Spatial Distribution of Mantis Shrimp (*Harpiosquilla raphidea*) in Small-Scale Gillnet Fishery: A Case Study in Kuala Tungkal, Tanjung Jabung Barat Regency, Jambi

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Abstract

Mantis Shrimp is one of economically important species due to its high value for export commodities. Mantis shrimp fishing in Kuala Tungkal is categorized as small-scale fisheries. This study aims to investigate the spatial distribution of mantis shrimp catches, both the number (individuals) and body length (BL) (cm) based on the distance from the shoreline to the fishing ground. A survey method was conducted in Kuala Tungkal, Tanjung Jabung Barat Regency, Jambi Province in December 2018. The observation covered 23 fishing trips by gillnet within 437 km^2. The results revealed that the spatial distribution of the average number (individuals) of mantis shrimp in various stratifications reached 28-31 individuals. However, the farther fishing ground with higher salinity levels obtained a larger average size of mantis shrimp body length (BL). In the 0-4 mile stratification, it was found that the average catch size is 17.3 cm under the first maturity size which should be 19 cm. Meanwhile, in average the observed water condition as follow temperature is 28.2^{o}C, DO = 7.4 mg/L, pH = 7, brightness = 1.1 m, and salinity is 20.9 ppt. At the end, the result of this spatial distribution may become an input for coastal resource management strategies and can support sustainable mantis shrimp fishing efforts.

KEYWORDS: Gillnet, Habitat, Mantis Shrimp, Spatial Distribution, Sustainable Fisheries.

INTRODUCTION

Mantis shrimp (*Harpiosquilla raphidea*) is one of economically potential crustacean species in Kuala Tungkal, Tanjung Jabung Barat Regency, Jambi Province. It is a worthy and most demanded fishery export commodity to several countries such as China, Hong Kong and Taiwan (Nofrizal *et al*., 2020). Besides that, it is also a popular and favorite cuisine in Singapore, Malaysia, Japan, Thailand, Philippine and some Mediterranean countries in Europe. Data demonstrated that in 2017 mantis shrimp export from Kuala Tungkal has earned Rp.264,954,130,000.00 taken from 3,785,059 individuals (BKIPM Jambi, 2018; Nofrizal *et al*., 2020).

Habitat of mantis shrimp is found in bottom waters characterized by a muddy sand substrate in which they perfectly live in a grouping distribution (Mashar and Wardiatno, 2011). Mostly, mantis shrimp was caught by gillnet as the main catch done by fishermen in Kuala Tungkal. The fishermen applied gillnet with a mesh of 4 inches and a net range is ±1 KM (Ramdhani *et al*., 2019). For transportation, small-sized fishermen accommodate vessels under 10 GT. This fishing can be categorized as a small-scale fishery which becomes an important economic driving base for coastal communities since it plays a role as a livelihood to earn direct income for most local people (Wiyono, 2012).

Nonetheless, it cannot be overlooked that the catch (exploitation) of mantis shrimp has the potential to undermine the sustainability and equilibrium of its habitat and recruitment process if it is not prudently regulated by the appropriate parties. In contrast, unregulated fishing can harm the

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quantity and quality of the fishery commodity. This may also have a negative long-term impact on the economy of the surrounding society, causing undesirable conditions for local residents and the national export industry.

Previous studies have been conducted to optimize mantis shrimp catch sustainability in several areas in Indonesia. A study by Arifin and Supriyono (2014) in Bogor, West Java, investigated the survival rate of mantis shrimp post-transportation with wet and dry transport systems. The result revealed that technology is needed to minimize transport stress levels. On the other hand, other studies are concerned with the biological (Widyaningtiwi and Saputra, 2013) and reproduction aspects of mantis shrimp (Hasibuan and Dimenta, 2022). Regarding biological aspects, the study done by Widyaningtiwi and Saputra (2013) in Cilacap, Central Java, aims to inform gonad maturity level and the first body size of maturity. Meanwhile, another study by Hasibuan and Dimenta (2022) in Labuhanbatu, North Sumatera, also highlights the growth pattern of mantis shrimp. However, a study concerning on spatial distribution of mantis shrimp is still limited, primarily conducted in a wide area of fishing ground.

