Population dynamics of jerbung shrimp (*Penaeus merguensis*) in Samboja Kuala Waters, Kutai Kartanegara Regency

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ABSTRACT

Jerbung shrimp (*Penaeus merguensis*) is one of the species caught in the waters of Samboja Kuala. In an effort to conserve and utilize as well as high fishing intensity, the possibility of exploiting shrimp resources will be threatened. This research was conducted in November-December 2022. This study aims to examine sex ratios, age groups, growth rates, mortality and exploitation, growth pattern, and yield per recruitment. Jerbung shrimp *(P.merguensis*) in Samboja Kuala waters, Kutai Kartanegara. Shrimp sampling using a mini trawl operated in the waters of Samboja Kuala, Kutai Kartanegara. The sex ratio of jerbung shrimp was 1:1.29. The coefficient of growth rate (K) is 0,770 and the estimated length in nature ($L\infty$) is 187,33. Jerbung shrimp with a natural mortality value (M) = 0,197/year, a mortality value due to fishing (F) = 0,143, and a total mortality value (Z) = 1,061, with an exploitation value (E) = 0,135 which means that it is still at level it should be. The peak of new additions to females occurred in July as much as 18,56%. The Y/R capability was 0,071/year, and E*max* calculated the Y/R relationship with the exploitation rate, which was 0,42.

INTRODUCTION

Samboja Kuala waters is one of the fishing grounds in Kutai Kartanegara Regency, East Kalimantan Province. One of the catches obtained by fishermen in Samboja Kuala waters is the *Penaeus merguiensis shrimp*. The catch of *Penaeus merguiensis* shrimp is taken at depths of 10-15 meters with muddy sand substrate. Penaeus merguiensis is a tropical aquatic organism that thrives in turbid waters rich in organic matter with muddy sandy bottoms. The capture of Penaeus merguiensis shrimp is carried out using mini trawl gear. Shrimp harvesting is highly dependent on natural conditions and can occur during both day and night. The utilization of shrimp in this area is intensive and increases every year. Although shrimp resources are renewable, continuous harvesting without regulation can deplete these resources.

Efforts to harvest Penaeus merguiensis shrimp in this area are continuous and, without proper utilization patterns, can lead to a decline in shrimp resource potential. Conservation efforts are needed to sustain the Penaeus merguiensis stock in nature. Effective management requires fundamental data on population dynamics at various life stages and habitats.

Given the indicator of decreasing catch rates in this area, efforts are aimed at improving shrimp resource management and promoting sustainable utilization. Therefore, this research aims to study sex ratio, age groups, growth rate, mortality and exploitation, recruitment patterns, and yield per recruitment of Penaeus merguiensis shrimp in Samboja Kuala waters, Kutai Kartanegara.

METHODOLOGY

Time and Location of the Study

This research was conducted in the coastal waters of Samboja Kuala, a landing area for fishermen. The sampling was carried out during daylight hours over a period of 5 weeks, from November 2022 to December 2022.

