BIOEDUSCIENCE
ISSN: 2614-1558
http://journal.uhamka.ac.id/index.php/bioeduscience

Condition Factors and Growth Patterns of Mantis Shrimp (*Harpiosquilla Raphidea*) in the Estuary Waters of Berombang River

Yulistiani [1] , Rivo Hasper Dimenta [1*]

[1] Biology Education Study Program, Faculty of Teacher Training and Education, Labuhanbatu University, Jalan Sisingamangaraja No.126, Bakaran Batu, Labuhanbatu Regency, North Sumatra, Indonesia, 21418.
* Correspondence: rivohd11@gmail.com

Abstract

Background: Mantis shrimp is one of the favorite shrimp caught by fishermen around the estuary waters of Berombang River, Labuhanbatu Regency. This study aimed to determine the mantis shrimp population's condition factors and growth patterns. **Methods:** Three station points were determined using a purposive random sampling method. The sampling of *Harpiosquilla raphidea* was carried out using trawl nets. The data analysis provided information on growth patterns and condition factors. **Results:** The results showed that the growth patterns of male *H. raphidea* belonged to the positive b> three allometric categories, where weight growth was faster than carapace growth. Moreover, the growth patterns of female *H. raphidea* belonged to the negative b<3 allometric category, where the carapace growth was more rapid than body weight growth. The value of Fulton (K) condition factors for male *H. raphidea* ranged from 3.54 to 13.18; for females, it went from 15.28 to 22.09. The value of correlation analysis of Physic-chemical parameters, water temperature (0.935), and DO (0.832) showed the high category correlation test results. **Conclusions:** This result indicated that from November 2021 to January 2022, the condition of *H. raphidea* population around the estuary waters of Berombang River was known and predicted to be in the adult stage.

Keywords: Condition factor; Estuary waters; Growth pattern; *Harpiosquilla raphidea*

Article history
Received: 5 May 2022
Accepted: 25 July 2022
Published: 31 Aug 2022

Citation: Dimenta, R.H. & Yulistiani. (2022). Condition Factors and Growth Patterns of Mantis Shrimp (*Harpiosquilla Raphidea*) in the Estuary Waters of Berombang River. *BIOEDUSCIENCE. 6*(2), 181-197. doi: 10.22236/j.bes/629054

Introduction

Mantis shrimp is one of the sea shrimp types, including *Arthropoda* phylum, *Crustacea* subphylum, *Malocostraca* class, and *Stomatoda* order. More than 100 genera and 400 species have been recognized (Erdmann & Barber, 2000; Pujawan et al., 2012). In addition, there are five superfamilies, namely *Erythrosquilloidea, Gonodactyliodea, Bathysquilloidea, Lysiosquilloidea,* and *Squilloidea*, and are divided into 20 families, in which the genus *Harpiosquilla raphidea* (Fabricius) is the largest species and can reach a total length of more than 300 mm (Manning, 1969; Astuti & Ariestyani, 2013). Mantis shrimp has other names: sudden shrimp, ronggeng shrimp, centipede shrimp, eiko shrimp, and grasshopper shrimp. It is called mantis shrimp or praying shrimp (Sukarni et al., 2018). In the Serang area, Banten, mantis shrimp is known as cakrek shrimp or plethok shrimp. In contrast to the Indera Giri Hilir area, the Riau mantis shrimp is the grandmother shrimp. While in Australia, the mantis shrimp is called the "Prawn killer" (Situmeang et al., 2017).

The morphology and appearance resemble a praying mantis, making *H. raphidea* shrimp called mantis shrimp. The mantis shrimp is unique and has two eyes that can rotate 360 degrees and function as radar (Astuti & Ariestyani, 2013). In addition, the body shape is a combination of shrimp, lobster, and praying mantis (Sukarni et al., 2018).

Wortham-Neal (2002); Nane (2019) stated that the mantis shrimp has separate sexes; the testicles are like a shorter thread and end in the body cavity. The ovary is like a long thread to the front of the body cavity. Ecologically, the mantis shrimp is one of the most conspicuous members of the large littoral and sublittoral benthic animals that live in soft sediments worldwide (Wardiatno et al., 2010; Dimenta et al., 2020).

Mantis shrimp is a catch with high economic value (Dimenta et al., 2019). Mantis shrimp has potential economic value if it is exported in living conditions to various countries. In Indonesia, mantis shrimp have been traded for export and consumption commodities (Wedjatmiko, 2007; Ramdhani et al., 2019). Mantis shrimp is one of the primadonnas of capture fisheries in Indonesian waters due to market demand and high economic value (Dimenta, Machrizal, Safitri, et al., 2020). The selling price of mantis shrimp among Berombang river traders ranges from Rp. 10,000/kg for small shrimp and Rp. 25,000 - Rp. 100.000/kg for medium and giant prawns. Then, international market prices range from $3.5/head, and national markets range from Rp. 45,000/kg (Wardiatno et al., 2010; Dimenta, R. H., et al., 2020).

