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Evaluating the utilization status of banana prawn (*Penaeus merguiensis*) in the Mukomuko Waters, Bengkulu, Indonesia

ARIEF ERIZAL[1], EKO SRI WIYONO[2,♥], AM AZBAS TAURUSMAN[2], ZULKARNAIN[2]

[1]Marine Fisheries Technology Study Program, Department of Fisheries Resources Utilization, Faculty of Fisheries and Marine Science, Institut Pertanian Bogor. Jl. Raya Dramaga, Babakan, Dramaga, Bogor 16680, West Java, Indonesia

[2]Department of Fisheries Resources Utilization, Faculty of Fisheries and Marine Science, Institut Pertanian Bogor. Jl. Raya Dramaga, Babakan, Dramaga, Bogor 16680, West Java, Indonesia. Tel./fax.: +62-251-8622909, ♥email: eko-psp@apps.ipb.ac.id

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Abstract. *Erizal A, Wiyono ES, Taurusman AA, Zulkarnain. 2025. Evaluating the utilization status of banana prawn (*Penaeus merguiensis*) in the Mukomuko Waters, Bengkulu, Indonesia. Biodiversitas 26: 1164-1170.* Since the 1980s, the prawn resources in the Mukomuko Waters (Sumatra, Indonesia) have been subject to exploitation through shrimp mini-trawling, causing high levels of pressure due to the intensive trawling in a relatively small fishing area. It is essential to implement appropriate management measures to ensure the sustainability of the prawn resources. The objective of this study is to assess the exploitation status of banana prawn (*Penaeus merguiensis*) in order to provide the basis for sustainable prawn management. A simple random sampling technique was employed to obtain a representative sample of the prawn stock. The sampled catch of *P. merguiensis* in Mukomuko Waters was predominantly female. The result of the relationship between length and weight species analysis demonstrates a negative allometric growth pattern. The Gonad Maturity Level (GML) of *P. merguiensis* was found to be dominated by GML II and GML III categories, indicating fish catch was developing virgin and maturing. Fishing mortality (F) was found to be higher than the natural mortality (M), with an exploitation rate (E) of 0.69. The Spawning Potential Ratio (SPR) was determined to be 0.20, further indicating that *P. merguiensis* in Mukomuko Waters is currently overexploited. Based on these findings, two management strategies are proposed: regulating the operation of shrimp mini-trawls based on the time and place of fishing activities and replacing shrimp trawls with more environmentally friendly fishing gear.

Keywords: Banana prawn, Mukomuko Waters, SPR, utilization

INTRODUCTION

Prawn is the most widely consumed seafood product globally. Local and global communities have a strong preference for shrimp as a food ingredient, largely due to its appealing taste and high nutritional value. Indonesia is among the largest exporters of shrimp, reaching 241,200 tons in 2022 (MMAF 2023). Beside the extensive shrimp farming using the pond method, Indonesia has also a great potential for shrimp fishing, with large fishing areas distributed in coastal waters. The distribution areas of shrimp in Indonesia include the west coast of Sumatra (Aceh, West Sumatra, North Sumatra and Bengkulu), the east coast of Sumatra and the Strait of Malacca (Aceh, North Sumatra and Riau), the north coast of Java and the south coast of Java. The waters of Kalimantan (West and East Kalimantan), Sulawesi (South Sulawesi) and Maluku-Irian Jaya (Lantang et al. 2023; et al. 2024) are also home to significant shrimp populations. Shrimp fisheries have become an important source of income for many local fishers in Indonesia, contributing to the overall economic growth of the region (Pane et al. 2023).