Considering the explanation above, it is crucial to support gillnet fishery activities in fishing mantis shrimp in Kuala Tungkal to be optimally and sustainably carried out. One of them is through observing spatial distribution pattern of mantis shrimp based on the distance to fishing ground which has not been certainly investigated so far. By using spatial distribution pattern, numbers and size of mantis shrimp can be also well noticed.

Therefore, this study endeavors to identify how the result of mantis shrimp fishing in terms of numbers (individual) and body length (BL) (cm) considering the distance from the shoreline to the fishing ground. It is expected that the result of this study can be a valuable input for coastal resource management strategies so that mantis shrimp fishing in Kuala Tungkal, Tanjung Jabung Barat Regency, Jambi Province can be carried out more effective and optimal. In addition, this study also an effort to actualize mantis shrimp fishing sustainability in Kuala Tungkal.

MATERIALS AND METHODS

This study was conducted in Kuala Tungkal, Tanjung Jabung Barat Regency, Jambi Province in December 2018. The location was chosen since it is the largest export center of mantis shrimp in Jambi Province to different countries such as China, Hong Kong and Taiwan done by using gillnet. The current study applied a survey method through doing direct observations in the field. Observing the fishermen directly in the fishing field was intended to obtain data representing number and size of the mantis shrimp.

The data regarding mantis shrimp catches were collected by direct observation at 23 fishing locations spread over 4 area stratifications considering fishermen's habit in fishing. The stratification pattern was obtained from the distance between shoreline and fishing ground which covered 0-4 miles, 4-8 miles, 8-12 miles, and > 12 miles. The results at each fishing ground were categorized based on the number of individuals and body length (BL) (cm). In addition, water quality parameters were also measured at the location of the mantis shrimp fishing. The location of study of mantis shrimp fishing and sampling of water quality parameters has presented in Figure 1.

Measurement of water quality parameters in Kuala Tungkal was carried out at 23 fishing locations according to stratifications generated by considering distances from the shoreline to the fishing ground (Figure 1). The parameters for measuring water quality include temperature (^{o}C), dissolved oxygen (mg/L), brightness (m) and salinity (ppt). However, only the salinity that was described intensely since salinity has the closest relationship with mantis shrimp habitat as cited in various literatures (Muslim, 2003; Wedjatmiko, 2011; Lantang 2020).

Information on the number (individuals) and body length (BL) (cm) of the catches will be analyzed descriptively with some supporting literatures. Meanwhile, data on water quality and distribution

Figure 1. Study location in Kuala Tungkal waters. Symbol S (S1-S23) on map indicates fishing grounds in this study

of mantis shrimp in Kuala Tungkal was spatially analyzed using ArcMap 10.8 software. Analysis of water quality parameters, especially salinity, was executed to identify the distribution of variations on the surface or transverse distribution using the Inverse distance weighted method. Data on the number and size of mantis shrimp were classified according to distance stratification of fishing ground, namely 0-4 miles, 4-8 miles, 8-12 miles, and > 12 miles.

RESULTS AND DISCUSSIONS

Based on direct observation in 23 points (fishing ground), it was identified that the fishing ground for mantis shrimp is between south latitude $0^{0}51'$–$0^{0}41'$ and east longitude $103^{0}45'$–$103^{0}33'$ covering 437 km^2. Mostly, the shrimp live in a bottom and muddy sand area which becomes a favorable habitat for them (Mashar and Wardiatno, 2011). It is in line with Situmeang *et al*. (2017) who stated in his study that mantis shrimp live in bottom water areas that have sandy and muddy substrates. While, the depth of the mud ranges from 50–200 cm (Astuti and Arestyani, 2013). Based on the results, the farthest catch from the shoreline to the fishing ground is ± 20.3 miles at the location 22 (S22) with coordinates South Latitude $0^{0}42'$ and East Longitude $103^{0}46'$. While the closest area from the shoreline to the fishing ground is ± 3.8 miles at location 18 (S18) with coordinates south latitude $0^{0}84'$ and east longitude $103^{0}63'$.

