Some Aspects of Bio-ecology of Walking Shark (*Hemiscyllium galei*) in Doreri Bay, Manokwari, Indonesia

Muhammad Fadil Insani, Ridwan Sala*, Duaitd Kolibongso

Department of Marine Science, Faculty of Fishery and Marine Science, University of Papua
Jl. Gunung Salju Amban, Manokwari, Papua Barat, Indonesia
Email: ridwansala@gmail.com

Abstract

Walking sharks are endemic to the New Guinea-Australian region, inhabiting shallow reef ecosystems. In Papuan waters there are four species of walking sharks, including *Hemiscyllium galei*. This research investigated ecological and biological aspects of *H. galei* in Doreri Bay near Manokwari, West Papua Province. The samples used in this study were collected from two locations in the waters of Doreri Bay, namely the islands of Arowi and Nusmapi between September and November 2020. This research was conducted using underwater visual census (UVC) during nighttime. Observations were made at two locations covering a total area 9,000 m^2. A total of 10 individuals (7 males and 3 females) of *H. galei* were collected during the study. They were identified as distinct individuals based on spot shapes on the pectorals. All of them were then measured their morphometric parameters including total length, precaudal-fin length, head length, and body weight. After measurements were taken, all individual sharks were safely released back into their habitat. Morphometric measurements showed the total length of individual walking sharks obtained was no more than 75 cm for both male and female individuals. The abundance estimates of *H. galei* at Arowi and Nusmapi were 13,33 $ind.ha^{-1}$ and 8,88 $ind.ha^{-1}$ respectively. Analysis of length-weight relationship showed a negative allometric growth pattern, where body length growth was faster than weight gain. Based on the present study, walking sharks probably occupies only a limited area in Doreri Bay, and are therefore very vulnerable to the daily activities of humans living in the vicinity.

Keywords: *abundance, meristic, length-weight relationship, growth, endemic species*

Introduction

Indonesia is known for its exceedingly rich marine biodiversity, located in the heart of the Coral Triangle region of southeastern Asia. It is the home of numerous endemic species (Allen and Erdmann, 2008), including several species of walking sharks belonging to the family Hemiscylliidae. There are nine species of walking sharks, including six species in eastern Indonesia, of which four occur in Papua and West Papua *i.e. Hemiscyllium henryi, Hemiscyllium strahani, Hemiscyllium galei, and Hemiscyllium freycineti* (Allen *et al*., 2016; Dudgeon *et al.,* 2020).

The Bird's Head Seascape (BHS) which encompasses the West Papuan region is inhabited by three species of walking sharks, including *H. freycineti* (mainly Raja Ampat Islands), *H. henryi* (Triton Bay region), and *H. galei* (Cenderawasih Bay). All three species are considered either vulnerable or endangered by the International Union for Conservation Nature (IUCN, 2021). *H. galei* inhabits coastal ecosystems, including coral reefs and seagrass of Doreri Bay. However, coastal ecosystems of Doreri Bay are degraded due to the increasingly massive development in coastal areas. This is indicated by the decreasing percentage of coral reef cover (Pattiasina *et al*., 2018; Dasmasela *et al*., 2018; Algutomo, *et al*., 2022). There is concern that degradation of coral reefs will directly impact the population of *H. galei.* Nearly all *Hemiscyllium* species have highly localized distributions and are particularly vulnerable to habitat degradation, including pollution and illegal fishing practices (*e.g.* use of cyanide), and climate change (Jutan *et al*., 2018). Their vulnerability is especially enhanced due to their egg-laying habits and low fecundity, poor swimming ability, and ease of detection by local fishers. Furthermore, these sharks are utilized by humans for food, medicine, and aquarium pets for display in public aquaria (Jutan *et al*., 2018).

In an effort to conserve and protect the species, information on its ecological and biological aspects are urgently needed, since this information is very

*) Corresponding author

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limited. The only information regarding this species is reported by Allen *et al.* (2016). Therefore, it is important to conduct this research to support the information needs of this species in the waters of Doreri Bay.

Materials and Methods

This research was conducted from September - November 2020 in Doreri Bay, Manokwari. Observations were made at 2 locations, namely Arowi and Nusmapi (Figure 1.). Observations of *H. galei* were carried out using Underwater Visual Census (UVC) with a total of 16 night dives (between 19:00 and 00:00 Eastern Indonesia Time), which were divided into 8 dives at each location. The reason for choosing the nighttime was because the walking shark is a nocturnal fish. The observations in each site were conducted twice in September 2020 and three times in October and November 2020. Ten dives were taken place during high tide and six dives were done during low tide.