Mantis shrimp have different mineral compositions due to the capture of mantis shrimp populations from other areas (Mashar & Wardiatno, 2011). The content in mantis shrimp is very vital for the intelligence and growth of children. Mantis shrimp contains Omega 3 vitamins B12 and D. In addition, microminerals such as calcium, potassium, sodium, iron, zinc, and nutrients in 43.91% protein, 12.35% fat, and 16.01% crude fiber. The efficacy of mantis shrimp is to maintain bone health, eye health, and the formation of red blood cells and to prevent anemia (Mashar & Wardiatno, 2011; Situmeang et al., 2017).

According to Mashar & Wardiatno (2011); Sukarni et al. (2018), many mantis shrimp are found in Indonesian waters, especially in coral reefs and muddy beaches, brackish waters, often found in coastal areas and aquaculture. Beach is the habitat for most mantis shrimp; being on the seabed, especially on the muddy sand, is a favorite of mantis shrimp. These organisms dig their burrows for shelter, reproduction, and foraging for food (Wardiatno & Mashar, 2013). Widyaningtiwi et al. (2013) stated that the growth pattern of mantis shrimp is also influenced by its habitat.

Other *H. raphidea* species are found in the most complex coral reefs. They play an important role in coral reef ecosystems as bioindicators in marine ecosystems, which protect and maintain all existing populations and species, either directly or indirectly. The habit of mantis shrimp that behaves in digging holes in the coral reef allows coral reefs to oxygenate to be healthier and more awake (Pujawan et al., 2012).

The cause of the low diversity of mantis shrimp is thought to be due to several factors; one of them is the fishing area. The following is a map of the mantis shrimp fishing area in the waters of the Berombang River.

The estuary of Berombang River is located in Panai Hilir District, Labuhanbatu Regency, North Sumatra (Murni & Dimenta, 2021). The community's main activities around the Berombang river are dominated by plantation activities, palm oil processing factories, farmers, river pier crossings, salted fish factories, and traditional fishing activities (Murni & Dimenta, 2021). Mantis shrimp of the *Harpiosquilla* genus are widely found in the waters of Bagan Sitoekang. The type of *H. raphidea* is one of the genus *Harpiosquilla* caught by fishermen.

The fishing gear used is another factor influencing the low diversity of the identified mantis shrimp species. The bottom of the water that is not rocky is one of the requirements for a good fishing area for catching, and water areas with a less sandy bottom need to be considered in determining the fishing area (Situmeang et al., 2017). This study aims to determine the condition factors and growth patterns of the mantis shrimp population in the estuary waters of Berombang River, Labuhanbatu Regency, North Sumatra.

Figure 1. Research Station Map

Method

Time and place

This study was conducted for three months, from November 2021 to January 2022. The research location was around Sei Berombang, Panai Hilir District, Labuhanbatu Regency.

Tools and materials

The tools used were a vernier caliper, ruler/vernier caliper with 0.1 mm accuracy, a digital scale with 0.1 g accuracy, a digital camera, trawl net (1-4 inch), markers, Styrofoam box, and stationery. The materials used were mantis shrimp, ice cubes, tissue, label paper, and 70% alcohol.

Sampling Procedure

The observation stations were determined by purposive random sampling so that it can be expected to obtain data representing the location. The samples were taken directly from the research location: of Poekat Beach, Bagan Sitoekang, and Sei Berommodelsee (Figure 1). The samples of various sizes were in perfect condition or had body parts still intact. The fishing location was recorded using a printed map given to fishermen as additional data. The collected samples were taken to the laboratory.

Data analysis

Growth Patterns

The growth patterns of mantis shrimp can be known through the relationship between carapace width and body weight through the equation referred to by Pratiwi & Dimenta (2021) below:

$$\mathbf{W = aLb \text{ atau } LnW = Lna + bLnL}$$

Description:
W = Wet weight (g);
L = Carapace width of *H. raphidea* (cm);
a and b = Constant.

The carapace width and weight growth can be estimated from the value of constant b, constant b (SPSS effect). The two parameters of the interaction correlation phase refer to Dimenta & Machrizal (2017); Ambarsari (2016). If the value of b = 3, the interaction relationship is isometric (the growth pattern of carapace width is proportional to weight growth). Moreover, if the value of b≠3, it belongs to the allometric category, in which, if the value of b>3, the allometric is positive (weight growth is faster than carapace growth). Moreover, if the value of b<3, the allometric is negative (carapace growth is more rapid than body weight growth).

Condition Factor

The condition factor is a parameter that shows an environment's physical and biological conditions for index growth and the average size of mantis shrimp (Iftitah et al., 2017). Here's the formula used to find the relative weight value (Wr):

$$Wr = W/Ws \times 100$$

Description:
Wr = relative weight gain;
W = weigexactf each sample;
Ws = same sample standardization weight prediction because it is calculated from the combined length-weight regression through the distance between species.

$$K = WL^{-3} \times 100$$

Description:
K = Condition Factor;
W = Weight (g);
L = Length (cm);
3 = Long coefficient to ensure that the value of K tends to approach the number 1 (one)

The condition factors indicate a species's good condition in terms of physical capacity for survival and reproduction (Wujdi et al., 2012). Several other factors, such as habitat, gender, and gonad maturity level, influence differences in condition factor values; differences in condition factor values are caused by differences in the needs of environmental conditions (Zulfahmi et al., 2021).