Banana prawn (*Penaeus merguiensis* De Man, 1888) is found in coastal and estuarine waters in the Indo-Pacific region, including Indonesia (Lantang et al. 2023; et al. 2024). *Penaeus merguiensis* is an important contributor to Indonesia’s fisheries sector, providing an important source of income for coastal communities and an important element in the socio-economic well-being of the region. However, the exploitation of *P. merguiensis* in Indonesian waters has raised concerns about its sustainability. As demand continues to increase, it is critical that fishing is carried out carefully and with consideration of the impacts of fishing activities on *P. merguiensis* populations and associated ecosystems (Pane et al. 2023). Understanding fishing practices, environmental impacts, and implementing sustainable management strategies are essential components in ensuring the long-term sustainability of *P. merguiensis* fisheries in Indonesia.

One of the *P. merguiensis* distribution areas in Indonesia is Mukomuko District, located in the north of Bengkulu Province, Sumatra. The district covers an area of approximately 4,150 km² and has a coastline of 100 km. Marine and Fisheries Office of Mukomuko (MFO Mukomuko District) stated that the waters of Mukomuko have significant fishery resources, particularly prawn (MFO Mukomuko District 2021). The Mukomuko marine area belongs to the State Fisheries Management Area of the Republic of Indonesia (WPPNRI) 572, situated in the waters of the Indian Ocean west of Sumatra Island. The Sunda Strait is an area where prawn fishing has exceeded Total Allowable Catch (TAC), as described in the Decree of the Minister of Marine Affairs and Fisheries No. 19/KEPMEN-KP/2022 (MMAF 2022).

Prawn is a renewable natural resource with a relatively short lifespan, around 1-2 years (Simbolon 2011). However, if exploitation levels are unsustainable and unchecked, this natural resource will be depleted. Nowadays, the common fishing gear used by fishermen to catch prawn is shrimp mini-trawls. Before the wide use of shrimp mini-trawls, fishermen in Mukomuko Waters still relied on traditional fishing gears, such as fishing rods and fish traps, to catch fish and shrimps. Shrimp mini-trawls were first used in Mukomuko Waters in the 1980s. The high fishing activity in a relatively small fishing area resulted in high fishing pressure in the district. Following the introduction of shrimp trawls, many people became interested in catching prawn with this fishing gear. This has caused the number of fishing fleets and fishing gear in Mukomuko Waters to increase (MFO Mukomuko District 2021). Uncontrolled exploitation of prawn resources in Mukomuko Waters will ultimately result in a decrease in the availability of wild prawn. Such a condition is largely driven by the ineffective management of shrimp fisheries and the lack of information on the status of shrimp resource utilization in Mukomuko Waters. In particular, data and information on growth parameters are important to inform exploitation rate to maintain the sustainability of the stock in the future (Suman et al. 2023a).

Effective shrimp resource management is critical to ensure the sustainability of shrimp resources in Mukomuko Waters. To provide a basis for sustainable fisheries management, it is therefore necessary to analyze the status of exploitation of prawn resources in Mukomuko Waters. When data is limited, management measurements from fisheries allow the use of natural history data to analyze the Spawning Potential Ratio (SPR). This method has been widely used by several researchers such as Prianto et al. (2021), Harlyan et al. (2023), Haser et al. (2023), and Suyasa et al. (2023) in studying the level of fisheries resource utilization and has proven to be quite effective. This study aims to determine the status of shrimp resource utilization as basic information for sustainable shrimp management in Mukomuko Waters through the SPR approach. The results of this study are expected to inform the Ministry of Marine Affairs and Fisheries (MMAF) and fishermen of the necessity for improved management measures for banana prawn fishing in Mukomuko Waters.

MATERIAL AND METHODS

Study area

Geographically, Mukomuko District, Bengkulu Province, Indonesia is located at 101°00'15.1"-101°051'29.6"E and 2°016'32.0"-3°007'46.0"S (Figure 1). Mukomuko is one of the Bengkulu districts located on the west coast of Sumatra Island and directly borders the Indian Ocean, with a coastline of approximately 98.218 km. Research was conducted at the Pasar Bantal fish landing base located in Pasar Bantal Village and Teramang Jaya Village. The selection of Pasar Bantal as the primary research location was driven by its status as the largest shrimp producer in Bengkulu Province, with a production capacity that meets the demands of West Sumatra and Bengkulu Provinces. The community of Pasar Bantal primarily relies on fishing as their primary livelihood, employing a diverse range of fishing techniques, including longlines, shrimp mini-trawls, millennium nets, and nylon nets.