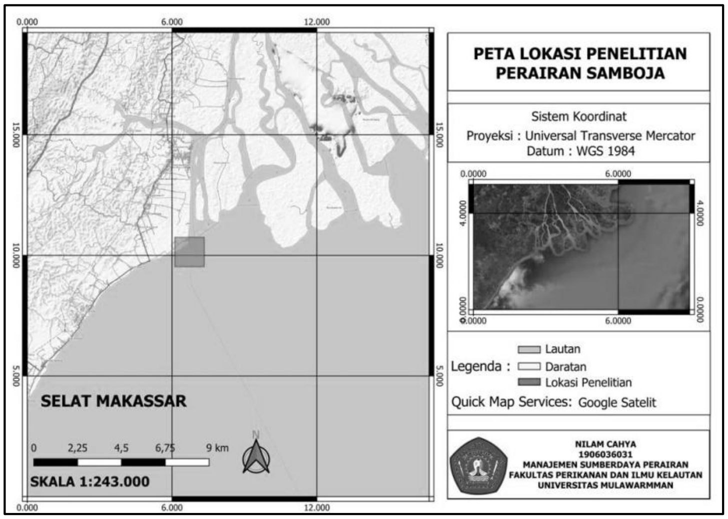

Figure 1. Study location map

Research Procedure

Sampling for this study involved collecting specimens from the catches of fishermen, specifically Penaeus merguiensis shrimp. Fishermen used mini trawl gear for the captures during daylight hours. Samples were collected weekly to facilitate measurement and prevent sample damage. Subsequently, the body length of Penaeus merguiensis shrimp was measured at the Conservation Laboratory of the Faculty of Fisheries and Marine Sciences, Universitas Mulawarman.

Data Analysis

Data obtained were analyzed using the following analytical methods:

1. Sex Ratio

Sex ratio of shrimp was calculated using the equation:

X = M : F

where:

- X = sex ratio
- M = number of male shrimp (individuals)
- F = number of female shrimp (individuals)

2. Age Estimation

Age estimation was performed using the Von Bertalanffy growth formula (Sparre et al., 1999):

$L_t = L_\infty (1 – e^{-K(t-t_0)})$

where:

- L_t = length of shrimp at age t (mm)
- L_∞ = asymptotic length of shrimp (mm)
- K = growth coefficient
- t_0 = theoretical age of shrimp when length equals zero (months)
- t = age (months)

The parameter t_0 was determined using the Pauly formula (1980):

$$\text{Log}(-t_0) = -0.3922 - 0.2752\ (\text{Log } L_\infty) - 1.038\ (\text{Log } K)$$

3. Mortality

Natural mortality estimation was calculated using the empirical Pauly formula (1980):

$$\text{Log } M = -0.0066 - 0.279\ \text{Log } L_\infty + 0.543\ \text{Log } K + 0.4634\ \text{Log } T$$

where:

- L_∞ = asymptotic length of shrimp (mm)
- K = growth coefficient
- T = average surface water temperature (°C)

Total mortality was estimated using the equation proposed by Beverton and Holt (1956) in Sparre et al. (1992):

Fishing mortality was estimated using the equation:

$$Z = F + M$$

where:

- F = fishing mortality
- Z = total mortality

Exploitation rate (E) was obtained using the Beverton and Holt formula:

$$E = F / Z$$

Recruitment Pattern

Recruitment pattern data were analyzed using the FiSAT II software's recruitment pattern sub-program, aiming to determine the temporal construction of length frequency recruitment peaks per year. The data were transformed into lfq format (grouped frequencies) and input with previously calculated values of L_∞ and K, resulting in recruitment pattern histograms.

RESULTS AND DISCUSSION

Location Condition of the Study

Kelurahan Samboja Kuala is a coastal area in Kutai Kartanegara Regency, known for its abundant shrimp resources. The majority of the population in this area are fishermen. The gear used by fishermen for catching shrimp is the mini trawl. Fishing activities in this area occur twice daily, both during daylight hours and at night.

Fishermen engage in fishing activities for six days a week, with each day lasting 12 hours. The timing of fishing trips depends largely on environmental conditions, particularly weather conditions. If weather conditions are unfavorable, such as heavy rain or high waves, fishermen may not be able to go out for shrimp fishing.

Sex Ratio

The sex ratio of Penaeus merguiensis shrimp found during the study is presented in Table 1.

Table 1. Sex ratio

Month	**Number of Individual**		**Ratio**	
November-Desember	Male	Female	Male	Female
	109	141	1.00	1.29

Based on Table 1, the sex ratio of *Penaeus merguiensis* shrimp shows that the number of females is greater than males with a ratio of 1:1.29. According to Saputra et al. (2013), in the waters of Kendal, Central Java, the sex ratio of Penaeus merguiensis shrimp is 1:0.95. In this comparison, when males and females are balanced or when females outnumber males, the population of shrimp is considered ideal for maintaining its sustainability. This finding aligns with Saputra et al.'s (2013) study in Cilacap waters, where the sex ratio was found to be 1:1.61. In contrast, Tirtadanu et al. (2016) found a balanced sex ratio in the northern waters of Central Java during April, May, and June.