Constitution of the Republic of Indonesia No. 23 of 2014 concerning Regional Government Chapter V explains that sea natural resources management is authorized and conducted by the province government for area at maximum 12 (twelve) nautical miles measured from the shoreline towards the high seas and/or towards archipelagic waters. In this study, it was found that most of the mantis shrimp catches are still conducted in the areas that are still accessible from the coast (<12 miles) through a oneday fishing time. Thus, these fishing activities are categorized as small-scale gillnet fisheries. According to Hutchings and Lamberth (2003), small-scale gillnet fisheries have fishing operations based on coast and estuaries or areas that are still accessible from both areas. The applied vessels have an average tonnage of ±5.9 GT. It is aligned with the definition of small fishermen in Constitution of the Republic of Indonesia No. 7 2016 concerning on the protection and empowerment of fishermen explaining that small fishermen is the fishermen who catch fish to meet their daily needs, either those who do not use fishing vessels or those who use fishing vessels with a maximum size of 10 (ten) gross tons (GT). In total, there are 253 vessels of mantis shrimp fishing fleets in Kuala Tungkal (Fisheries Department of Tanjung Jabung Barat Regency, 2018). The model and size of the vessels tend to be similar made from a teak wood with a length of 8.8 m, width 1.7 m, height 1.6 m. Unlike the case for large-scale gillnet fisheries in several areas such as in the Southern region of Brazil, mostly the length of the vessels are 26.7 – 39.6 m with a tonnage ranging from 72 – 362 GT. They are also equipped with a frozen storage on board which has a capacity between 45 – 110 tones and operated in the oceans offshore (Perez and Wahlrich, 2004).

In terms of the catch number, mantis shrimps obtained during the study range from 3 up to 56 individuals per fishing ground. The number of catches are visualized through different colors classified in three classes (low, medium, high). Grey symbolizes the lowest catch number with range about 3-22 individuals, pink symbolizes medium catches with range about 23-35 individuals. Meanwhile the high catch number was symbolized by red with range about 36-56 individuals (Figure 2). Overall, each fishing location shows different numbers (individuals) (Figure 2). However, looking at the average number of mantis shrimp in each distance stratification of fishing grounds, it almost has the same average number ranging from 28–31 ind/distance stratification of fishing grounds (Figure 3). It can indicate that the distribution of mantis shrimp is similarly distributed at every distance of the fishing grounds.

The size of mantis shrimp obtained in this study ranges from 9.2 to 33.2 cm. Heterogeneous sizes are spread out in different stratifications. The average size of mantis shrimp based on the distance stratification is as follows (mean ± standard deviation); area distance of 0-4 miles has average body length (BL) of mantis shrimp about 17.3 ± 3.10 cm, area distance of 4-8 miles has average body length (BL) of mantis shrimp about 20.9 ± 2.84 cm, area distance of 8-12 miles has the mean body length (BL) of mantis shrimp about 21.2 ± 2.22 cm, and area distance >12 miles has the average body length (BL) of mantis shrimp about 23.3 ± 4.3 cm. The information regarding the average size of mantis shrimp is also described in Figure 4.