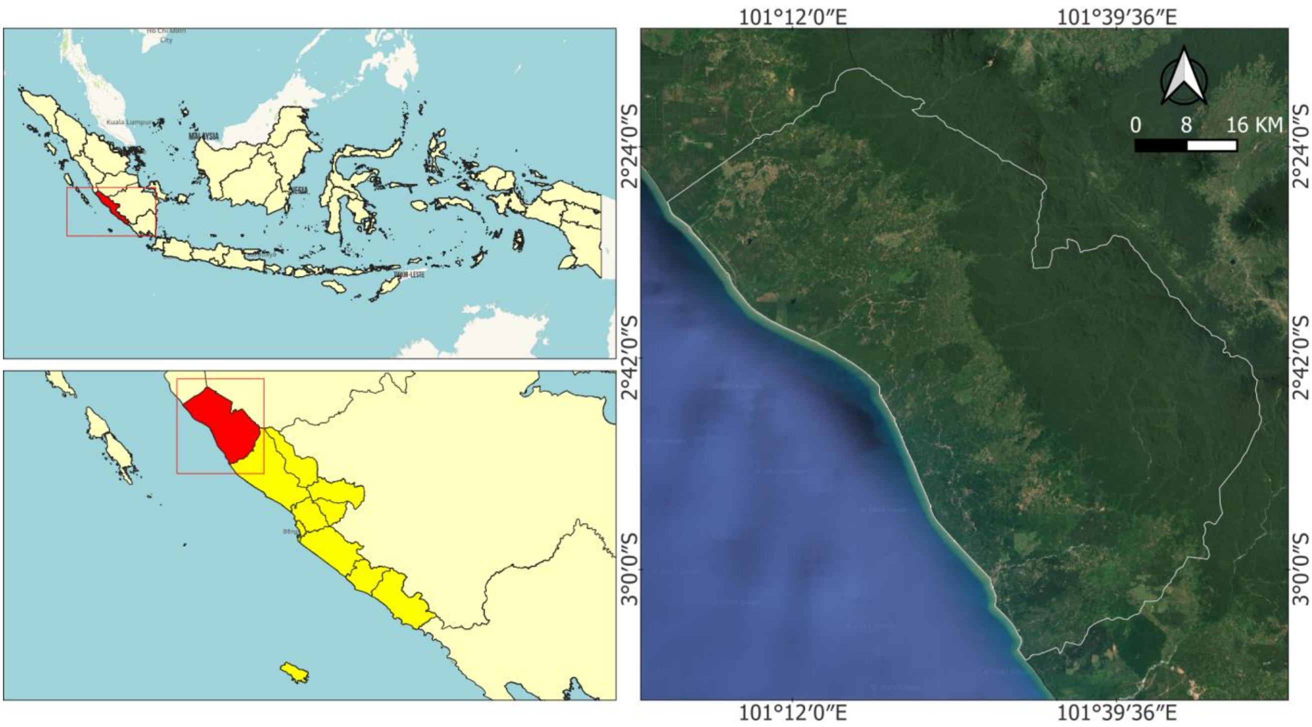

Figure 1. Study area in Mukomuko District, Bengkulu, Indonesia

Data collection

Data on fishing gear, catch composition, and prawn samples was collected in Pasar Bantal fish landing base over three months, from January to March 2023. The prawn fishing area in Mukomuko is located in the waters of West Sumatra, specifically in the waters of Teramang Jaya and the coastal waters of Mukomuko abrasion at a depth of 5-20 meters. The data collection focused on the frequency distribution of prawn carapace length from shrimp mini-trawl catches in Mukomuko Waters. The data was collected using simple random sampling technique, wherein 10% of the operating shrimp mini-trawlers were selected. From the 165 operating vessels, 17 mini-trawlers were selected, and sampling was carried out daily. A total of 3,600 samples of each prawn species and 150 samples for the level of gonad maturity of each prawn species were collected during the study period. The samples were meticulously observed based on the daily catch landing records for a period of three months, during which measurements were taken of the Carapace Length (CL), body weight, and the sexual maturity and gonadal maturity of the prawns.