Table 2. *Chi-Square Tast*

Sex	N	Fo%	F%	(Fo-f)	$(Fo-f)^2$	$(Fo-f)^2/F$
Male	109	44	50	-6	36	0.72
Female	141	56	50	6	36	0.72
	250		100		X^2	1.44

Based on the chi-square test, the calculated chi-square value (X^2) is 1.44, with 1 degree of freedom (df), and the critical chi-square value (X^2 table) at a significance level of 0.05 is 3.841. Therefore, the calculated X^2 value is less than the critical X^2 value, indicating that there is no significant difference, and the sex ratio between males and females is considered balanced. The higher capture of females than males in this study can be influenced by factors such as the fishing grounds selected by fishermen in different areas, food availability, water quality conditions, and differences in mortality between male and female brown spot shrimp (P. merguensis). When males and females are balanced, or females outnumber males, it suggests that the population is still ideal for sustainability (Saputra, 2013).

Age Group

Based on the age groups analyzed, the data obtained for jerbung shrimp in Samboja Kuala waters at 1 year old reached an average length of 145.06 mm. Age groups were analyzed using length analysis, as length frequencies generally originate from the same age and tend to create a normal distribution.

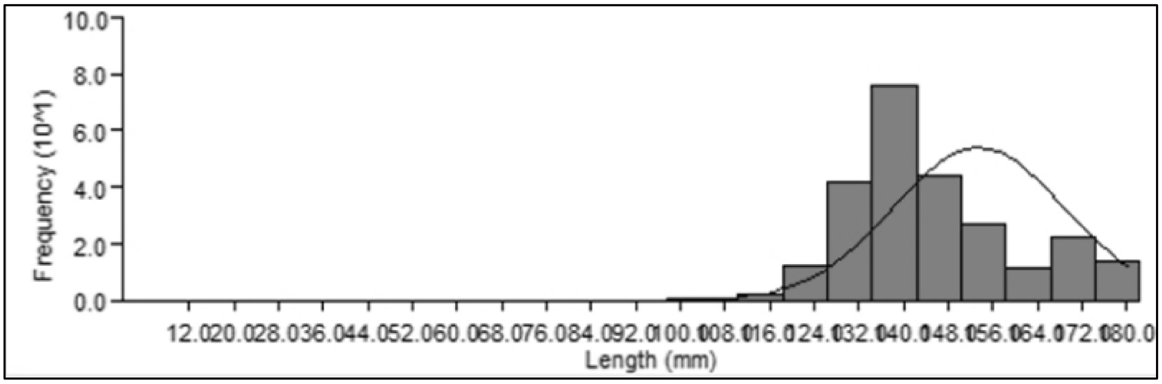

Figure 2. Age group distribution

Growth Rate

The analysis includes the asymptotic length (L∞), growth coefficient (K), and age at zero length (t0) for both male and female jerbung shrimp, presented in Table 3.