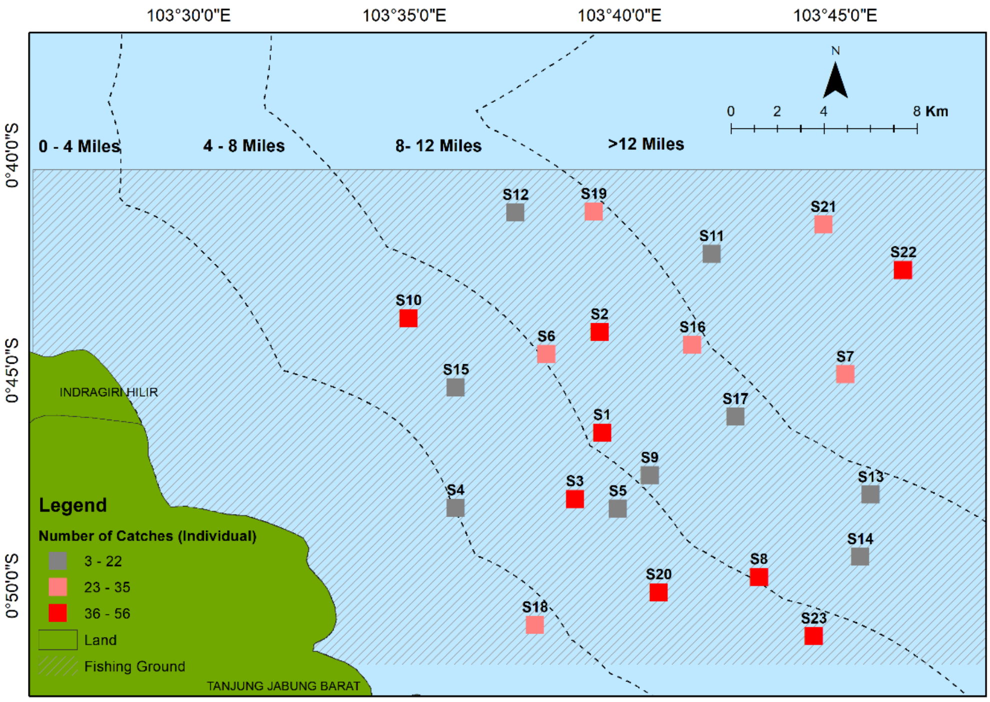

Figure 2. Spatial distribution of mantis shrimp based on distance stratification of fishing grounds.

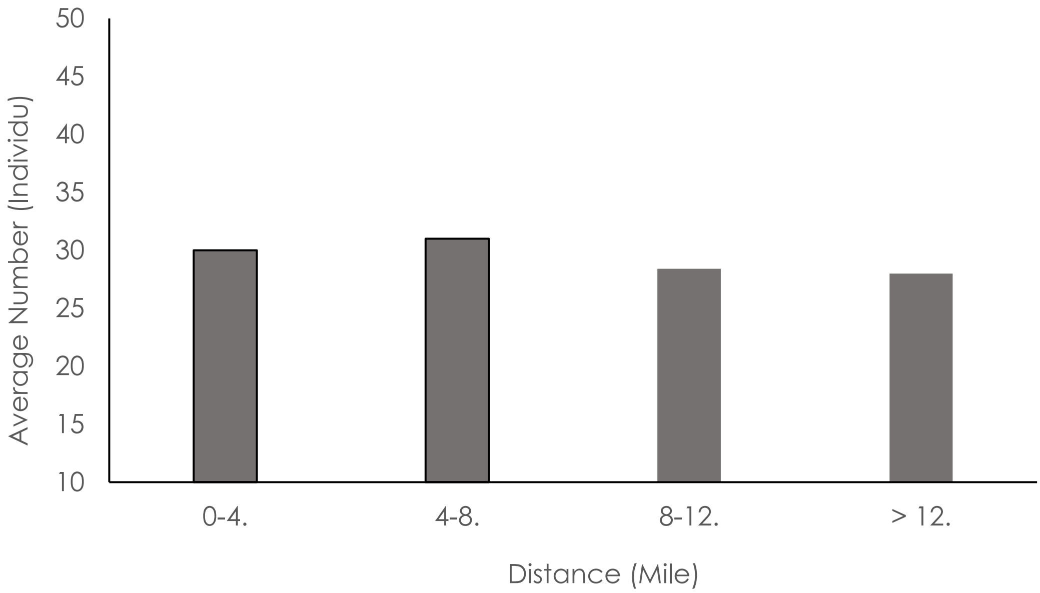

Figure 3. Spatial distribution of the average number of mantis shrimp based on distance stratification of fishing grounds

