Size distribution and growth patterns of banana prawn (*Penaeus merguensis*) in the shallow waters of Merauke District, Indonesia

[1,2]Bonny Lantang, [3]Najamuddin, [3]Alfa F. P. Nelwan, [3]Muhammad F. Samawi

[1] Graduate School, Department of Agricultural Science, Faculty of Agricultural, Hasanuddin University, Makassar, South Sulawesi, Indonesia; [2] Department of Aquatic Resources Management, Faculty of Agricultural, Musamus University, Merauke, South Papua, Indonesia; [3] Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar, South Sulawesi, Indonesia. Corresponding author: Najamuddin, najaunhas@gmail.com

Abstract. The shallow waters of Merauke District, Indonesia, have biological resources such as banana prawns (*Penaeus merguensis*). However, studies on the size distribution and growth patterns based on habitat in the shallow water are limited. This study aims to answer what habitats are suitable for prawn fishing areas and as nursery grounds. Additionally, it aims to determine whether growth patterns differ in each habitat. The results showed that juvenile prawns were found in some habitats in March, related to the spawning season in the previous month. The increase in the size of banana prawns as sub-adults begins in April, with adult size being reached in different months in each habitat, due to increased water salinity and temperature decreases. The presence of adult prawns in estuarial habitats and sandy beaches at Lampu Satu in September was related to the spawning season. A decrease in size, from adult to juvenile prawns, was observed in estuarine habitats and sandy beaches in Lampu Satu, in mangroves in Yobar, and on sandy beaches in Payum. In contrast, adult prawns could be found in mangrove habitats in Bokem, from October to January, but in the sandy beach habitat of Payum, they can be found until February, and in the mangroves in Bokem, until December. This is due to the influx of fresh water, causing the spawning of adult prawns in the preceding month (namely September), to conclude. Juvenile prawns then take their place in areas adjacent to the estuary. The increase in size from March onward is due to the low supply of fresh water, a decrease in temperature, and a pH above 7. These conditions are signals for both sub-adults and adults to spread more widely, replacing juvenile prawns in some habitats. The growth pattern in all habitats for males and females were negative allometric (b<3).
Key Words: coastal waters of Merauke District, different habitat, negative allometric, size distribution.

Introduction. Resource sustainability is a global issue and a direct challenge to overcome. An increase in the world population, conflicts between countries, the Covid-19 pandemic, and climate change will trigger a food crisis (FAO et al 2023). This condition may lead to an increased exploitation of resources, such as overfishing (FAO 2016). Anticipating this, one of the United Nations programs, namely the Sustainable Development Goals (SDGs), emphasizes the importance of maintaining and managing marine ecosystems for resource sustainability (FAO 2021). To support this program, studies focusing on biological aspects of aquatic species, such as length-weight relationships, life stage, and ecology, need to be conducted. The importance of studying the length-weight relationship for banana prawn (*Penaeus merguensis*) is in providing information about population analysis in a habitat, showing the population's development over time and whether there is or not a change in size or an increase in population numbers (Hargiyatno et al 2015; Tirtadanu et al 2018; Kaka et al 2019). It provides information on the right time for fishing, it helps set permissible sizes and permits small sized organisms to grow and develop (Hargiyatno et al 2015). Understanding the life stages of prawns is essential for effective management of coastal waters and marine areas. This knowledge allows us to monitor the location of prawns throughout their

spawning stage, larval phase, juvenile, sub-adult, and adult stages. Additionally, it aids in planning resources for the future (Tirtadanu et al 2018; Oliveira et al 2020; Vance & Rothlisberg 2020; Arief et al 2023). Ecologically, it provides information about changes in environmental factors, including salinity, temperature, pH, and food availability, which will affect the growth and overall population (Widiani et al 2021; Lantang et al 2023).

