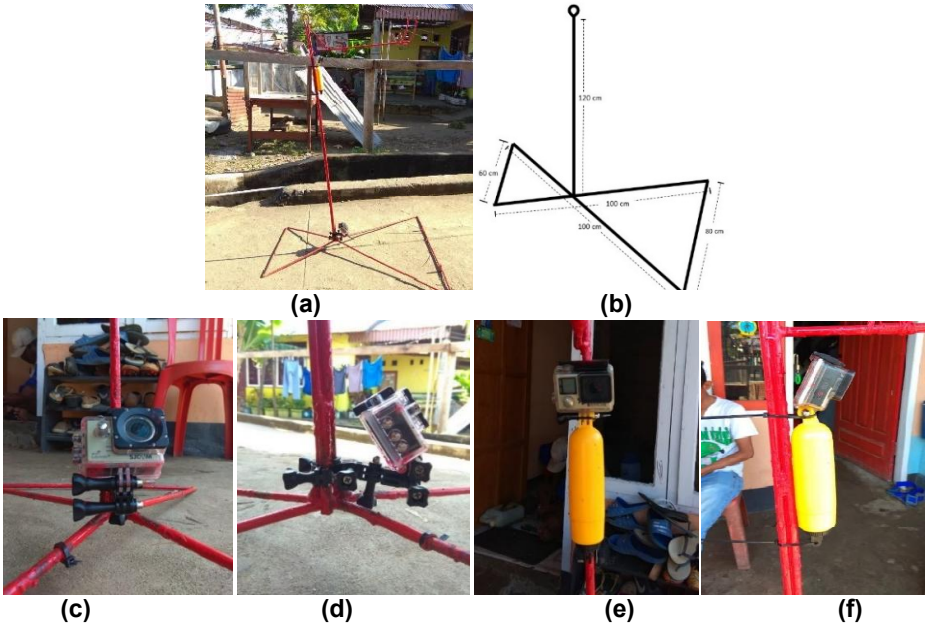



**Fig. 2. BRUV, (a) VBUV series; (b) size of the BRUV framework; (c) front view's bottom Camera; (d) Side View's bottom camera; (e) front view's top camera; (f) side view's top camera**

Observation of emergence data in this study does not separate the appearance of sharks based on behavior, but only observing their appearance. Data was collected in the time range of 08.00 - 17.00 WIT. Calculated sharks may not all get Photo IDs, but they can be estimated from physical signs by observers. The appearance of Blacktip reef sharks can be seen in the distribution area where Blacktip reef sharks are most dominant.

Blacktip reef shark was identified by videographic record. The most prominent characteristic that can be used in identifying *C. melanopterus* is the dorsal fin and caudal fin that have black color. Before the black part of the dorsal fin is a white part (Fig. 3).

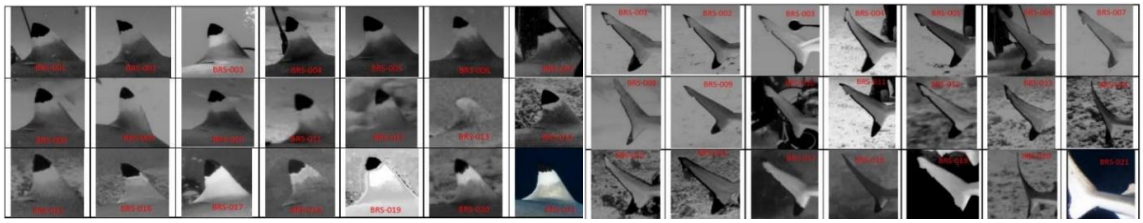
### 2.2.2 Characteristics observation of blacktip reef shark habitat (*Carcharhinus melanopterus*)

Observation of Blacktip reef shark habitat characteristics was done by measuring the percentage of coral reef cover, observing physical-chemical parameters, and observing the moon and tidal phases at 4 research stations in the waters of Morotai Island.

#### *2.2.2.1 Percentage of coral cover*

Data collection on the percentage of coral cover is done using the Point Intercept Transect (PIT) method. The PIT method is used to determine sessile communities (biota that lives on the bottom or attached to the bottom of the water) on coral reefs based on growth form in percent units, by recording the number of benthic biotas present at each point along the transect line (25 m) [12]. PIT is established and used to monitor the condition of coral reefs in detail by placing permanent transects at the Marine Protected Area [13]. The PIT procedure is to calculate the percentage of live hard coral cover (% cover) of the substrate randomly by using ropes marked at each distance of 0.5 meters or also with a scale tape (roll meter) in (Fig. 4.). The depth is determined between 10 - 12 meters, the transect is pulled along the coastline and the island or land part is next to the observer. Coral lifeform and biota categories in Table 1.

Retrieval of coral reef data is carried out at each station. At each station, coral reef data was collected using the 100 meter PIT method (Fig. 4).



(a) (b)

**Fig. 3. Blacktip reef shark (a) dorsal fin; (b) caudal fin [6]**

**Table 1. Code for recording permanent transect data in the coral reef information and training centers (CRITC) version of the reef health monitoring activities - COREMAP LIPI**

| Code | Biota category | Description |
|---|---|---|
| AC | Acropora | Acropora Reef |
| NA | Non-Acropora | Non-Acropora Reef |
| DC | Death Coral | Dead coral colored white |
| DCA | Death Coral Algae | Dead coral whose color changes color because it is overgrown with algae filament |
| SC | Soft Coral | Types of Soft Coral |
| FS | Fleshy Seaweed | Types of Macro Algae: Sargassum, Turbinaria, Halimeda |
| R | Rubble | Branched Coral Fault (dead) |
| RK | Rock | Hard base substrate (rock) |
| S | Sand | Sand |
| SI | Silt | Fine muddy sand |