The observations were taken along transects of 300 m in length with a width of 5 m. Observations were carried out 3 times at each station by two divers. Transects were located parallel to the shoreline at a depth range of 3 to 7 m. Specimens were captured by hand, placed in a container filled with seawater, and brought ashore for morphological measurements. After the measurements were completed, the sharks were released back into the water.

To ensure that the same walking shark was not measured more than once in different dives or times, we conduct identification of each individual based on observing the shape and size of dark spots on the pectoral fins, which differ between individuals. The blackspot shape on the pectoral fin of walking sharks is a characteristic possessed by each Hemiscyllium individual (Allen *et al.*, 2016). Examples of spot shapes on the pectorals of some walking sharks are shown in Figure 2.

Measurements included total length (TL), precaudal-fin length (PCL), head length (HL), body diameter (BC), and body weight (BW) (Omar, 2011; Madduppa *et al*. 2020). However, BC measurement was performed. Linear measurements with an accuracy of 0.1 cm, were made on a measuring board and sharks were weighed using a scale with an accuracy of 0.01 gram.

Estimation of the abundance of walking shark used formula D= N_i/A, D denotes density in ind.ha^{-1}, N_i is the number of individuals found in each site, and A is the estimated area covered during the dives. Le Cren (1951) as cited by Khouw (2016), states that length-weight relationship analysis was carried out to determine growth patterns The relationship follows the formula W= aL^b, where W= individual weight; L= individual total length; a and b= constant. When the value of b equals 3, it indicates an isometric growth pattern, and when b≠3, it shows an allometric growth pattern (negative allometric when b<3 and positive allometric when b>3).

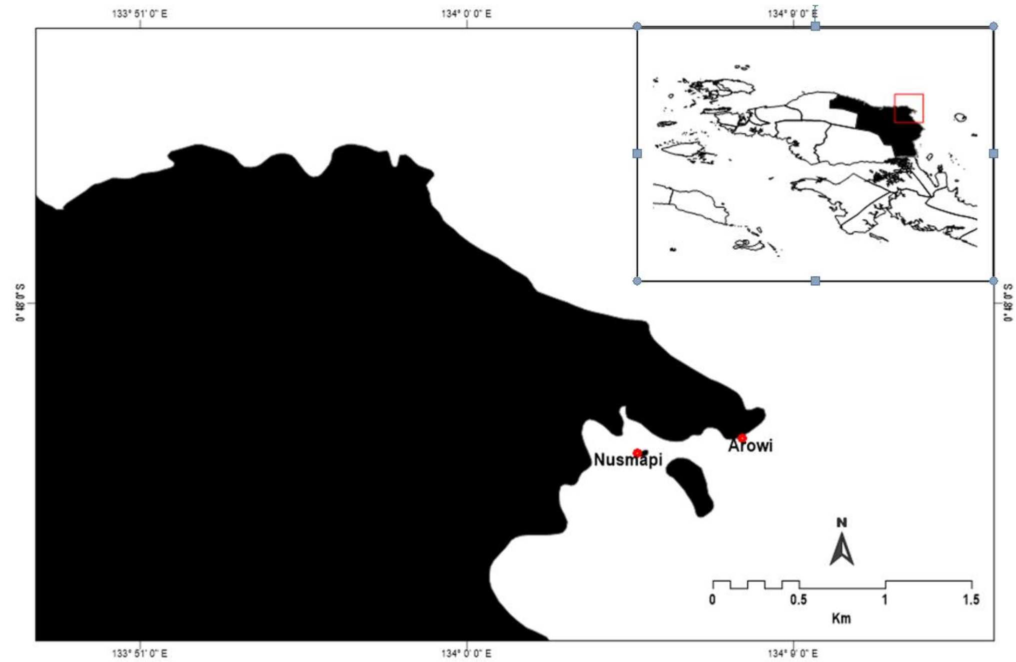

Figure 1. Sample collection sites of *Hemiscyllium galei* in Doreri Bay, Manokwari.