Result and Discussion

This study examines the mantis shrimp (*H. raphidea*) in the estuary waters of the Berombang River area. A thorough intensive still needs to be carried out in the estuary waters of Berombang River, North Sumatra Province. This is done to determine the continuation of the stock of mantis shrimp production in the future.

Growth Patterns

The relationship between growth patterns of mantis shrimp in the estuary waters of Berombang River is calculated based on the sex ratio. The value of the relationship between the length and weight of male *H. raphidea* with a (b) value is 3.184, while the growth value of female *H. raphidea* is (b) 2.954. The relationship between the length and weight of *H. raphidea* can be seen in figure 2.

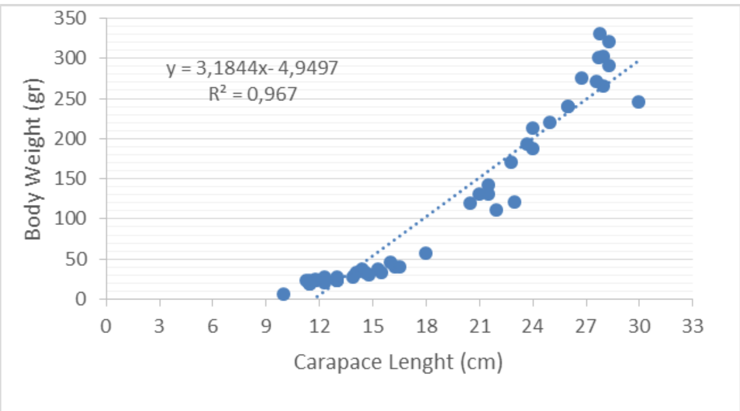

Figure 2. Length and Weight Relationship of Male *Harpiosquilla raphidea*

The analysis of male *H. raphidea* shows that b>3, which indicates a positive allometric growth pattern. In contrast, the analysis results of female *H. raphidea* b<3, female mantis shrimp in the estuary area with waves, is allometric negative. The constant values for male and female *H. raphidea* based on the b value test of mantis shrimp (*H. raphidea*) in estuary waters of Berombang River indicate that at three points, the station has a different b value. The relationship between the length and weight of female *H. raphidea* can be seen in figure 3.

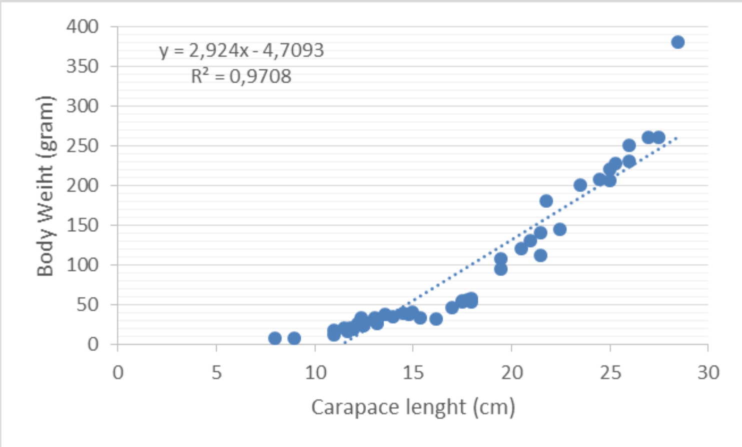

Figure 3. Length and Weight Relationship of Female *Harpiosquilla raphidea*

According to Ekalaturrahmah et al. (2020), the relationship between the length and weight of both male and female mantis shrimp is due to environmental characteristics such as food supply and habitat. In addition, seasons also affect differences in the abundance of male and female mantis shrimp. This is similar to Ambarsari's (2016) statement that seasonal conditions affect fishing activities in Pelabuhanratu bay. In Pelabuhanratu waters, the growth pattern of mantis shrimp is negative allometric (b<3), the length and weight values of male mantis shrimp are 2.7191 grams, and the length of the female mantis shrimp is 2.5923 grams, where the pattern of growth in length is faster than the growth in body weight. Meanwhile, in the estuary waters of Berombang River, the length-weight relationship of male *H. raphidea* shows b>3 (3.184). The allometric growth pattern is positive, and the female *H. raphidea* shows b<3 (2,954), which means the alloharmfulrowth pattern is negative. Muzammil (2010); Mulyono et al. (2016) informed that the minimum and maximum lengths of male mantis shrimp on the Kuala Tungkal Beach, Jambi Province are 5.2 cm–22.8 cm, and the minimum and maximum lengths of female mantis shrimp are 2.75 cm and 23.3 cm. Based on morphological characteristics, the most extended total is found in Ba. The which is 331 mm, and the most petite mantis shrimp is found in Banten bay with a value of 135 mm (Salim et al., 2020), while the length of male and female mantis shrimp in Tarakan waters is recorded at 14.01±4.13 cm and 12.92±2.74 cm, respectively. In another study conducted by Arshad et al. (2015) in the coastal waters of Remis, Perak, Peninsular Malaysia, male mantis shrimp's total length and total body weight is 2.538-2.858 grams, and female is 2.784-2.984 grams. This indicates that the growth pattern is negative allometric (Antony et al., 2014). Moreover, the carapace length and total weight of male (103-207 mm) and female (104-222 mm) mantis shrimp in the southeastern coastal waters of India shows negative allometry.