Data analysis

A descriptive approach was employed to provide an accurate and detailed account of the shrimp mini-trawl fishing gear, the primary fishing gear utilized to catch *P. merguensis* in Mukomuko Waters. To determine the proportion of *P. merguensis* in the total shrimp mini-trawl catch, this study also analyzed the composition of the shrimp mini-trawl catch, which was based on the composition of fish caught daily. Furthermore, to ascertain the distribution of the maturity level of *P. merguensis* caught by the shrimp mini-trawl, the degree of Gonad Maturity Level (GML) was evaluated through the observation of shrimp gonads, including the shape, color, and development of the gonads. As outlined by King (1995), the development of shrimp GML was analyzed using the following criteria: (i) GML 0: Ovaries are not visible, with internal organs and muscles visible at the cephalothorax-abdomen junction; (ii) GML I is defined by milky white ovaries that are not visible through the shell, with the intestines and muscles visible; (iii) GML II is characterised by pale yellow ovaries, which are not visible through the shell. For shrimp which the intestines and muscles are visible, the following criteria was applie; (iv) GML III is characterised by yellow ovaries and transparent red chromatophores, with the ovaries visible through the shell; (v) GML IV is characterised by orange ovaries, prominent red chromatophores, and most of the ovarian lobes are visible.

To describe the growth of *P. merguensis*, an analysis of the relationship between length and weight was conducted. The results of this analysis will be used to describe the isometric and allometric patterns of shrimp growth. Two equations were used to analyse these two patterns, as outlined by King (1995):

$$W = cLn$$

After transforming the variables into logarithms, the following equation is obtained:

$$\text{Log } W = \log c + n \log L$$

W represents weight in grams, L denotes length in millimeters, and c and n are constants. The value of b is either 3 or $b \neq 3$, with the latter representing the alternative hypothesis. When b = 3, the relationship between length and weight is isometric. However, when $b \neq 3$, the relationship is allometric.

Furthermore, the growth parameters associated with the status of the prawn stock were assessed using the TropFishR program in the Rstudio software (Mildenberger et al. 2017). Based on the mean and maximum carapace length and the length frequency, this analysis yields the growth parameters asymptotic length ($L\infty$), growth coefficient (K), first gonad size or length at first maturity (Lm), the proportion of 50% gonadally mature prawn (L50), and the proportion of 95% gonadally mature prawn (L95), natural mortality rate (M), fishing mortality rate (F), total mortality rate (Z), and the resulting exploitation rate (E).

After generating the growth parameters and fishing mortality, the next step to estimate the resource status of *P. merguensis* was to calculate an estimated Spawning Potential Ratio (SPR). SPR is a good biological reference point and can be used for fisheries management with limited data (Hordyk et al. 2015). Data on biological parameters ($L\infty$, M/K, and L50) were processed by Rstudio software at situs online The Barefoot Ecologist's Toolbox Length-Based Spawning Potential Ratio (LBSPR) (http://barefootecologist.com.au/lbspr) (Hordyk et al. 2015). The reference value of SPR was based on Prince et al. (2015), where the status of fish stocks is divided into three criteria categories, which are over-exploited (SPR<20%), moderately exploited (20%≤SPR≤40%), and under-exploited (>40%).