*Source: Manuputty and Djuwariah [12]*

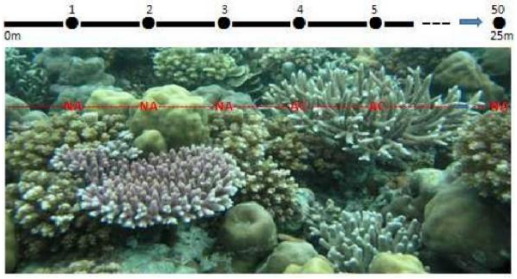



**Fig. 4. Scheme of recording data on coral colony**
*Source: Manuputty dan Djuwariah [12]*

The percentage value of live hard coral cover is obtained from the measurement of Point Intercept Transect (PIT) which is then processed using a formula according to Giyanto et al. [13] as follows:

$$Number\ (\%)\ of\ cover = \frac{Number\ of\ substrate\ categories}{Total\ category\ points\ in\ one\ transect}\ x\ 100\%$$

The assessment of the condition of coral reef ecosystems is determined based on the percentage of live coral cover with CRITC-COREMAP LIPI criteria based on Gomez and Yap (1998) in Manuputty and Juvenile (2009) as follows:

Very good = 75 - 100%
Good = 50 - 74,9%
Moderate = 25 - 49,9%
Poor = 0 - 24,9%.

Indicators of the health of coral reef ecosystems consist of the physical condition of the ecology of coral reefs (in the form of percent of live coral cover) and the association biota of coral reefs that affect live rock corals. The physical condition of coral reef ecosystems is also influenced by the basic substrate of coral reefs.

*2.2.2.2 Parameters of water physical-chemistry*

Measurement of physical-chemical parameters in the waters of Morotai Island was carried out at each research station. Measurement of physical-chemical parameters was carried out at each time the data collection of the appearance of Blacktip reef sharks. The parameters measured are temperature, current, salinity, brightness, depth. Temperature, current, salinity, brightness, and depth data are obtained from field observations.

## 2.3 Data Analysis

The analysis used to describe the distribution of Blacktip reef sharks concerning habitat is used comparative descriptive analysis or commonly referred to as descriptive comparison. Descriptive research seeks to describe a phenomenon, event, event that is happening now. Descriptive research focuses on actual problems as they are when the research takes place. Through descriptive research, researchers try to describe the events and events that are the center of attention without giving special treatment to those events. The variables studied can be single (one variable) can also be more and one variable [14].

Descriptive research is concerned with studying phenomena in more detail or differentiating them from other phenomena. An analysis, if the data that has been obtained by comparison then that is what is called comparative descriptive [15]. This study presented two data comparisons namely between the comparison of the distribution of Blacktip reef sharks with the condition of coral reefs and comparison of the physical-chemical conditions of the environment. The results of the comparison can later be known as what habitat characteristics are most dominated by Blacktip reef sharks. The results of the comparison and analysis will be compared in the form of descriptive analysis.

## 3. RESULTS AND DISCUSSION

### 3.1 Coral Reef Cover

#### 3.1.1 Station 1 galo-galo point

At Station 1 (Galo-galo Point), the live coral cover percentage is relatively low when compared to other stations. The live coral cover percentage is 11% and is classified into the bad category [12]. The most dominant category at station 1 was the soft coral category (44%) followed by fleshy seaweed (23%) (Fig. 5).

Station 1 has the steepest contours among the four research stations. Station 1 is located in a channel contour on Morotai Waters. The closest island to this station is Galo-galo Basar Island, but this station is not exactly in front of the Big Galo-galo Island.

#### 3.1.2 Station 2 daloha point

Based on Fig. 6, station 2 has a live coral cover percentage of 55% and is classified as a good

category [12]. The rest is dominated by sand, which is recorded as much as 12% and stones as much as 10%. The most dominant category at station 2 is the Non-Acropora category (35%) followed by Acropora (20%). The live coral cover percentage is strongly influenced by water quality. In the Morotai waters, there is a shift in the mixed layer, this condition can provide a beneficial contribution to biological productivity [16].

Station 2 is located behind Dodola Island and directly faces the Halmahera Sea. This station has a fairly steep contour but is not as steep as Station 1. Station 2 has the highest percentage of live coral cover compared to other stations.