Biological and Conditional Factors (Fulton)

The results of the three stations show that the value of relative weight factor (Wr) for male *H. raphidea* (46.15-143.85) is on average (101.87±12.83), and for female *H. raphidea* (60,13–147.03) is on average (100.89±11.16). The value of the Fulton condition factor (K) in the estuary waters of Berombang River, Labuhanbatu Regency, at three stations are male *H. raphidea* (3.54–13.18) on average (8.27±0.75) and female *H. raphidea* (15.28–22.09) on average (18.23 ± 1.25). The condition factor values studied at the three stations are generally not much different. Thus, based on the results of the condition factor values, it can be concluded that the mantis shrimp (*H. raphidea*) has almost the same level of plumpness. The value of the relative condition factor (W) and the value of the Fulton condition (K) of the three research stations can be seen in table 1.

Table 1. Biological Parameters of *H. raphidea*

Parameter	Male (n=112)	Average	Female (n=153)	Average
Carapace Width (cm)	10,10 – 30,25	18,79 ± 1,52	8,13 – 28,52	17,14 2,11
Shrimp weight measured, W (gram)	5,52 – 330,38	115,4±15,37	7,15 – 380,63	86,72 ± 7,26
Predicted weight, Ws (gram)	10,83 – 358,19	113,88±7,21	5,89 – 309,72	84,65±5,42
Relative weight (Wr)	46,15 – 143,85	101,87±12,83	60,13 – 147,03	100,89±11,16
Fulton condition factor (K)	3,54 – 13,18	8,27 ± 0,75	15,28 – 22,09	18,23 ± 1,25
Coefficient of determination (r^2)	0,967	-	0,9708	-
b value	3,184	-	2,954	-

Napisah & MaChrizal (2021) informed that if the Fulton condition factor value reaches above 100, the population in water is still in good condition. On the other hand, if the Fulton condition factor is below 100, the water population is in poor condition. Kasril et al. (2017) added that if the Fulton condition factor value is 100, the waters are still in a balanced state.

Based on the analysis results, the condition factor value of Fulton (K) *H. raphidea* in the estuary waters of Berombang River, Labuhanbatu Regency, belongs to the low category. The common condition factor of mantis shrimp (*H. raphidea)* may be influenced by feed availability in natural habitats or nutritional resources.

The Correlation Analysis of Environmental Parameters on the Abundance of H. raphidea

The results of the correlation analysis of environmental parameters on the abundance of *H. raphidea* in the estuary waters of the Berombang River area are presented in table 2.

Table 2. Pearson'S Correlation of Environmental Parameters on the Abundance of *H. raphidea*

	Parameter	r^2
Physics		
1	Water Temperature	0,935
2	Water Brightness	0,629
Chemical		
3	DO	0,832
4	Water pH	0,468
5	Water Salinity	0,792
6	Nitrate	0,727
7	Phosphate	0,704

The value of correlation analysis shows that water temperature is a Physico-chemical parameter with the highest positive correlation and most influences the diversity of mantis shrimp in the estuary waters of the Berombang River area by 0.935. The acquisition of water temperature values also affects the Physical-chemical measurements carried out daily. Noor & Ngabito (2018) explained that changes in the intensity of solar radiation would be in sync with changes in water temperature. Sugianti & Astuti (2018) added that temperature conditions significantly affect water gas solubility and biological activity.

The DO parameter with a value of 0.832 indicates a positive correlation test result with a high level of correlation. Decree of the Minister of Environment No. 51 of 2004 states that >5 mg/l is a good DO level for aquatic biota. Sanusi (2004); Dimenta et al. (2020) stated that the range between 5.45-8 mg/l is a good DO value for marine biota life. Barus (2004); Harahap (2019) mentioned that the level of pollution in an aquatic ecosystem is described by the value of the solubility of oxygen as an indicator. Organic compounds in the form of waste discharged into river bodies will increase the bacteria population that decompose organic compounds in water. A decrease in dissolved oxygen value indicates contamination of organic compounds in water.