RESULTS AND DISCUSSION

Fishing gear

The fishing gear employed in Mukomuko for shrimp capture is a shrimp mini-trawl (Figure 2). The net's primary components include the cod end (1.5 m), the body net (9 m), the warp rope (80-90 m), and the otter board (0.8x0.5 m). This gear is classified as active fishing gear, which is operated using a boat. The dimensions of the vessel employed for this purpose are 10 meters in length, 2.5 meters in width, and 1.1 meters in depth. The net, which possesses a bag-like shape, is pulled horizontally using the boat to sweep the bottom of the water, thereby capturing shrimp and other fish species. The shrimp fishing grounds of the Mukomuko fishermen are located in the waters of the Teramang Jaya sub-district of Mukomuko City and the Mukomuko Abrasion Beach, extending from the shoreline at a distance of 9-13 km. The depth of this area ranges from 5-20 m, characterized by muddy and sandy bottoms.

Catch

Based on Figure 3, the fishes caught using shrimp mini-trawls in Mukomuko Waters were classified into five groups, namely fish (74.58 kg, 56%), Crustacea (51.16 kg, 39%), Mollusca (5.21 kg, 4%), Coelenterata (0.84 kg, 1%), and Echinodermata (0.43 kg, 0.3%). The main catch of shrimp mini-trawls was banana prawn (*Penaeus* spp.), rainbow shrimp (*Parapenaeopsis* spp.), brown shrimp (*Metapenaeus* spp.), and kadal shrimp (*Metapenaes dobsoni*). The by-catch included hairtail (*Trichiurus savala*), stingray (*Gymnura poecilura*), cuttlefish (*Sepia apama*), crab (*Portonus* spp.), white pomfret (*Pampus argenteus*), silver croaker (*Pennahia argentata*), and several other fish including discard fish.

Gonad Maturity Level (GML)

The analysis of banana prawn (*P. merguiensis*) samples in Mukomuko Waters revealed a predominance of females, constituting 65% of the total catch, while males constituted 35%. The GML analysis of these samples indicated that the majority fell within the GML II and GML III categories. Specifically, the GML I category constituted 10% of the sample, while the GML II, GML III, and GML IV categories represented 29%, 34%, and 27%, respectively (Figure 4).

Growth pattern

The carapace length class interval of the sampled *P. merguiensis* ranged from 22 to 71 mm. The greatest frequency of prawns recorded (874) had a carapace length range of 38-42 mm (Figure 5).

The relationship between carapace length and weight of *P. merguiensis* shows a high coefficient of determination (R^2) value (0.884), as illustrated in Figure 6. The results of this calculation indicate that the relationship between weight and length of *P. merguiensis* is significant. The growth pattern of *P. merguiensis* in Mukomuko Waters based on the length-weight relationship shows negative allometry. This indicates that the increase in body length of shrimp is more significant than the increase in weight.

Length at maturity (Lm) and length at first capture (Lc)

According to the maturity-selectivity curve, length at maturity was 31.43 mm, and size at first capture (Lc) was 32.6 mm (Figure 7). As Lc is greater than Lm, meaning that the size of first capture is larger than the average size at maturity, *P. merguiensis* in the study region was first caught after reaching maturity, indicating some potential for reproduction.