Table 3. Estimated Growth Parameter Values

Parameter	Parameter value
L∞	187.33
K	0.770
t0	0.125

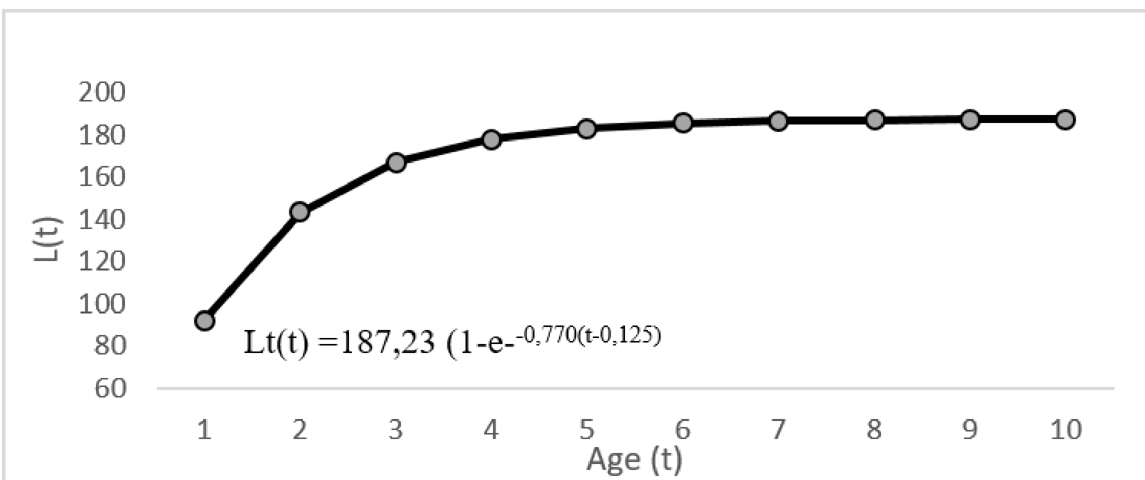

Figure 3. Age estimation

Based on Table 3 and Figure 3, the estimated growth parameters and the age estimation graph of jerbung shrimp show that the growth of jerbung shrimp increases every year. At the age of 8 years, the growth of jerbung shrimp starts to slow down, reaching its asymptotic length. The asymptotic length (L∞) of jerbung shrimp is 187.33 mm, and the growth coefficient (K) is 0.770. In the study by Suman et al. (2022) in the Arafura Sea, different values of L∞ and K were found, specifically 50.2 mm and 1.62/year, respectively. Similarly, in the study by Wagiyo et al. (2018) in Cilacap waters, L∞ and K were 44.6 mm and 1.47/year, respectively. These differences in L∞ and K values among studies in different locations, including Samboja Kuala waters, may be influenced by various environmental conditions (Tsoumani et al., 2006, cited in Suman et al., 2022), such as water temperature, food availability, dissolved oxygen, and gonad maturity. Effendi (2022) suggests that differences in L∞ and K values can be attributed to both internal factors (such as genetics, parasites, and diseases) and external factors (such as temperature and food availability).

Mortality and Exploitation

Based on the growth parameter values and growth rates at the average water temperature in Kalimantan waters (27-29ºC according to BMKG, 2021), the values of total mortality (Z), natural mortality (M), and fishing mortality (F) can be seen in Table 4.

Table 4. Mortality and exploitation rate

Parameter	Parameter value
Total mortality (Z)	1.061
Natural mortality (M)	0.917
Catching mortality (F)	0.143
Mortality rate (E)	0.135

Based on Table 4, the natural mortality (M) value of 0.917/year is higher than the fishing mortality (F) value of 0.143/year for jerbung shrimp in Samboja Kuala waters. This indicates that jerbung shrimp mortality in Samboja Kuala is primarily due to natural factors such as food availability or predators, as noted in the study by Tirtadanu and Chodrijah (2020). Natural mortality is influenced by environmental conditions including predation, food availability, competition, stress levels, diseases, and changes in environmental quality.

In Mollynda et al.'s study (2022) in Kendal waters, the natural mortality (M) of jerbung shrimp was 1.07/year, higher than the fishing mortality (F) of 0.44/year. High natural mortality can be attributed to environmental factors such as temperature, salinity, predation, and competition. The lower fishing mortality compared to natural mortality suggests a low exploitation rate of jerbung shrimp in Samboja Kuala waters.

The exploitation rate (E) for jerbung shrimp in Samboja waters is 0.135, where $E < 0.5$, indicating that the exploitation rate is below the optimum E of 0.5. This implies that the exploitation rate is currently at a sustainable level. According to the assumption that the optimum exploitation rate (F opt) should be balanced with natural mortality (M), the expected optimum exploitation should be around 0.5, or $E < 0.5$ (Pauly et al., 1984).