Another parameter that shows a high correlation is water salinity, with a value of 0.792. This indicates that the salinity value is still in the appropriate category for the life of *H. raphidea* around the estuary waters of the Berombang River. Arizuna et al. (2014) informed that research conducted in the river and estuary waters of Wedung Demak river, carried out at three different times, resulted in salinity values of 25, 25, and 24. While in the Kapuas Kecil River, Purnaini et al. (2018) reported that the distribution of Horizontal salinity from upstream to downstream during the dry season at several stations shows values ranging from 1.55-15 ppt and 5-30 ppt. In contrast to the research by Husen (2016), the results of the salinity analysis of Kao Bay, North Halmahera, are carried out twice, namely in the morning and evening. In the morning, the salinity value of the water is 26,264 ppt, and in the afternoon is 27,311 ppt. The effect of the season plays an essential role in the salinity level in the seas of Kao Bay. The salinity value affects the content produced by waters, such as phosphorus and nitrate, and productivity in tropical areas with high nutrients.

The value of water brightness has a low correlation in the estuary waters of Berombang River, which is around 0.629. This is because, in areas near the coast, the turbidity of water is caused by land sediments. Brightness is a condition that indicates the ability of light to penetrate the depths of the ocean. Koniyo (2012) stated that the fermentation process that occurs in waters is closely related to water brightness. Water turbulence is caused by dissolved materials such as microorganisms, plankton, and mud. Hamuna et al. (2018) also added that the level of water brightness significantly affects the photosynthesis process and the growth rate of marine biota. Patty et al. (2020) that the results of measurements of water brightness in Tumbak-Bantenan waters, Southeast Minahasa, show a value of 4.5-31.5 meters with an average value of 19.0 ± 9.43 meters. Meanwhile, Edrus & Setyawan (2013) reported that the brightness of local waters varies from 1.5 to 15 meters on the island of Belitung.

Based on the results of correlation analysis, water pH is an environmental parameter with the lowest correlation, namely 0.468. Water pH conditions influence sweet shrimp's presence in the Berombang River area's estuary waters. The life of mantis shrimp is increastatepportive of the condition of pH value in the Berombang river area. The population of mantis shrimp will have an effect if the pH value of the water exceeds the tolerance threshold. Noor & Ngabito (2018) state essential parameter as a determinant of water quality: water pH. Chandra et al. (2015) informed the value of the Physico-chemical parameters of the mantis shrimp habitat in the Juata waters of Tarakan city, namely pH 8.12; DO 7.46 (mg/I); temperature 29.4 (0C); salinity 20 (ppt). Dimenta et al. (2020) found that the correlation analysis of Physico-chemical factors in the Sei Berombang mangrove area has a DO value of 0.776, water pH 0.656, salinity 15-35%, and a temperature of 0.124. Sugianti & Astuti (2018) added that the parameter conditions in the Citarum river have temperatures ranging from 24.3-29.80C; DO 0.00-7.79 mg/l, with a mean of 3.52 mg/l. Widianingsih et al. (2019) also informed that in Panikel village, Segara Anakan, Cilacap, the salinity level is 26 ppt; and a temperature of 27^{0}C. Meanwhile, in the coastal waters of the Cirebon River, Sudirman & Husrin (2014) reported that the pH value shows a range of 7.87-8.52.

Conclusions

The growth pattern of male mantis shrimp (*H. raphidea*) is allometric positive b>3. This means that weight growth is faster than carapace growth. At the same time, the growth pattern of female mantis shrimp (*H. raphidea*) is negative allometric b<3. This means that the growth of the carapace is faster than the growth of body weight. The value of the Fulton condition factor (K) in the estuary waters of Berombang River, Labuhanbatu Regency shows male *H. raphidea* (3.54-13.18) with an average (8.27±0.75) and female *H. raphidea* (15, 28-22.09) with a mean (18.23±1.25). The value of correlation analysis of the Physico-chemical parameters of water temperature (0.935) and DO (0.832) shows the high category correlation test results. This condition may be caused by the salinity value, which is still in the appropriate category for the life of mantis shrimp organisms.

Acknowledgments

The authors would like to thank the Science team of the Faculty of Teacher Training and Education, Labuhanbatu University, who have helped and participated in the collection and facilitated this study to provide helpful information for the wider community. Moreover, the authors would like to thank other parties involved whose names cannot be mentioned.

Declaration statement

The authors reported no potential conflict of interest.

References

Ambarsari, R. N. (2016). *Pengelolaan Sumberdaya Udang Mantis (Oratosquillina gravieri Manning, 1978) Di Teluk Palabuhanratu*. Institut Pertanian Bogor.

Antony, P. J., Rahman, M. M., Rajkumar, M., Yunus, K., & Khan, S. A. (2014). Relative growth of Harpiosquilla raphidea (Fabricius, 1798) (Crustacea: Stomatopoda) male and female populations. *Sains Malaysiana*, *43*(9), 1305–1310.