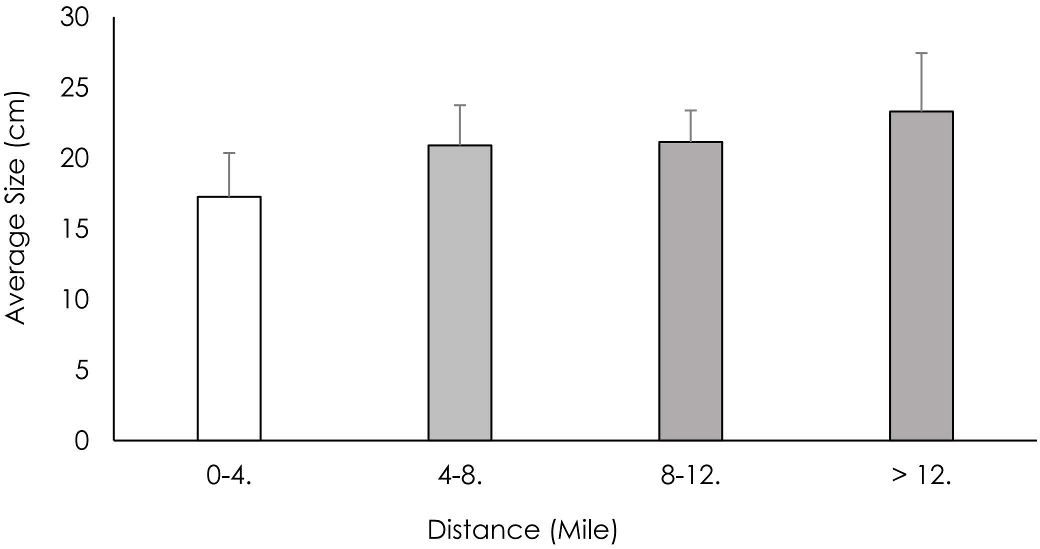

Figure 4. Spatial distribution of the average size of mantis shrimp based on the distance stratification of fishing grounds. The white histogram shows the body length (BL) of mantis shrimp under the maturity size

Based on the graph in Figure 4, it shows that the spatial distribution of the average body length (BL) have different sizes in each distance stratification of fishing grounds. The average size of mantis shrimp is directly proportional to the increasing distance between the fishing ground and the shoreline. Regarding this, another finding is also recognized identical circumstance in other crustaceans such as crab (Portunus pelagicus). Similar with mantis shrimp carb size heading to offshore is greater than those which are nearer to the shoreline as indicated from the crab's carapace width (Radifa *et al*., 2020). Small-sized mantis shrimp were mostly found in the areas close to the shoreline (estuarine) which are addressed in the distance stratification of the fishing grounds 0-4 miles. A study done by Wardiatno and Mashar (2011) also found that mantis shrimps with body length (BL) range between 8.75-13.75 cm were almost always caught at the distance less than 4 miles. At this distance, the area is the best place for a nursery and feeding ground of the small mantis shrimp. It is assumed that the area stores a lot of natural food supply derived from the mainland as needed for fish growth. On the other hand, the mature mantis shrimp will look for water areas which have a higher salinity as a need to maintain their life cycle (Mashar and Wardiatno, 2011). Therefore, mantis shrimp with a larger size will be easily found in the areas that are far from the coast with a higher salinity level. This is also supported by measurements of salinity level at the study site demonstrating that the farther fishing areas from the shoreline contain a higher salinity compared to the nearer ones (Figure 5).

At the study site, it was identified that its salinity ranges from 18-24 ppt. the differences in water salinity may occur due to different evaporations and precipitations (Hamuna *et al*., 2018). In addition, Sukarni *et al*. (2018) supported that in West Kalimantan, mantis shrimps are generally tolerant to salinity between 14-24 ppt. Commonly, water conditions with a salinity of 14.40 – 30.10 ppt are still suitable for shrimp habitat (Wedjatmiko, 2011; Lantang *et al*., 2020). Salinity less than 32.0 ppt is still found in the coastal water (Arinardi, 1997; Lantang *et al*., 2020).