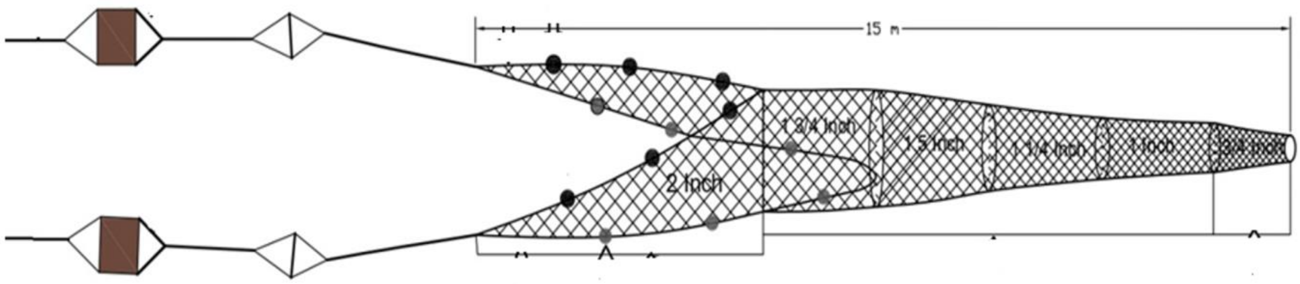

Figure 2. Shrimp mini-trawl fishing gear used in Mukomuko Waters, Bengkulu, Indonesia

Figure 3. Fish catch of shrimp mini-trawl in Mukomuko Waters, Bengkulu, Indonesia. A. Banana prawn (*Penaeus merguensis*); B. Rainbow shrimp (*Parapenaeopsis sculptilis*); C. Bycatch; D. Discards

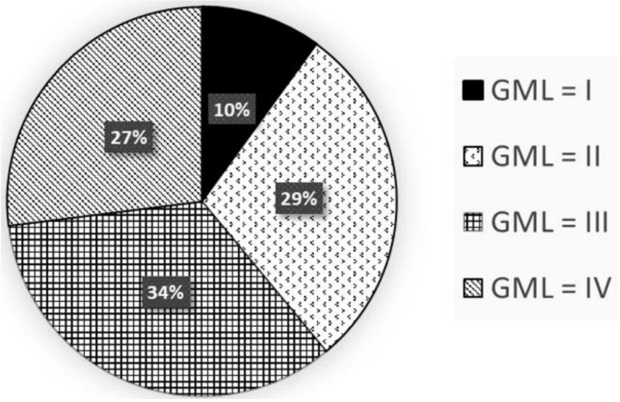

Figure 4. The proportion of Gonad Maturity Level (GML) of *Penaeus merguensis* samples caught using shrimp mini-trawl in Mukomuko Waters, Bengkulu, Indonesia

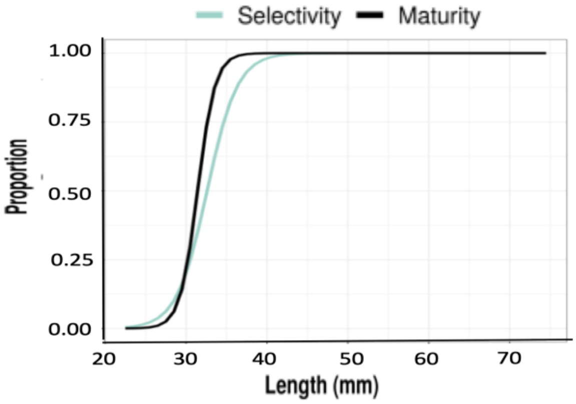

Figure 7. Maturity-selectivity curve of *Penaeus merguensis* samples caught using shrimp mini-trawl in Mukomuko Waters, Bengkulu, Indonesia

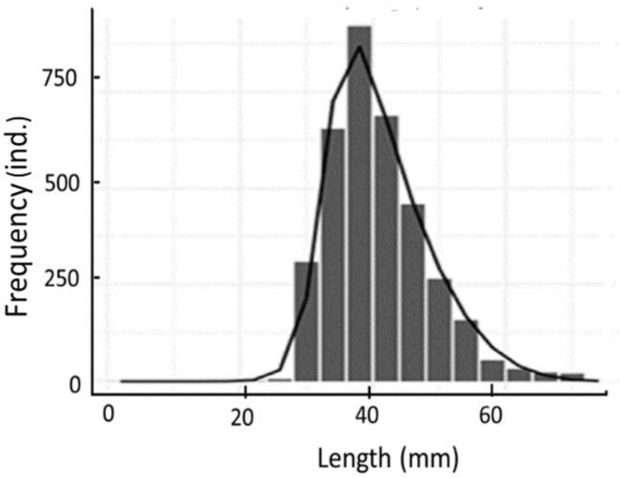

Figure 5. Frequency distribution of carapace length of *Penaeus merguensis* samples caught using shrimp mini-trawl in Mukomuko Waters, Bengkulu, Indonesia