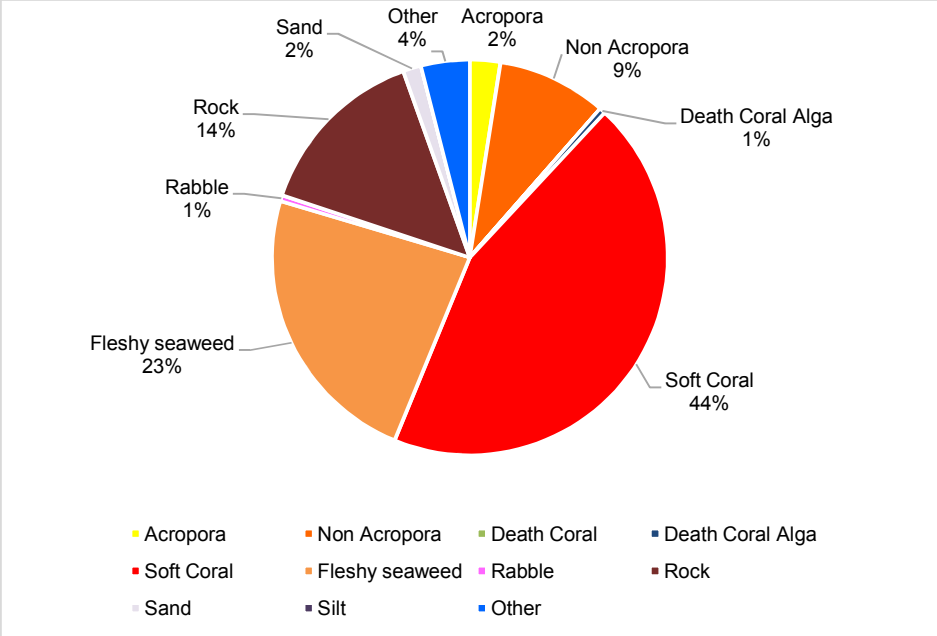



**Fig. 5. Percentage of coral reef cover station 1**

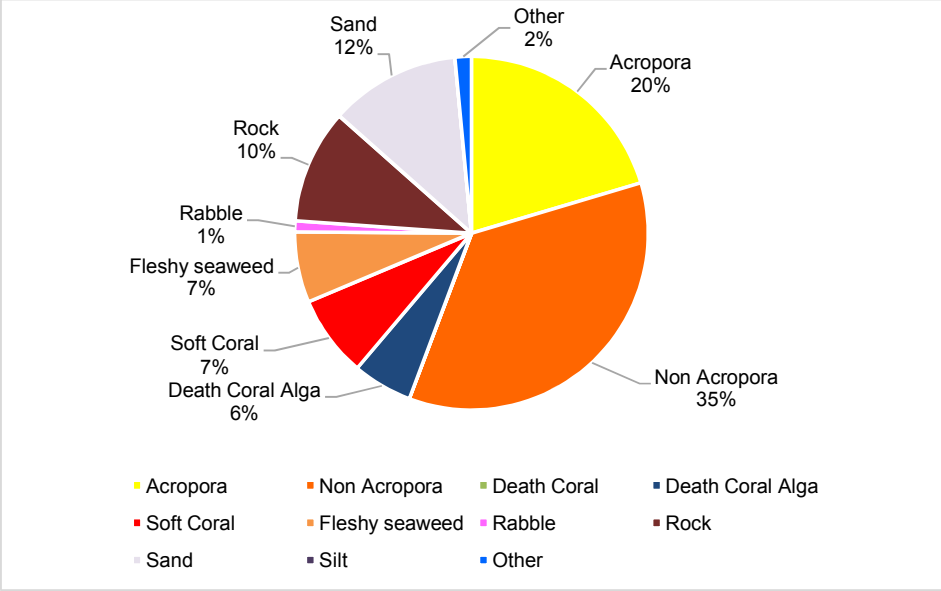



**Fig. 6. Percentage of coral reef cover station 2**

### 3.1.3 Station 3 pulau pasir point

At station 3, the live coral cover percentage (Fig. 7) is quite high compared to stations 4 and 1. The live coral cover percentage is 29% and belongs to the moderate category [12]. The rest is dominated by soft coral, which is recorded as much as 26%. The most dominant category at station 3 is the soft coral category (26%) followed by Acropora (20%). Station 3 has a fairly even diversity of coral reefs compared to other stations. Based on the results of the data collection, there was no category that was too prominent at station 3. The live coral cover at this station was also classified as moderate with a percentage of live coral cover of 29%.

Station 3 is in front of the Sand Island and faces the Morotai Island Waters. This station has a fairly gentle contour but is not as sharp as Station 4. Station 3 has a depth of ± 18 meters. This station is located between 2 pinnacles which makes this station not easily affected by currents in the surrounding waters.

### 3.1.4 Station 4 mitita point

Station 4 (Mitita Point) is in front of Mitita Island and faces the Morotai Island Waters. This station has a depth of ± 17 meters with sloping contours. The contour at this station is the most gentle of the four research stations. Station 4 has the lowest percentage of live coral cover compared to other stations. At this station, the percentage of live coral cover was 1% and this was classified as poor [12], the rest was dominated by sand, which was recorded as much as 40% and followed by soft corals at 25% (Fig. 8).

Station 4 has the largest sand cover compared to other stations and has a flat contour and only a small amount of live and dead coral cover.

## 3.2 The Appearance of Blacktip Reef Shark

### 3.2.1 Temperature

Overall, the temperature during seawater sampling takes place in the range of 27 - 29°C (Table 2). The stable temperature of seawater around Morotai Island illustrates that the mass of water around this island originates or is greatly influenced by the mass of seawater. The temperature in the Morotai waters is influenced by the spread of tropical water masses from the Pacific Ocean into the waters of Eastern Indonesia, one of which is through the Morotai Waters to the Indian Ocean. Morotai Island seawater temperature is also influenced by the dynamics of local water motion such as tides and water masses which are not far from the tropical warm pools of the western Pacific Ocean, which cause seasonal and annual temperature change surface differences not less than 2°C [17].