The increasing level of salinity value from the estuary to the sea is caused by the mixing of fresh water and seawater masses at the mouth of the estuary which is driven by tidal phenomena, evaporation, and rainfall. At high tide, salinity-rich seawater enters the estuary, agitating the water column and increasing the salinity level in the estuary region (Heltria *et al*., 2021). On the other hand, the salinity in the sea area does not change because it does not get fresh water flow from land so that the salinity remains high. Salinity is an environmental factor that significantly influences the shrimp survival. Dede *et al*. (2014) stated that at low salinity the growth rate of shrimp will decrease and when it is too high it will endanger the life of shrimp. This is related to the osmotic pressure of the environment in shrimp. At higher salinity in the area towards the sea, the greater osmotic pressure causes the lower shrimp's osmotic work. The shrimp with a low osmotic work will have a better growth rate compared to the shrimp with a high osmotic work. It is due to the energy obtained from food will be consumed mostly for growth process (Muslim, 2003).

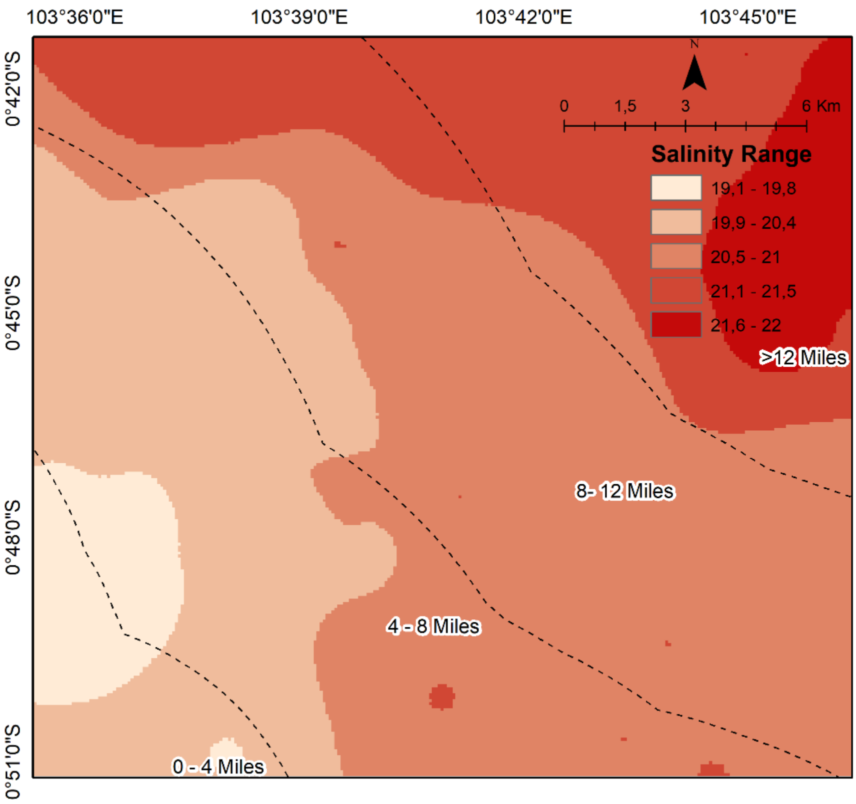

Figure 5. Distribution of salinity distance of fishing ground

One of the factors that determines the shrimp viability is temperature which significantly affects metabolism and growth. It was found that the range of temperature at the study site is 24.5-32.1°C with average temperature measurement is 28.2°C. Hoang *et al*. (2002) stated that temperatures above 27 °C in waters have a higher survival rate for shrimp compared to lower temperatures. Based on temperature measurement obtained an average result of 28.2°C indicates still classified as good with temperature range for the survival and growth of crustaceans such as shrimp is 26-31°C (New, 2002). In contrast, the shrimp survival rate will decrease in waters that have higher temperatures (Dall *et al*., 1990).