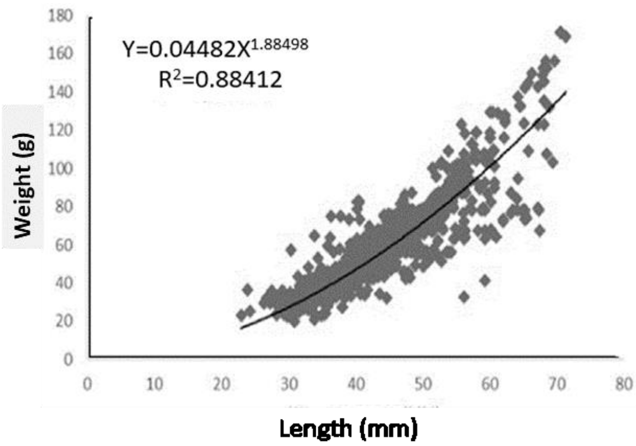

Figure 6. Relationship between carapace length and weight of *Penaeus merguensis* samples caught using shrimp mini-trawl in Mukomuko Waters, Bengkulu, Indonesia

Spawning Potential Ratio (SPR)

The results of the analysis of growth parameters indicate that the asymptotic value (L∞) for *P. merguiensis* is 72.22 mm, with a growth coefficient of K: 1.23 per year. The value of K for *P. merguiensis* Prawn is greater than 1, suggesting that the growth rate is relatively fast. This suggests that *P. merguiensis* attains their asymptotic length at a more rapid rate. The total mortality (Z value) was determined to be 4.58 per year, of which natural mortality rate (M) comprised 1.4 per year, fishing mortality (F) was calculated to be 3.18 per year, indicating that fishing mortality (F) was more than twice as high as natural mortality (M). The exploitation rate (E), calculated as E: F/Z, had a value of 0.6. The SPR values are derived from calculations based on estimates sourced from the website www.barefootecologist.com.au. The SPR value of *P. merguiensis* is 0.20 or 20%, indicating that the utilization of the assessed stock is very high. While the value still falls within the "moderate utilization" condition, it is very close to over-exploited (Prince et al. 2015).

Discussion

The analysis of the relationship between the length and weight of *P. merguensis* reveals that the growth of these crustaceans is negatively allometric, with a 'b' value greater than 3. This suggests that the increase in shrimp weight is not directly proportional to the increase in length. These findings are consistent with those reported in other regions of Indonesia, including the waters of Merauke, Papua (Suman et al. 2023b), the waters of the Tukad Aya estuary (Siagian et al. 2020), the waters of Bengkalis (Suman et al. 2020) and the Langsa mangrove area (Maulida et al. 2021). The negative allometric growth pattern indicates that a species is attempting to adapt to changes in local conditions, including environmental factors and food availability, as well as the level of exploitation (Maulida et al. 2021). Furthermore, the analysis of the proportion of catches revealed that the catch rate of female shrimp exceeded that of male shrimp. Concurrently, the results of the Gonad Maturity Level (GML) analysis of *P. merguiensis* fish in Mukomuko Waters during January and March indicated that the majority of the fish were classified as fish undergoing gonadal development and maturation. The results of this study suggest that female shrimp have migrated to the spawning area, where shrimp are typically caught by fishermen. This hypothesis is further substantiated by the analysis of the initial catch size and the size at gonad maturity, which indicate that *P. merguiensis* in the study area were captured at the time of gonad maturity.