The distribution of banana prawn covers several regions, such as the Arabian Sea, India, the Persian Gulf, southern China, the Philippines, Malaysia, Indonesia, Papua New Guinea, and tropical Australia (Safaie 2015; Vance & Rothlisberg 2020). In Indonesia, this prawn is found in Aceh, North Sumatra, Central Kalimantan, the North Coast of Central Java, Bengkalis waters, and the Arafura Sea (Nurdin & Kembaren 2015; Hargiyatno et al 2015; Saputra et al 2018; Putra et al 2020; Suman et al 2020; Widiani et al 2021). The Arafura Sea is endowed with abundant biological resources, including prawns, fish, and various other organisms. In 1984, these waters were recognized as the sole location with the highest potential for penaeid prawn resources among Indonesian waters (Muawanah et al 2021). Some resource problems have occurred, but over time, prawn fishing has begun to increase in these waters (Suman & Satria 2014; Lantang et al 2023). The coastal waters of Merauke District's Arafura are the habitat of banana prawns (Hargiyatno et al 2013; Hargiyatno et al 2015). This commodity is interesting to study because it has high commercial value, a short life, and has a complicated life cycle (Hargiyatno et al 2015; Tirtadanu & Panggabean 2018; Kaka et al 2019; Widiani et al 2021).

The utilization of these resources continues to this day, but studies on size distribution and growth patterns specific to each habitat should be carried out. Relevant research was conducted by Hargiyatno et al (2015) in Dolak waters, Merauke District. They reported that the banana prawn allowed to be caught was in the adult stage, with a carapace length (CL) greater than 38.7 mm. Therefore, the aims of this study are to analyze the size distribution and growth patterns of banana prawns based on their habitat. It is important to determine in which habitats juveniles, sub-adults, and adults can be found, as well as the growth patterns in each habitat. Additionally, it may provide information about when and in which habitats prawn fishing can be carried out. This knowledge can aid the planning of coastal ecosystems and ensure the sustainability of banana prawn resources in the shallow waters of the Merauke District.

Material and Method

Research location. This research has been conducted in the shallow waters of Merauke District, Indonesia. Prawn fishing areas were divided into five habitats based on the characteristics of the area (Figure 1). The habitat division includes the Maro River estuary habitat, sandy beach in Lampu Satu, mangrove in Yobar, sandy beach in Payum, and mangrove in Bokem. Data collection was carried out for thirteen months, from March 2022 to March 2023. Sampling in each habitat used the purposive sampling method (Indarjo et al 2023a; Indarjo et al 2023b). Data collection was carried out twice monthly, in five habitats in shallow waters with a depth of less than 1.5 m. The prawn samples used in this study were obtained from fishermen's catches, and there were no ethical violations during sampling or in sample observation. The analysis of the length-weight relationship was conducted at the Musamus University Laboratory.

Size distribution of banana prawn. 2876 prawns have been measured in this study, 944 males and 1932 females. Banana prawns caught by beach seine were separated according to sex (De Farias Lima et al 2014; Safaie 2015; Kaka et al 2019). Thelycum in females and petasma in males were used to make this distinction (Kembaren & Ernawati 2015). CL measurement was done according to Kembaren & Ernawati (2015), by using digital calipers, with an accuracy of 0.01 mm (Putra et al 2018; Kaka et al 2019; El-Deeb et al 2023). Determination of size distribution was based on Hargiyatno et al (2015), the prawns being separated in juveniles (<32 mm CL), sub-adults (<38.7 mm CL) and adults (>38.7 mm CL).