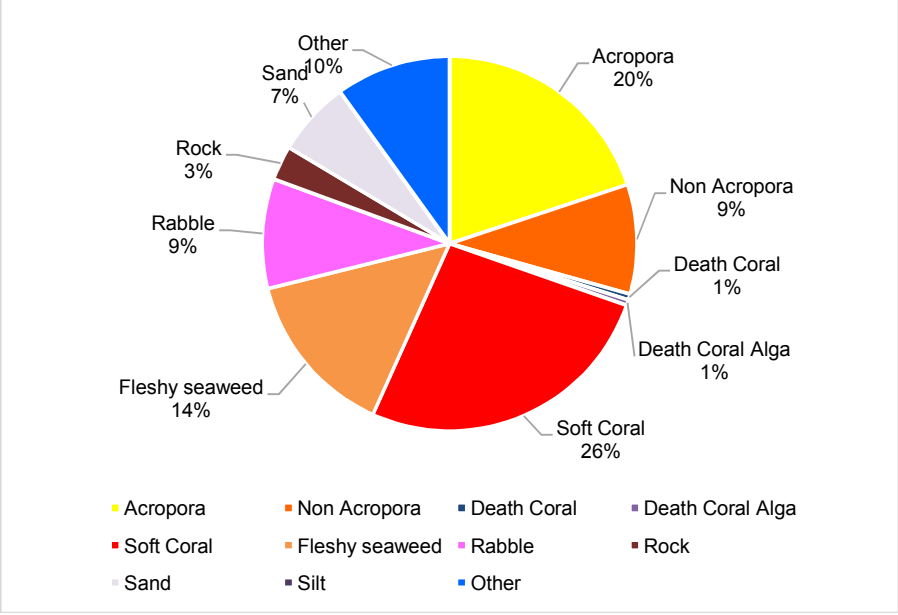



**Fig. 7. Percentage of coral reef cover station 3**

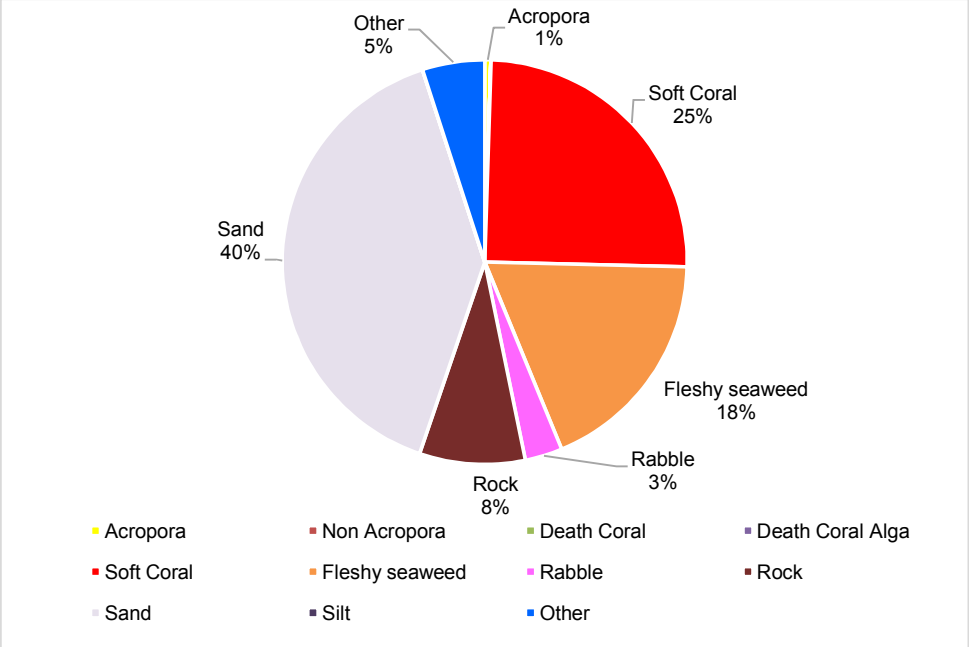



**Fig. 8. Percentage of coral reef cover station 4**

**Table 2. Waters conditions of data retrieval station occurrence of blacktip reef sharks**

| Station | Time of data collection (UTC+09:00) | Water parameters | | | | |
|---|---|---|---|---|---|---|
| | | Temperature (°C) | Salinity (ppt) | Acidity | Visibility (meter) | Current type (knot) |
| *Stasiun 1* | 09.00 - 16.00 | 27 - 29 | 35 - 41 | 8,13 - 8,41 | 5 - 15 | 0 - 2,5 |
| *Stasiun 2* | 09.00 - 16.00 | 28 - 29 | 36 - 40 | 8,25 - 8,4 | 10 - 15 | 0 - 2 |
| *Stasiun 3* | 09.00 - 16.00 | 29 | 34 - 40 | 8,25 - 8,31 | 8 - 10 | 0 - 2 |
| *Stasiun 4* | 09.00 - 16.00 | 27 - 29 | 34 - 41 | 8,27 - 8,44 | 6 - 17 | 0 - 2,5 |

The appearance of Blacktip reef sharks in the waters can be influenced by several conditions, including water temperatur. This can occur because almost all types of sharks have ectothermic properties that can not regulate their body temperature. In some studies, temperature is one of the factors focused on shark distribution and movement [18].

Based on the data on the emergence graph (Fig. 9) it can be concluded that the appearance of the highest black fin reef shark is at 29°C with 55 occurrences and the least appearance of fin reef sharks is at 27°C with 20 occurrences. Overall, the temperature during observation ranged between 27 - 29°C. The stable surface temperature of sea water around Morotai Island shows that the mass of water around this island originates from or is greatly influenced by the mass of seawater. Based on observations that have been made, a stable temperature does not greatly affect the presence of Blacktip reef sharks at the study site. At Station 1 Galo-Galo Point no sharks were found during data collection. The temperature range at station 1 is between 27 - 29°C. The appearance of Blacktip reef sharks at the other three stations is more than that of Station 1 where the temperature range between the four stations is relatively the same, namely between 27 - 29°C.

The water temperature range at station 2 is between 28 - 29°C. The appearance of Blacktip reef sharks was obtained at a temperature of 28°C as many as 3 occurrences. At a temperature of 29°C with 3 occurrences while no emergence was found at a water temperature of 27°C. The water temperature at station 3 is stable at 29°C. At this temperature, 10 Blacktip coral reef sharks appeared.

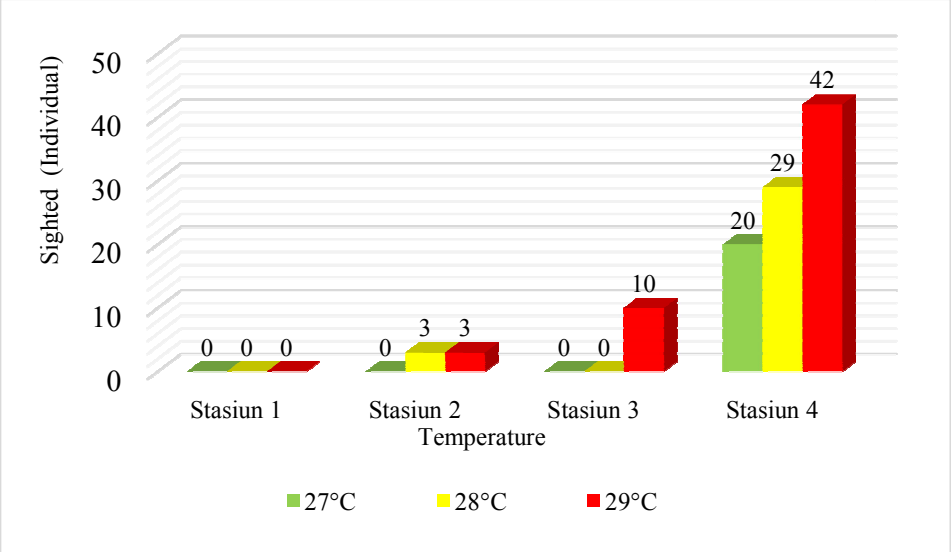



**Fig. 9. Percentage of occurrences based on water temperature**

The most occurrences occur at station 4 with a range of water temperatures between 27 - 29°C and the optimal temperature for the appearance of Blacktip reef sharks at station 4 is 29°C. The influence of water temperature on the appearance of Blacktip reef sharks seen at this station is the higher the temperature of the waters, the more emergence. This is consistent with research conducted in Makassar waters which states that the Carcharhinidae Family generally appears at depths of 0–22 meters in the temperature range between 24 - 30°C with optimal temperatures ranging from 27 - 29°C [19].