The asymptotic length (L∞) of *P. merguiensis*, as determined by the analysis of the sampled specimens, was found to be 72.22 mm. On the other hand, the observed K value is greater than 1, indicating that the growth rate of *P. merguensis* is relatively fast. The growth rate observed in this study is within the same range as that found for the same species in other regions of Indonesia. However, the asymptotic length of the stock in Mukomuko Waters is significantly greater than that observed in other areas. Furthermore, the exploitation rate (E) of *P. merguiensis* is indicated as being subject to overfishing. Therefore, exploiting these resources must be managed with the utmost care and precision. This has implications for the long-term sustainability of shrimp fisheries. These findings are corroborated by the results of the analysis of the *P. merguiensis* Spawning Potential Ratio, which indicates that the stock has been over-exploited (Prince et al. 2015; Suman et al. 2023b). This suggests that the *P. merguiensis* resources in Mukomuko Waters have been over-exploited. It is feared that if current shrimp fishing controls are not improved, the conservation and sustainable utilization of shrimp fishing in the Mukomuko area may be threatened in the long term.

The rapid development of fisheries requires up-to-date information on the speed of fish stock regeneration. The results of this study indicate that a rapid analysis using the LB-SPR model can provide valuable insights into the condition of shrimp fisheries (Ernawati et al. 2021; Nabila et al. 2022a; Hapsari et al. 2023; Lelono et al. 2023; Shertzer et al. 2024). This is crucial for effective management and utilization of fisheries resources, which requires up-to-date scientific expertise. A sustainable fishing model can be developed based on accurate and up-to-date scientific information. Fisheries management can generally be categorized into four different aspects: biological, ecological, economic, and social (including political and cultural) (FAO 1995). The biological and environmental aspects of shrimp mini-trawl fisheries are negatively affected by the highly effective and non-selective nature of the fishing gear. The main objective of shrimp stock management is to ensure the sustainability of shrimp production in the long term. This can be achieved primarily through the implementation of regulatory measures and corrective actions. The ultimate goal is to improve the economic and social welfare of fisherfolk.

Shrimp resources in Mukomuko Waters have been exploited for a long time, with the use of shrimp mini-trawls as the main characteristic of this activity. The shrimp fishing industry operates continuously throughout the year, with high fishing pressure concentrated in a narrow fishing area. If this situation continues, it will endanger the survival and sustainability of shrimp resources. As asserted by Sandoval and Rocha (2024) in the Yucatan Peninsula, Mexico and Nabila et al. (2022b), it is imperative to implement measures for the management of shrimp fisheries in the Mukomuko area. This necessitates the organization of environmentally sustainable mini-shrimp trawl fishing operations, contingent on temporal and spatial parameters for fishing activities. This approach is further reinforced by the Decree of the Minister of Maritime Affairs and Fisheries Number 18/KEPMEN-KP/2021, which stipulates the management of shrimp mini-trawls as fishing gear. This is due to the potential for shrimp mini-trawls to cause harm to the habitat of fish resources, including shrimp. Consequently, as asserted by Lauden et al. (2024) and Widhiastika et al. (2024), stakeholders bear the responsibility to ensure adherence to conservation measures, namely by transitioning to eco-friendly fishing gear, thereby fostering long-term sustainability in the region.

In conclusion, the result study indicates that banana shrimp (*P. merguiensis*) resources in Mukomuko Bengkulu are under significant fishing pressure. The study found that the dominant growth stage of banana shrimp species in the waters of Mukomuko was at GML II (29%), GML III (34%), and GLM IV (27%) indicating that the catch is primarily composed of mature individuals. The study also found that the growth coefficient (K) value of banana shrimp in Mukomuko Waters is 1.23 per year, suggesting that they grow relatively quickly. However, the calculation of the SPR value indicates that banana prawns in Mukomuko Waters are being over-exploited with regard to their reproduction rate. To address this issue, it is recommended that fishing pressure in Mukomuko Waters be reduced by transitioning from shrimp mini-trawl to alternative, more environmentally friendly fishing techniques, such as static fishing gear like trammel nets and semi-active fishing gear like Danish seine.

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