pH or the degree of water acidity signifies condition of acidic or alkaline in a water area. A low pH can causes shrimp to be hypersensitive so that their bones become porous since they are not being able to form new skin (Masyar and Wardiatno, 2011). Meanwhile, at a high pH, it causes an increasing concentration of ammonia which can harm the shrimp growth. In this study, the range of pH is 6.8-7.4 with average pH measurement at the site is 7. This value is in accordance with the water quality standard for marine biota including mantis shrimp according to the Decree of the State Minister of the Environment Number: 51 of 2004, namely 7.0-8.3. The tolerance limit of organisms to pH varies and in general most aquatic organisms are sensitive to changes in pH (Ira, 2014).

The average dissolved oxygen content at the site is 7.4 mg/L. According to the Decree of the State Minister of the Environment Number: 51 of 2004, the water area which is suitable for marine biota including mantis shrimp has a dissolved oxygen is > 5 mg/L. So that, it can be assumed that Kuala Tungkal area is a good place for mantis shrimp growth. Wardiatno *et al*. (2009) in their study related to the waters quality of Kuala Tungkal also obtained that the results of dissolved oxygen measurements in the range of 6.7 – 7.6 mg/L. The dissolved oxygen content in these waters is quite high and suitable for marine life. The high dissolved oxygen content at the study site according to Wardiatno *et al*. (2009) is supposed due to the strong current at high tide and low tide caused by the significant difference in water level. Besides that, it can also be influenced by currents coming from the waters of Kuala Tungkal which are quite large towards the estuary.

Brightness shows the light penetration power entering the waters, if the light penetration is reduced it will result in a low water brightness so that the waters become cloudy. At the study site, the brightness near the estuary is lower, namely 0.6 m compared to the area near the sea which is 1.9 m. The brightness level at the study site is low and below the quality standard value according to the Minister of Environment Decree No. 51 of 2004, which is < 5 m. Some factors that contribute to this condition are rain and sediment resuspension by currents and waves. As confirmed that the brightness level is strongly influenced by weather, measurement time, turbidity and suspended solids (Effendi, 2003).

Indeed, the existence of fishing activities should be conducted by good management in order to create sustainable environment as well as earn optimal benefit of the natural resources. One of the efforts to conserve fishery resources is by paying attention on size of the catch. In this case, the minimum size of mantis shrimp to be fishing object is at first maturity. At this size, the mantis shrimp has got at least one chance of spawning (reproduction) in its life cycle so that the mantis shrimp recruitment process will be maintained. The size of first maturity in mantis shrimp life cycle has a standard in which at the length (BL) of 19 cm (Wardiatno and Mashar, 2010). At this length, the mantis shrimp begins to reach age of gonad maturity (first maturity) which is the first development stage out of three stages. Contrary to that, mantis shrimp at the size <19 cm cannot give optimal benefit for fishermen since the commercial mantis shrimp offered by a high economic value in the market is mostly the shrimp with the size above 20 cm (Wedjatmiko, 2007). Different size of mantis shrimps that were taken from the study site can be seen in the following pictures (Figure 6).

In this condition, the small mantis shrimps tend to be a useless catch even categorized as discard. The existence of discarded catch is considered as a waste. In this study, the direct observation showed that a lot of the catch that were caught under the ideal size or below the first