New Recruitment Pattern

The analysis of jerbung shrimp length data captured during daytime in Samboja waters shows monthly percentages over the course of a year, from January to December. The highest new recruitment for jerbung shrimp occurs in June-July. Van Zalinge and Naamin (1975) cited in Saputra et al. (2013) state that fishing effort and rainfall are significant factors influencing stock abundance in Cilacap waters. Rainfall affects the 37 spawning seasons of shrimp, with peaks occurring at the beginning and end of the rainy season (Naamin and Poernomo, 1972 cited in Saputra et al., 2013). Therefore, it is important to consider these factors to ensure that new recruitment continues to occur in a sustainable manner.

Yield Per Recruitment

Yield per Recruitment (Y/R) was analyzed using Beverton & Holt estimates. Based on the analysis, the estimated Y/R value is 0.017, which represents the yield captured per recruitment event. This indicates that 0.017 of each recruitment event is taken as catch. The relationship between exploitation rate and yield per recruitment can be seen in Figure 4.

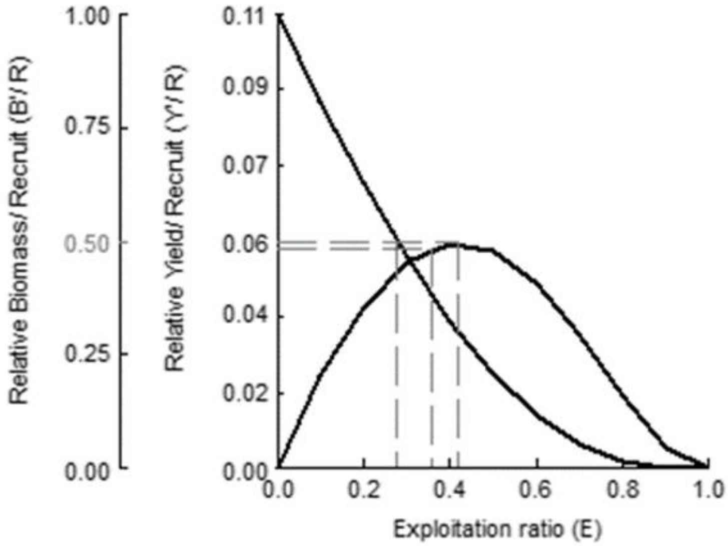

Figure 4. Graph of the relationship between Exploitation Rate and Yield Per Recruitment

The exploitation rate of jerbung shrimp in Samboja waters is 0.135, and the Y/R obtained is 0.017. This shows that the exploitation rate does not exceed the optimum value. The Emax obtained in the relationship between exploitation rate and yield per recruitment is 0.42. To achieve optimal catch results, it is advisable to reduce fishing effort by approximately 37%, as suggested by Pauly et al. (1984) with E opt = 0.5. This approach would maximize yields without compromising the ability of jerbung shrimp to replenish in those waters.

CONCLUSION

1. The sex ratio of captured jerbung shrimp is 1:1.29, indicating a balanced ratio between males and females, confirmed by Chi-Square test.
2. The von Bertalanffy growth parameters ($L\infty$ and K) for jerbung shrimp are 187.33 mm and 0.770/year, respectively.
3. The total mortality (Z), natural mortality (M), and fishing mortality of jerbung shrimp are 1.061, 0.197, and 0.143, respectively.
4. The exploitation rate (E) for jerbung shrimp is 0.135, indicating $E < 0.5$, which means it does not exceed the optimum exploitation rate.
5. Recruitment of jerbung shrimp peaks in July, accounting for 18.56% of the total.
6. The estimated Yield per Recruitment (Y/R) is 0.017/year. Considering the relationship between exploitation rate and Y/R, Emax is found to be 0.42.

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