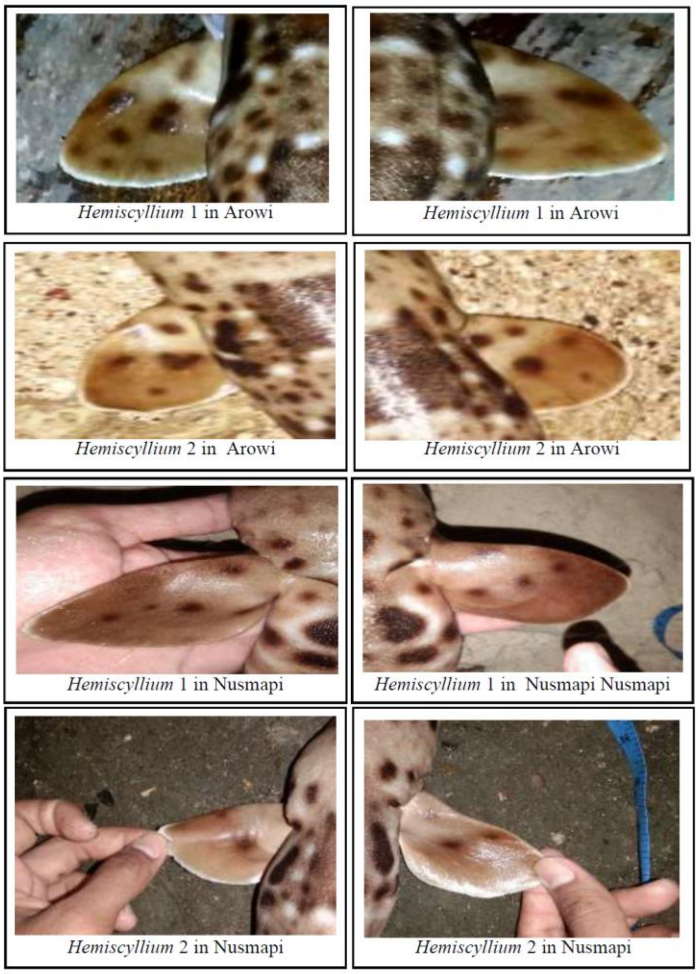

Figure 2. Examples of spot shapes on the pectorals of some walking shark. Photo: Muhammad Fadhil Insani

Result and Discussion

Morphological characteristics

H. galei has a relatively slender body morphology with two dorsal fins of similar size. The shape of the mouth is short and blunt. Other diagnostic features included two or more black spots or saddles on the anterior edge of the dorsal fins, and a combination of white lines and patches along the body (Figure 3.). A detailed description of this species was provided by Allen *et al.* (2016).

A total of 7 walking shark individuals were identified as male, while the other 3 individuals were female. Table 1 shows the morphometric measurements for each individual. The average total length was 67.2±5.4 cm. The largest male was 74 cm TL and the largest female was 72 cm TL. The average size of males tended to be larger than that of females. Generally, *Hemiscyllium* sharks have a small body size of no more than 85 cm, with an average total length of about 70 cm (Heupell *et al.*, 1999; Allen and Erdmann, 2008; Allen *et al.,* 2013; Widiarto *et al.*, 2020; Madduppa *et al.*, 2020; Mu'min *et al.*, 2021). Allen *et al.* (2016) reported that the largest size for the genus is 81.5 cm TL, recorded for *Hemiscyllium henryi*. In addition, Last and Steven (2009) reported a maximum size of 107 cm TL for *Hemiscyllium ocellatum* from Australia, while Janson *et al.* (2012) and Allen *et al.* (2016) reported 84.0 cm TL and 65.7 cm TL, respectively for the same species.

Abundance and habitats of H. galei

Observations of *H. galei* were made at two locations in Doreri Bay with a total coverage area of 9,000 m^2 (observation area of 4,500 m^2 per location per night). The highest abundance value was at the Arowi, which had a density of 13.33 ind.ha^{-1}, while at the Nusmapi Island, the estimated density was 8.88 ind.ha^{-1}. The difference in the number of *H. galei* encountered at the two locations was probably influenced by tidal conditions. It was easier to detect individuals of *H. galei* during high tide; six individuals were found at high tide from a total of 16 dives. Tapilatu (2021) mentioned the low abundance of walking sharks. Likewise, that walking shark occupies only a limited area. Thus, the population is very vulnerable to exploitation by humans.

The genus *Hemiscyllium* was commonly found foraging in shallow water of coral reefs and seagrass beds. Their foraging activities were influenced by tides and light. Most of the sharks actively forage at night or after dusk (Compagno, 2001; Allen *et al.*, 2013; Bennett *et al*, 2015). Our observations revealed that walking sharks were generally found on seabed substrates in the form of live coral reefs, coral patches in sandy areas, or coral rubble. Rubble was the most common substrate type (Table 2.).