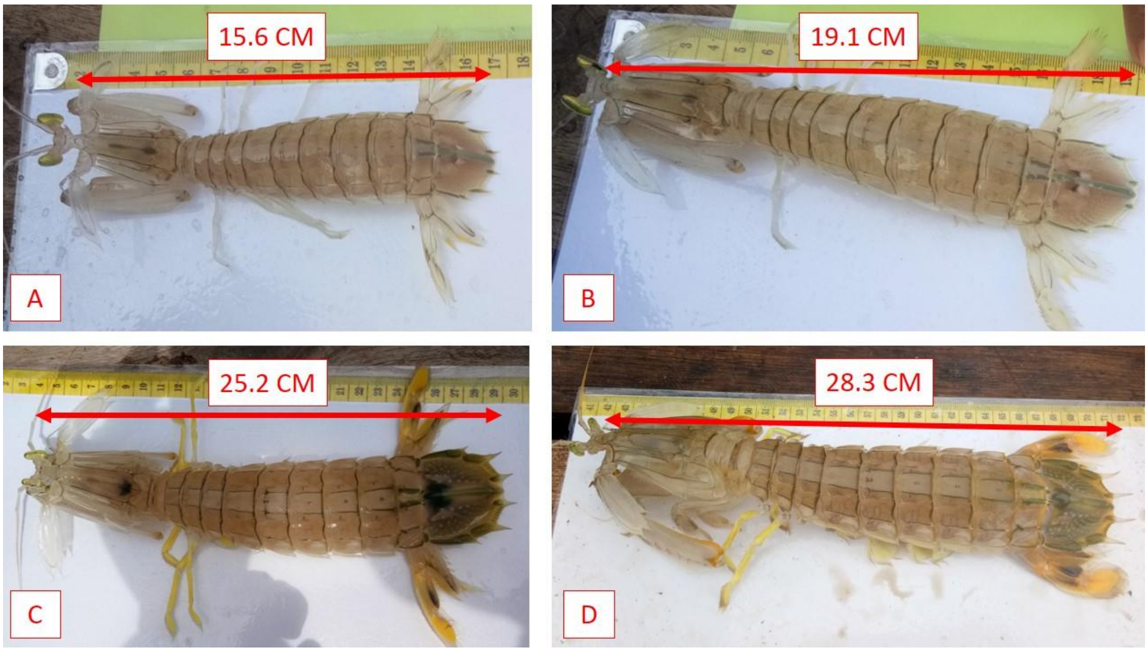

Figure 6. Different size of mantis shrimps. Picture A shows mantis shrimp with size under the first maturity size; Picture B shows mantis shrimp with size at the first maturity size; Picture C and D shows mantis shrimp with high values marketable size.

maturity size which are about 17.3 ± 3.10 cm in a fishing ground stratification of 0-4 miles. This fact consequently contradicts the concept of responsible fishing for sustainable fisheries (Ramdhani, 2019). Unfortunately, if such condition remains uncontrolled, a declining stock of mantis shrimp may become a new problem for mantis shrimp catch in Kuala Tungkal in the future. In other words, this small-scale fishery has a potential to threat the sustainability of mantis shrimp resources. Therefore, it is necessary to evaluate the minimum distance between fishing ground to the shoreline in order to obtain main catches that meet the ideal criteria regarding the concept of sustainability resources. Djuwito *et al.* (2013) added that the small size of mantis shrimp caught will result in a decrease in the stock of mantis shrimp so that it will damage the water conditions because the potential for growth overfishing is very high. Ma'mun (2018) stated that sustainable fisheries cannot be separated from good and planned fisheries management. Sustainable fisheries management must have controlled and measurable fishery conditions for their utilization. The presence of small mantis shrimp (under first maturity size) indicates uncontrolled fishing activity and tends to be over-exploited (Djuwito *et al.*, 2013). Therefore, with the information on the spatial distribution of the mantis shrimp number (individual) and body length (BL) based on the distance from the shoreline to the fishing ground, it can contribute to sustainable coastal resource management.

CONCLUSION

The distribution (individuals) of mantis shrimp catches spatially in different stratifications of regional distances shows an almost even distribution with an average of 28-31 individuals. This is different from the body length size distribution (BL) for mantis shrimp caught in various regional distance stratifications, where larger mantis shrimp are found in stratified areas farther from the shoreline with higher salinity levels. In the 0-4 mile fishing distance stratification, it was found that the catch of mantis shrimp was under the minimum standard for catching (size first maturity) which was 19 cm. This needs serious attention because in a long-term period it will threaten the sustainability of mantis shrimp resources in particular and sustainable fisheries in general. Then it is necessary to evaluate the minimum area distance that catching mantis shrimp can be conducted especially for small-scale gillnet fisheries at the study site.

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