Arizuna, M., Suprapto, D., & Muskananfola, M. R. (2014). Kandungan Nitrat dan Fosfat Dalam Air Pori Sedimen di Sungai dan Muara Wedung Sungai Wedung Demak. Diponegoro. *Journal of Maquares*, *3*(1), 7–16. https://doi.org/10.14710/marj.v3i1.4281

Arshad, A., Sofea, T., Zamri, Z., Amin, S. M. N., & Ara, R. (2015). Population dynamics of mantis shrimp, Harpiosquilla harpax in the coastal waters of Pantai Remis, Perak, Peninsular Malaysia. *Iranian Journal of Fisheries Sciences*, *14*(1), 15–26.

Astuti, I. R., & Ariestyani, F. (2013). Potensi dan Prospek Ekonomis Udang Mantis di Indonesia. *Media Akuakultur*, *8*(1), 39–44. https://doi.org/10.15578/ma.8.1.2013.39-44

Barus, T. A. (2004). Environmental Abiotic FactPlanktonThe Diversity Of Plnnkton As Water Quality Indicators In Lake Toba, Nort Sumatera, Indonesia. *Manusia Dan Lingkungan*, *xi*(2), 64–72.

Chandra, T., Salim, G., & Wiharyanto, D. (2015). Model Populasi Pendekatan Pertumbuhan dan Indeks Kondisi Harpiosquilla raphidea Waktu Tangkapan Pada Pagi Hari di Perairan Utara Pulau Tarakan. *Jurnal Harpodon Borneo*, *8*(2), 122–131. https://doi.org/10.35334/harpodon.v8i2.133

Dimenta, R. H., & Machrizal, R. (2017). Faktor Kondisi Dan Pola Pertumbuhan Udang Kelong (Penaeus Indicus) Pada Perairan Ekosistem Mangrove Belawan, Sumatera Utara. *Jurnal Eduscience*, *4*(2), 39–44.

Dimenta, R. H., Machrizal, R., & Khairul. (2019). Information reproductive morphology and sex ratio of mScorpiohrimp Cloridopsis scorpio (Latreile, 1828) in Belawan's aquatic ecosystems mangrove. *Jurnal Pendidikan Biologi Nukleus*, *5*(2), 24–33.

Dimenta, R. H., Machrizal, R., Khairul, K., Hasibuan, R., Manurung, A. Q., & Ihsan, M. (2020). Biologi reproduksi udang mantis Cloridopsis scorpio di ekosistem mangrove Belawan, Sumatera Utara. *Depik*, *9*(2), 227–334. https://doi.org/10.13170/depik.9.2.15188

Dimenta, R. H., Machrizal, R., Safitri, K., & Khairul, K. (2020). Hubungan Distribusi Makrozoobenthos dan Lingkungan Pada Kawasan Ekosistem Mangrove di Kelurahan Sei Barombang Kabupaten Labuhanbatu, Sumatera Utara. , 3(1), . *Fisheries Journal*, *3*(1), 23–41.

Edrus, I. N., & Setyawan, I. E. (2013). Pengaruh Kecerahan Air Laut Terhadap Struktur Komunitas Ikan Karang di Perairan Pulau Belitung. *Jurnal Penelitian Perikanan Indonesia*, *19*(2), 55–64. https://doi.org/10.15578/jppi.19.2.2013.55-64

Ekalaturrahmah, Y. A. C., Zairion, & Wardiatno, Y. (2020). Population dynamics of mantis shrimp Harpiosquilla harpax and oratosquillina sp. In the waters south of Madura Island, Indonesia. *Biodiversitas*, *21*(4), 1458–1466.

https://doi.org/10.13057/biodiv/d210425

Erdmann, M. V., & Barber, P. H. (2000). Molecular systematics of the Gonodactylidae (Stomatopoda) using mitochondrial cytochrome oxidase C (Subunit 1) DNA sequence data. *Journal of Crustacean Biology*, *20*(2), 20–36. https://doi.org/10.1163/1937240X-90000004

Hamuna, B., Tanjung, R. H. R., Suwito, S., Maury, H. K., & Alianto, A. (2018). Kajian Kualitas Air Laut dan Indeks Pencemaran Berdasarkan Parameter Fisika-Kimia di Perairan Distrik Depapre, Jayapura. *Jurnal Ilmu Lingkungan*, *16*(1), 35–43. https://doi.org/10.14710/jil.16.1.35-43

Harahap, A. (2019). Peranan Makrozoobentos Sebagai Bioindikator Kualitas Air Di Sungai Bilah Labuhanbatu. *Disertasi*.

Husen, A. (2016). Analisis Kualitas Air Sungai yang Bermuara di Perairan Teluk Kao Halmahera Utara. *Jurnal Ilmiah Agribisnis Dan Prikanan*, *9*(1), 9–15. https://doi.org/10.29239/j.agrikan.9.1.9-15

Iftitah, D., Abinawanto, Wardhana, W., Ulayya, N., & Magisma, I. (2017). Morphometric study of mantis shrimp Harpiosquilla harpax (De Haan, 1844) (Crustacea: Stomatopoda) in Pelabuhan Ratu and Cirebon waters, Indonesia, based on length-weight relationship and condition factor. *AIP Conference Proceedings*, *1862*, 1–5.