Measurement of temperature data is carried out from January to March 2019 wherein that month the west monsoon is taking place. During the western monsoon, warm waters in Indonesia are affected by warm currents and winds from the Asian Continent. Conversely, during the east monsoon, a cold water mass flows from Eastern Australia affecting eastern Indonesian waters [20].

### 3.2.2 Salinity

The measurement results obtained salinity range between 34 - 41 ppt. Stations 4 and 1 have the highest salinity value (41 ppt) compared to other stations. The value of salinity in water is influenced by evaporation, the amount of freshwater entering the waters, "run-off" or surface runoff, tides, rainfall, and seasons [16].

Blacktip reef shark is a type of pelagic and demersal fish that is euryhaline that is a high degree of tolerance to salinity variation, so it can live in brackish water, in addition to the sea as its main habitat [1]. The salinity of open sea waters ranges from 33 - 37 ppt with normal values of 35 - 36 ppt [21]. The distribution of salinity is influenced by several factors such as the pattern of water circulation, evaporation, rainfall, and the surrounding river flow [22].

Based on Fig. 10 it can be concluded that the appearance of most Blacktip reef sharks is 39 ppt salinity with 29 appearances and the least is 34 ppt salinity with 0 occurrences. Salinity on the surface of Morotai waters varies between 33.7 - 34.2 ppt. Salinity at various depths of mixed surface layers (10, 25, and 50 meters) varies between 34.0–34.3 ppt [16]. The salinity is relatively high and indicates that the mass of water around the Morotai waters is the mass of seawater which is estimated to originate from the Pacific Ocean.

Station 1 has a salinity range of 35–41 ppt. At this station, no Blacktip reef sharks were found. Station 2 has a salinity range of 34 - 40 ppt. The appearance of Blacktip reef sharks at this station was only obtained at salinity 39 and 40 ppt. At 39 ppt salinity, counted the appearance of 3 Blacktip reef sharks, as well as at 40 salinity, counted as 3 tails also appeared. This shows that at station 2, high salinity is more optimal for the appearance of Blacktip reef sharks.

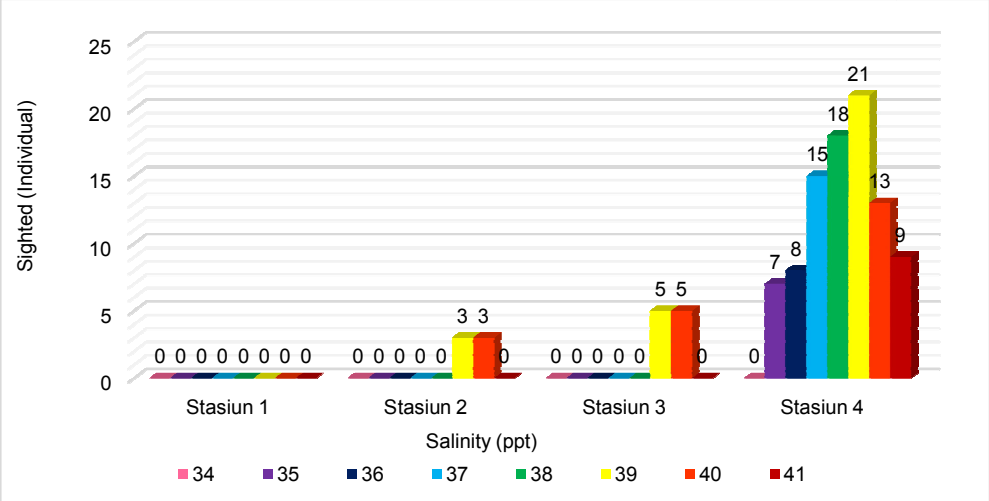



**Fig. 10. The occurrence of blacktip reef shark based on salinity**

Station 3 has a salinity range of 36 - 40 ppt. The appearance of Blacktip reef sharks at this station was only obtained at salinity 39 and 40 ppt. At 39 ppt salinity, counted the appearance of 5 Blacktip reef sharks, as well as at 40 ppt salinity, counted as well as 5 tails. This shows that at station 3, high salinity is optimal for the appearance of Blacktip reef sharks. Station 4 has a salinity range of 35–41 ppt. The appearance of Blacktip reef sharks is found in all levels of salinity. Most occurrences were found at 38 ppt salinity with 18 occurrences and 39 ppt with 21 occurrences.

Overall salinity in the study was 34–41 ppt. No appearance of black fin reef sharks in 34 ppt salinity conditions. The optimal salinity to obtain the appearance of Blacktip reef sharks is 38–40 ppt. The source of freshwater mass in the Morotai waters is thought to originate from the mainland by surface runoff such as river runoff, drainage from the land by residents or by vessels dumping fresh water into the sea [16].

### 3.2.3 Visibility

Visibility is measured based on how far an object can be seen clearly. Visibility is best obtained at station 2 with an average visibility of ± 13 meters. The worst visibility was found at Station 1 with an average visibility of ± 8 meters.

Seawater visibility is influenced by several factors, including currents, tides, and particles dissolved in the waters themselves. Strong currents that come in contact with the water substrate will cause visibility to deteriorate. The high tide will result in improved visibility because the high tide carries water masses from the clear and cold high seas, while tidal waves will cause visibility to deteriorate because tidal waves carry the mass of water from the coast which tends to be turbid and warm. Substrate rocks, corals, and sand will cause visibility tends to be good while mud substrate will cause visibility tends to be bad because the mud will be easily lifted by currents and waves. Indrayana et al. (2014) state that the number of suspended solids in the waters will prevent sunlight from entering the water. The pattern of brightness distribution also depends on the physical process of seawater. Ocean currents can carry suspended solids spread in various directions. Ocean currents have a more important role in the distribution of turbidity in the water column.