Oceanographic conditions recorded in each sites shows values as follows. Water temperature of 28.03-30.06 ^{o}C, water transparency of 12–14 m, current speed of 0.4–0.7 ms^{-1}, Salinity of 33–36 ‰, pH of 7.0–7.6 and dissolved oxygen of 6.3–7.0 mg.L^{-1}. Referring to the environmental quality standard reference issued by the Indonesian

a b c

Figure 3. (a) *Hemiscyllium galei*; (b) Female specimen showing vent; (c) Male specimen showing claspers. Photo: Muhammad Fadhil Insani

Table 1. Meristic comparison between *H. galei* male and female

	Females (n= 3) (mean±SD)	Males (n= 7) (mean±SD)	All (n= 10) (mean±SD)
TL (cm)	66.3±7.4	67.6±5.1	67.2±5.4
PCL (cm)	55.7±7.1	57.9±5.0	57.3±5.4
HL (cm)	9.5±0.9	9.9±1.3	9.8±1.1
BW (g)	820±269.3	773±121.1	787±162.6

Note: TL (total length), SL (standard length), HL (head length), and BW (body weight).

Table 2. Data collection at two sites with sample ID including meristic of individual *Hemiscyllium galei* which was found at their substrates in each site

Site	Sample ID	TL	PCL	HL	BW	Sex	Substrate types
Arowi	Arowi-01	72	61	10,3	920	F	Sandy corals
Arowi	Arowi-02	70	60	10.2	800	M	Sandy corals
Arowi	Arowi-03	60	51.7	9	565	M	Coral reefs
Arowi	Arowi-04	58	47.6	8.6	515	F	Coral rubbles
Arowi	Arowi-05	62	52.4	9.3	670	M	Coral rubbles
Arowi	Arowi-06	71	62.5	10.8	820	M	Coral rubbles
Nusmapi	Nusmapi-01	74	63.2	12	940	M	Coral reefs
Nusmapi	Nusmapi-02	66	54.2	8	785	M	Coral rubbles
Nusmapi	Nusmapi-03	69	58.5	9.8	1085	F	Sandy corals
Nusmapi	Nusmapi-04	70	61.8	10	830	M	Coral rubbles

Note: Total length (TL), precaudal-fin length (PCL), Head Length (HL), body weight (BW). Length measurements are in centimeters (cm) and weight in gram (g). Sex (Male= M, Female= F)

Table 3. The relationship between length and weight of *H. galei* including number of samples (n), a and b coefficient, correlation coefficient (r) and growth pattern

Location	n	a	b	The correlation coefficient (r)	Growth patterns
Arowi	6	0.040	2.341	0.98	Allometric negative
Nusmapi	4	4.295	1.257	0.49	Allometric negative

Ministry of Environment (Minister of Environment Decree No. 51 of 2004), the water quality at the research sites is classified as good. Thus, it can be said that walking sharks need a good quality aquatic environment to support their lives. There is very limited scientific information regarding environmental impact on walking shark lives. One useful information is a finding that optimum growth of *Hemiscyllium ocellatum* occurs at temperature higher that 27°C and the growth decreases when reach temperature of 31°C (Wheeler *et al*., 2021).

Length-weight relationship (LWR) and growth pattern

LWR analysis of *H. galei* in the waters of Doreri Bay is shown in Table 3. The values of the regression coefficients (b) were 2.341 dan 1,257 for the walking shark population in Arowi and Nusmapi respectively. The correlation coefficient (r) for LWR of population of *H. galei* found in Arowi was 0.98 and in Nusmapi was 0.49. Positive r values of LRWs show that the weight increase as the length increases (Walpole, 1995). Based on the b values, it indicated that *H. galei* in Doreri Bay had negative allometric growth, which indicates the length increase is faster than the weight gain. Allometric negative growth patterns found in this study agree with the pattern of growth of *H. halmahera* found in Kao Bay, Halmahera (Jutan *et al.,* 2017). In general, the growth pattern of fishes depends on physiological and environmental conditions such as temperature, pH, salinity, geographic location and also biological conditions such as gonadal development and food availability (Froese, 2006).

Conclusion

The abundance of walking shark (*H. galei*) in Doreri Bay was relatively low with individual sizes, both male and female, not exceeding 75 cm. In addition, the growth form of this species was found to tend to follow the negative allometric, where the length gain was faster than the weight gains or the fish tended to be thin. Some of this information has management implications, especially for protecting the species from exploitation by the surrounding communities. Further, there is a need for habitat protection, especially coastal ecosystems (coral reefs) and prevention of pollution of the waters of Doreri Bay, especially due to increased development and settlements in the city of Manokwari which can increase domestic waste from the mainland.

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