Kasril, Dewiyanti, I., & Nurfadillah. (2017). Relationship Between Carapace Width and Body Weight of Manggrove Crab (Scyllaserrata) and Condition Factors Harvested from Aceh Singkil Wate. *Jurnal Ilmiah Mahasiswa Kelautan Dan Perikanan Unsyiah*, *2*(3), 444–453.

Koniyo, Y. (2012). Analisis Kualitas Air Pada Lokasi Budidaya Ikan Air Tawar Di Kecamatan Suwawa Tengah. *Jurnal Technopreneur*, *8*(1), 52–58. https://doi.org/10.30869/jtech.v8i1.527

Manning, R. B. (1969). A Review of the Genus Harpiosquilla (Crustacea, Stomatopoda), with Descriptions of Three New Species. *Smithsonian Contributions to Zoology*, *36*, 1–41. https://doi.org/10.5479/si.00810282.36

Mashar, A., & Wardiatno, Y. (2011). Distribusi Spasial Udang Mantis Harpiosquilla raphidea dan Oratosquillina gravieri di Kuala Tungkal, Kabupaten Tanjung Jabung Barat, Provinsi Jambi. *Jurnal Pertanian*, *1*(1), 41–46. https://doi.org/10.31219/osf.io/en35x

Mulyono, M., Patria, M. P., Abinawanto, & Affandi, R. (2016). Keragaman Genetik Berdasarkan Karakter Morfomerik Udang Mantis Harpiosquilla raphidea Fabricius, 1798 Asal Perairan Indonesia. *Teknologi Dan Penelitian Terapan*, *18*(1), 221–231. https://doi.org/10.31219/osf.io/en35x

Murni, S., & Dimenta, R. H. (2021). Bioekologi Udang Swallo (Penaeus merguiensis). *Pendidikan Biologi Dan Sains*, *4*(1), 99–111. https://doi.org/10.31539/bioedusains.v4i1.2282

Muzammil, W. (2010). *Studi Morfometrik dan Meristik Udang Mantis (Oratosquillina gravieri dan Harpiosquilla raphidea) di Daerah Pantai Berlumpur Kuala Tungkal, Provinsi Jambi.* Institut Pertanian Bogor.

Nane, L. (2019). *Buku Petunjuk Praktikum Mata kuliah Biologi Perikanan Fakultas Perikanan dan Ilmu Kelautan*. Universitas Negeri Gorontalo.

Napisah, S., & MaChrizal, R. (2021). Hubungan Panjang Berat dan Faktor Kondisi Ikan Gulamah (Johnius trachycephalus) di Perairan Sungai Barumun Kabupaten Labuhanbatu. *Bioscientist : Jurnal Ilmiah Biologi*, *9*(1), 63–71.

Noor, S. Y., & Ngabito, M. (2018). Tingkat Pencemaran Perairan Danau Limboto Gorontalo. *Gorontalo Fisheries Journal*, *1*(2), 30–39.

Patty, S. I., Nurdiansah, D., & Akbar, N. (2020). Sebaran Suhu, Salinitas, Kekeruhan dan Kecerahan di Perairan Laut Tumbak-Bantenan, Minahasa Tenggara. *Jurnal Ilmu Kelautan Kepulauan*, *3*(1), 77–87. https://doi.org/10.33387/jikk.v3i1.1862.g1431

Pratiwi, I., & Dimenta, R. H. (2021). Populasi Kepiting Bakau (Scylla serrata) Di Perairan Muara Sungai Barumun Kabupaten Labuhanbatu Ditinjau Dari Pola Pertumbuhan Dan Faktor Kondisi. *Bioscientist : Jurnal Ilmiah Biologi*, *9*(1), 209–222. https://doi.org/10.33394/bjib.v9i1.3749

Pujawan, A., Kade Mahardika, I., & Sari Nindhia, T. (2012). Identifikasi Spesies Udang Mantis (Stomatopoda) Di Perairan Pemuteran Dengan Menggunakan Gen Cytochrome C Oxidase Subunit-1 Dari DNA Mitokondria. *Indonesia Medicus Veterinus*, *1*(2), 268–280.

Purnaini, R., Sudarmadji, S., & Purwono, S. (2018). Pengaruh Pasang Surut Terhadap Sebaran Salinitas Di Sungai Kapuas Kecil. *Jurnal Teknologi Lingkungan Lahan Basah*, *1*(2), 021–029. https://doi.org/10.26418/jtllb.v6i2.30239

Ramdhani, F., Nofrizal, N., & Jhonnerie, R. (2019). Studi Hasil Tangkapan Bycatch dan Discard Pada Perikanan Udang Mantis (Harpiosquilla raphidea) Menggunakan Alat Tangkap Gillnet. *Marine Fisheries: Journal of Marine Fisheries Technology and Management*, *10*(2), 129–139. https://doi.org/10.29244/jmf.v10i2.29496