Based on the appearance graph (Fig. 11), it can be concluded that 13 differences in water visibility have been obtained. Based on the measurement results, the visibility of the waters is generally quite clear. Good or bad visibility is caused by the lifting of the substrate (sand) due to the shallow physical processes of the waters [23]. Lifting sediments affected by wind as well as waves and terrestrial runoff can sometimes reduce visibility [24].

Station 1 has a visibility range of 5 - 15 meters. At station 1 the worst visibility conditions (5 meters) were recorded during the study. Recorded twice and both together with a strong current state. This shows that the flow affects the merits of the visibility of the waters. At this station also recorded the best visibility conditions (15 meters) during the study and occurred during calm currents. When the current is calm, visibility

at this station will be good because the station has a deep enough depth of ± 36 meters and has a rocky substrate so that it is not easily lifted by calm currents.

Station 2 has a visibility range of 10 - 15 meters. At this station, the appearance of Blacktip reef sharks is only obtained at 10 meters of visibility. Visibility of 10 meters was obtained two times with each observation to get the appearance of 3 Blacktip reef sharks.

Station 3 has a visibility range of 8 - 10 meters. At this station, the visibility range is not large at only 2 meters. This is presumably because during the data collection there were no significant differences in currents and also because the live coral cover that was classified as good at this station made sediments not easily lifted by currents.

Station 4 has a visibility range of 8 - 12 meters and Blacktip coral reef sharks are found in all visibility ranges. At this station, the highest Blacktip reef shark appearance was found at the visibility of 10 meters with a total appearance of 36 tails and the lowest appearance was found at the visibility of 12 meters with a total appearance of 7 tails.

Overall, visibility during the study ranged from 5 - 17 meters but no appearance of Blacktip reef sharks appeared at the visibility of 5, 6, 7, 13, 14, 15, 16, and 17 meters. The appearance of Blacktip reef sharks is only found at the visibility of 8 - 12 meters with optimal visibility of 9 - 11 meters. The appearance of Blacktip reef sharks is the highest invisibility of 10 meters with a total of 44 tails. Visibility of 10 meters is preferred by Blacktip reef sharks for foraging allegedly because this visibility has a pretty good clarity for Blacktip reef sharks looking for prey. Visibility above 12 meters did not result in the appearance of Blacktip reef sharks, presumably because water temperatures declined when visibility was above 12 meters, water temperature decreases were expected due to the mass source of clear water originating from the deep sea.

### 3.2.4 Acidity

The results of field measurements obtained a pH range between 8.13 - 8.44. Station 4 has the highest average pH value of 8,365 and Station 2 has the lowest average pH value of 8.288.

A pH parameter is a unit of concentration of hydrogen ions in solution, usually used to express the acidity or basicity of a solution. The pH value of seawater is generally greater than the neutral pH value. Sea surface pH generally ranges from 7.9 to 8.3 [25]. The variation in pH values is also based on differences in regions and variations in seasons. The pH of seawater is relatively more stable and usually in the range of 7.5 and 8.4, except near the coast. The ideal pH value for waters is 7 - 8.5 [26].

Based on the appearance graph (Fig. 12) it can be concluded that the appearance of the highest Blacktip reef shark is at a pH value of 8.3 with a total of 58 tails and no appearance at pH values 8.1 and 8.2. pH values of 8.1 and 8.2, respectively, were only obtained once in observations. The highest average pH value is station 4 with a value of 8.4 and the lowest average pH is station 3 with a value of 8.3.

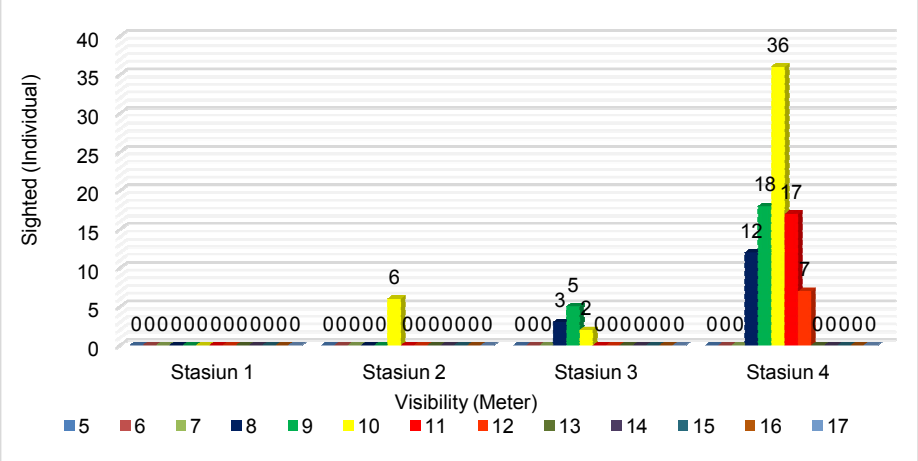



**Fig. 11. Occurrence of blacktip reef shark based on water visibility**

Station 1 has a pH range of 8.1 - 8.5. No Blacktip reef sharks appeared at this station. Station 2 has a pH range of 8.3–8.4 and the appearance of Blacktip reef sharks appears at each of these pH values. At Station 2 at a pH value of 8.3, there were 3 occurrences, and at a pH of 8.4, there were 3 occurrences. Station 3 has a pH value of 8.3. Station 4 has a pH range of 8.3–8.5. At station 4, the appearance of Blacktip reef sharks appeared at all pH values obtained. The most appearances at this station were found at a pH value of 8.3 with a total appearance of 45 animals and the lowest occurrence was at a pH of 8.5 with a total appearance of 9 animals.

Overall, the pH value or the degree of acidity of the waters ranged from 8.1 to 8.5 with the optimal pH to get the appearance of Blacktip reef sharks is 8.3 - 8.5. The pH value obtained at the time of research observation did not differ significantly. Changes in the value of the acidity (pH) which acts as an indicator of water quality can occur as a result of an abundance of chemical compounds, both pollutant, and non-pollutant. Seawater generally has a pH value above 7 which means it is alkaline, but under certain conditions, the value can be lower than 7 so it is acidic. Most aquatic biota is sensitive to changes in pH. The ideal value for aquatic biota life is between 7 - 8.5 [27].

### 3.2.5 Current type

The assessment of the current type is subjective and is measured by the amount of effort made to drive while diving (Personal Communication, Shark Diving Researcher Indonesia 2019). Current types are classified into 4, which is between 0–3. No current is given a value of 0, a quiet current is given a value of 1, a medium current is given a value of 2 and a strong current is given a value of 3. At station 4, during data retrieval, the current strength is included in the strong category. Current conditions at station 3 are in the medium category. Station 2 has a quiet current category. The last station, station 1, has a strong current category.

A general description of circulation in Indonesian ocean waters that clearly shows a seasonal reversal of the surface flow pattern and a clearer seawater mass distribution originating from various locations of the northern or western Pacific Ocean. The Indonesian Ocean is the only inter-oceanic link between the western Pacific and the eastern Indian Ocean [9]. The extent of turbidity in the ocean can be affected by currents, waves, and tides. This is because the movement of seawater carrying suspended substances in the water column spreads in various directions [28]. Surface currents and the interior is more dominant to move south to southwest, this illustrates that the current is the flow across Indonesia, namely the mass of water from the southern Pacific Ocean through the Halmahera Sea [9].

One of the factors that influence the appearance of Blacktip reef sharks is the presence of various types of currents during data collection. In studies conducted on the island of Palau, currents are one of the physical factors that influence the presence of coral sharks [29]. Under various current conditions, the chance of meeting a reef shark is greater than the current majority, which is calm.

Based on the emergence graph (Fig. 13) it can be concluded that the appearance of the highest Blacktip reef shark is in the medium current with a total appearance of 62 tails and the least occurrence is in a state of no current with 0 occurrences. Overall, the current during observation ranged from 0 - 2.5 knots. Based on observations that have been made, a good current to get the appearance of Blacktip reef sharks is a medium current. This happens at station 4 where most sharks occur when the current is strong. At station 2, the Blacktip reef shark only appears at medium current strength with a total of 6 occurrences. No occurrence occurs when the situation is not current.

Measurement of this flow is carried out in January - March 2019, which in this month the west season period takes place. Ocean currents in eastern Indonesian waters reach a minimum due to the presence of Arlindo which is not so strong, especially in the west season. Arlindo which is short for Lintas Lintas Indonesia or better known by oceanographers with the term "Indonesian Through Flow", is the mass flow of water between oceans passing through Indonesian waters [30]. Local tide factors, equatorial currents, Arlindo, and monsoon winds are thought to be the main components driving the current movement in Morotai waters [16].

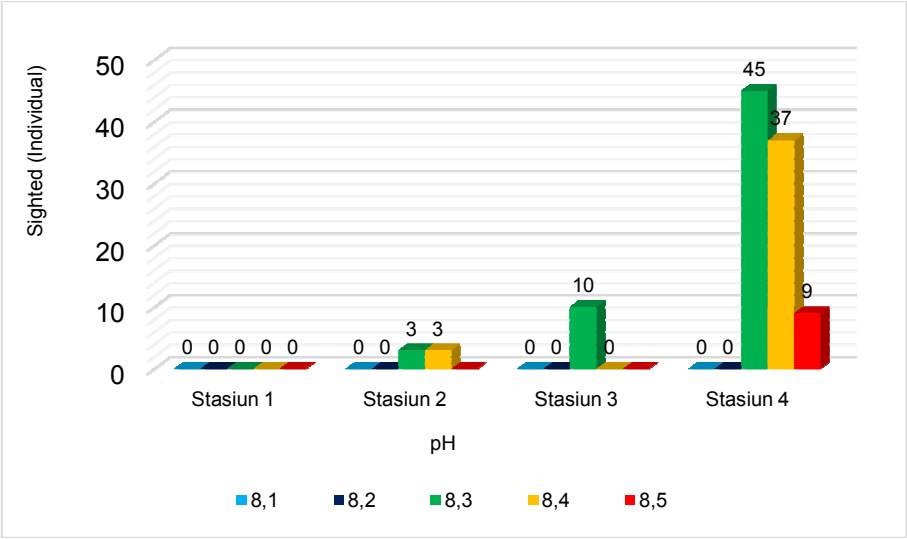



**Fig. 12. The occurrence of blacktip shark fin based on acidity**

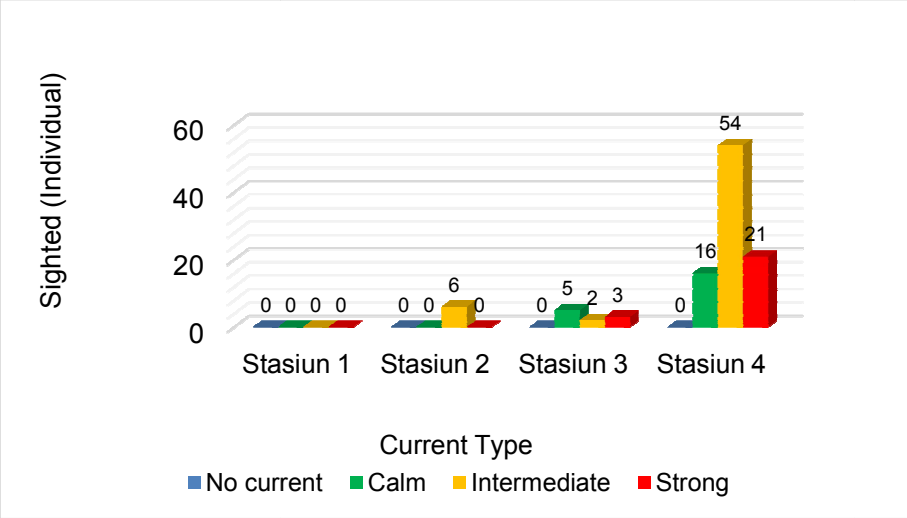



**Fig. 13. The appearance of blacktip reef sharks based on the current type**

### 3.3 Distribution of Blacktip Reef Sharks

*Carcharhinus melanopterus* is a widely distributed type of coral shark. The distribution of Blacktip reef sharks is not only influenced by the physical-chemical characteristics of water but is also influenced by the condition of coral reefs. The moon and tidal phases can also affect the appearance of Blacktip reef sharks in the waters.