Salim, G., Handayani, K. R., Anggoro, S., Indarjo, A., Syakti, A. D., Ibrahim, A. J., Ransangan, J., & Prakoso, L. Y. (2020). Morphometric analysis of harpodon nehereus, harpiosquilla raphidea, and scylla serrata in the coastal waters of tarakan, north kalimantan, indonesia. *Biodiversitas*, *21*(10), 4829–4838. https://doi.org/10.13057/biodiv/d211049

Sanusi, H. S. (2004). Karakteristik Kimiawi dan Kesuburan Perairan Teluk Pelabuhan Ratu Pada Musim Barat dan Timur (Chemical Characteristic and Fertility of Pelabuhan Ratu Bay Waters at East and West Monsoon). *Ilmu-Ilmu Perairan Dan Perikanan Indonesia*, *11*(2), 93–100.

Situmeang, N. S., Purnama, D., & Hartono, D. (2017). Identifikasi spesies udang mantis (Stomatopoda) di perairan kota Bengkulu.

Jurnal Enggano, *2*(2), 239–248. https://doi.org/10.31186/jenggano.2.2.239-248

Sudirman, N., & Husrin, S. (2014). Status Baku Mutu Air Laut Untuk Kehidupan Biota dan Indeks Pencemaran Perairan di Pesisir Cirebon Pada Musim Kemarau. *Jurnal Ilmiah Perikanan Dan Kelautan*, *6*(2), 149–154. https://doi.org/10.20473/jipk.v6i2.11300

Sugianti, Y., & Astuti, L. P. (2018). Respon Oksigen Terlarut Terhadap Pencemaran dan Pengaruhnya Terhadap Keberadaan Sumber Daya Ikan di Sungai Citarum. *Jurnal Teknologi Lingkungan*, *19*(2), 203–212. https://doi.org/10.29122/jtl.v19i2.2488

Sukarni, S., Rina, R., Samsudin, A., & Purna, Y. (2018). Harpiosquilla raphidea, Udang Belalang Komoditas Unggulan dari Provinsi Jambi. *Jurnal Penyuluhan Perikanan Dan Kelautan*, *12*(3), 179–188. https://doi.org/10.33378/jppik.v12i3.108

Wardiatno, Y., & Mashar, A. (2013). Morphometric study of two indonesian mantis shrimps (*Harpiosquilla raphidea* and *Oratosquillina gravieri*). *Buletin PSP*, *21*(3), 19–30.

Wardiatno, Yusli, & Mashar, A. (2010). Biological information on the mantis shrimp, Harpiosquilla raphidea (Fabricius 1798) (Stomatopoda, Crustacea) in Indonesia with a highlight of its reproductive aspects. *Journal of Tropical Biology and Conservation*, *7*(1), 65–73.

Wedjatmiko, W. (2007). Sebaran dan Kepadatan Udang Mantis (Carinosquilla spinosa) di Perairan Arafura. *Jurnal Penelitian Perikanan Indonesia*, *13*(1), 61–69. https://doi.org/10.15578/jppi.13.1.2007.61-69

Widianingsih, W., Nuraini, R. A. T., Hartati, R., Redjeki, S., Andanar, C. E., Endrawati, H., Riniatsih, I., & Mahendrajaya, R. T. (2019). Morfometri Dan Pertumbuhan Scylla serrata (Filum : Arthropoda, Famili : Portunidae) di Desa Panikel, Segara Anakan, Cilacap. *Jurnal Kelautan Tropis*, *22*(1), 57–62. https://doi.org/10.14710/jkt.v22i1.4207

Widyaningtiwi, W. A., Djuwito, & Saputra, S. W. (2013). Beberapa Aspek Biologi Udang Mantis (Oratosquilla oratoria De Haan, 1844) di Perairan Cilacap, Jawa Tengah. *Management of Aquatic Resources Journal*, *2*(3), 56–64. https://doi.org/10.14710/marj.v2i3.4182

Wortham-Neal, J. L. (2002). Reproductive morphology and biology of male and female mantis shrimp (Stomatopoda: Squillidae). *Journal of Crustacean Biology*, *22*(4), 728–741. https://doi.org/10.1163/20021975-99990287

Wujdi, A., Suwarso, & Wudianto. (2012). Hubungan panjang bobot, fakor kondisi dan struktur ukuran ikan Lemuru (Sardinella lemuru Bleeker, 1853) di Perairan selat Bali. *Bawal*, *4*(2), 83–89. https://doi.org/10.15578/bawal.4.2.2012.83-89

Zulfahmi, I., Yuliandhani, D., Sardi, A., Kautsari, N., & Akmal, Y. (2021). Variasi Morfometrik, Hubungan Panjang Bobot dan Faktor Kondisi Ikan Famili Holocentridae yang Didaratkan di Pelabuhan Perikanan Samudra (PPS) Lampulo, Banda Aceh. *Jurnal Kelautan Tropis*, *24*(1), 81–92. https://doi.org/10.14710/jkt.v24i1.9767