Station 1 has the steepest contours compared to other stations. Station 1 is located in a channel contour on Morotai Waters. This station has a depth of ± 35 meters which is the deepest of the four research stations. The percentage of live coral cover at station 1 is 11% and is classified as a bad category. The coral reef at Station 1 was dominated by the soft coral category at 44% and followed by the fleshy seaweed category at 23%.

The distribution of Blacktip reef sharks at Station 1 (Galo-galo Point) does not exist, meaning that no Blacktip reef sharks was observed during data collection. Station 1 is recorded to have the strongest average current compared to other stations. The coral reefs at this station have the softest coral cover compared to other stations at 44%. Coral reefs are known to play an important role as a place to live a variety of marine life.

Poor coral reefs will result in reduced marine life that occupies the coral reef ecosystem. The absence of the appearance of sharks caught at this station is following Compagno [31] which states that *C. melanopterus* lives in shallow water reefs.

Station 2 (Dodola Point) has a sloping contour but not as steep as the contour of Station 1. This station has a depth of ± 28 meters. Station 2 has a percentage of live coral cover of 55% and is classified as good category. This percentage is the largest percentage of live coral cover compared to the other four stations. Station 2 is dominated by Non-Acropora category coral reefs which recorded as much as 35% and followed by the Acropora category as much as 20%.

The distribution of Blacktip reef sharks at station 2 is relatively less compared to distribution at station 3 and station 4. During 7 observations made, only 2 observations succeeded in capturing the appearance of Blacktip reef sharks. Each of the observations managed to capture 3 occurrences. Therefore, the total appearance of Blacktip reef sharks caught during the research observation was 6. Based on the physical-chemical properties obtained together with the emergence data, the parameters that most influence the occurrence are flow, salinity, and moon phase.

The current range recorded at station 2 is from no current to moderate current. The current is recorded twice, accompanied by the appearance of Blacktip reef sharks. 39 ppt salinity was recorded once and 40 ppt salinity was also recorded once. The appearance of Blacktip reef sharks was found in both salinity conditions. The new moon phase is the phase when the percentage of moonlight is 0 - 10%. During the 3 observations made in the new moon phase, two of them found the appearance of Blacktip reef sharks.

Station 3 (Pasir Point) Island has a fairly gentle slope but not as a contour as Station 4. This station has a depth of ± 18 meters. Station 3 has a percentage of live coral cover of 29% and belongs to the medium category. The coral reef at station 3 is dominated by soft coral by 26%. At station 3, the diversity of coral reefs was fairly even compared to other stations. There is no coral reef category that is too prominent at station 3.

The distribution of Blacktip reef sharks at station 3 has a pretty good percentage compared to station 1 and station 2. During the research data collection, station 3 had 8 emergences of Blacktip reef sharks. The largest occurrences were obtained as many as 5 occurrences which occurred at a temperature of 29°C, 40 ppt salinity, 9 meters visibility, pH 8.3, type of calm current, full moon phase, and tide in a loose state. At station 3, the parameter that most influences the appearance of Blacktip reef sharks are the tidal state. This can be seen from the 3 observational data that showed the appearance of Blacktip reef sharks during sagging tides.

Station 4 (Mitita Point) has the sloping contours compared to the other three stations. This station also has a depth of ± 17 meters which is the most shallow compared to other stations. Station 4 has the lowest percentage of live coral cover of 1%. From the results of measurements using the PIT method, station 4 is dominated by sand covering 40% and followed by soft coral by 25%.

The distribution of Blacktip reef sharks at Station 4 has the largest percentage of the four research stations. Of the eight times, the data collection appears, all of them managed to capture the appearance of Blacktip reef sharks 91 times. This is following Compagno [31] which states that *C. melanopterus* can live in shallow waters of coral reefs.

The highest Blacktip reef shark appearance at station 4 counted as many as 18 tails. This occurs at temperatures of 29°C, the salinity of 38 ppt, visibility as far as 11 meters, pH value of 8.3, medium current, half-moon phase, and “loose” tide type. At station 4, the appearance of the second-highest Blacktip reef shark counted as many as 15 tails. This occurs at temperatures of 29°C, the salinity of 37 ppt, visibility as far as 10 meters, pH value of 8.3, medium current, half-moon phase, and tidal type. Based on this, the appearance of optimal Blacktip reef sharks occurs at temperatures of 29°C, the salinity of 37 - 38 ppt, visibility as far as 10 - 11 meters, pH value of 8.3, moderate magnitude currents, half-moon phase and tidal type or "slack ".

## 4. CONCLUSION

The results of the study of the distribution of Blacktip reef sharks (*C. melanopterus*) based on habitat characteristics using the Baited Remote Underwater Video (BRUV) method can be concluded as follows:

- Black fin reef shark distribution was found in three of the four research stations.

Station 4 is the station with the most black fin coral reef sharks, which is 91 birds. This station has the most gentle contours and has the smallest live coral cover of only 1%. Station 4 is dominated by sand covering 40%.

- The preffered factor for *C. melanopterus* to appear are temperature 29°C, salinity 38 – 40 ppt, 10 meters of visibility, acidity 7, durring rhe new moon phase, tide are loose and currents are quite strong.

## 5. RECOMMENDATIONS

Some recommendations based on the results of research that has been done are as follows:

- The appearance of Blacktip reef sharks in Morotai waters also needs to be assessed based on seasonal differences.
- Research results can be used as a reference in determining the location of diving for the dive operator.
- Habitat conservation for coral shark protection needs to be done in Morotai.

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## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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