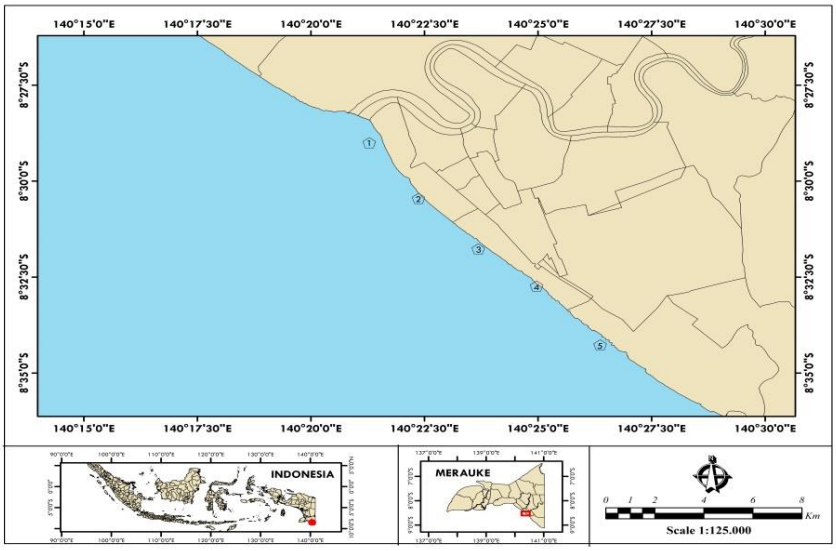

Figure 1. Research locations based on habitats; 1 - estuary of the Maro River; 2 - sandy beach at Lampu Satu; 3 - mangroves in Yobar; 4 - sandy beach in Payum; 5 - mangroves in Bokem.

Measurement of oceanographic parameters. Water salinity (psu) was measured using a refractometer, water pH was determined using a digital pH meter, and water temperature (°C) was recorded with a digital thermometer (Equbal et al 2018; De Oliveira Dias et al 2018; Wan et al 2020; Indarjo et al 2023b). Oceanographic parameters data were collected in each habitat following Lantang et al (2023). Measurements in this study were conducted three times at varying intervals, ranging from 1 to 1.5 hours, during the banana prawn capture. This was done to assess fluctuations in the measured oceanographic parameters. Prawn fishing activities commenced in the morning and concluded at noon, or began at noon and ended in the afternoon. The data obtained were averaged and grouped according to the time (month) of collection.

Growth pattern of banana prawn. Analysis of growth patterns was conducted using total length and weight data. Each sample obtained was measured to obtain the total length and weighed according to Kembaren & Ernawati (2015). Length measurements were obtained with a digital caliper with an accuracy of 0.01 mm, and weighting was conducted using a digital scale with an accuracy of 0.01 g (Putra et al 2018; Kaka et al 2019; El-Deeb et al 2023).

The growth pattern was calculated using the formula $W=aL^b$, where W is the weight (g), L is the total length (mm), a is the intercept, and b is the allometry coefficient (Safaie 2015; Tirtadanu & Panggabean 2018; Samad et al 2022; Razek et al 2022; Masoumi et al 2023;). If $b<3$ were considered negative allometric, if $b>3$ were considered positive allometric, and if $b=3$ were considered isometric (Saputra et al 2018; Oliveira et al 2020; Putra et al 2020; Fauziah et al 2022). The value of $b=3$ was tested using the t-test, which has a 5% error rate. If the t-test result is greater than the t-table value, it was considered a significant effect, and vice versa (Safaie 2015; Putra et al 2020). Additionally, this study analyzes the correlation coefficient using length and weight data. The data were processed using Microsoft Excel to determine the correlation coefficient in males and females in each habitat.

Regarding the size allowed for capture, the CL data was used. The data were grouped by habitat and time of collection. The determination of the permissible size for capture was based on Hargiyatno et al (2015), where >38.7 mm CL was defined as the size of an adult prawn.

Results. In March, juvenile prawns dominated two habitats: mangroves in Yobar and sandy beaches in Lampu Satu (Figure 2). This was related to the increase in water temperature in the habitat, 30.32-31.35°C and low salinity of 18.5-19 psu, as well as a pH of 6.8-6.9 (Tables 1, 2, and 3). In some habitats, such as the estuary of the Maro River, sandy beaches at Lampu Satu, and mangroves at Bokem, in March and April, no prawn fishing was carried out, so data for those month were unavailable. This is due to the high temperature of the water, which causes low catches. Additionally, the juvenile and sub-adult dominance in the waters prevents the presence of adult prawns.

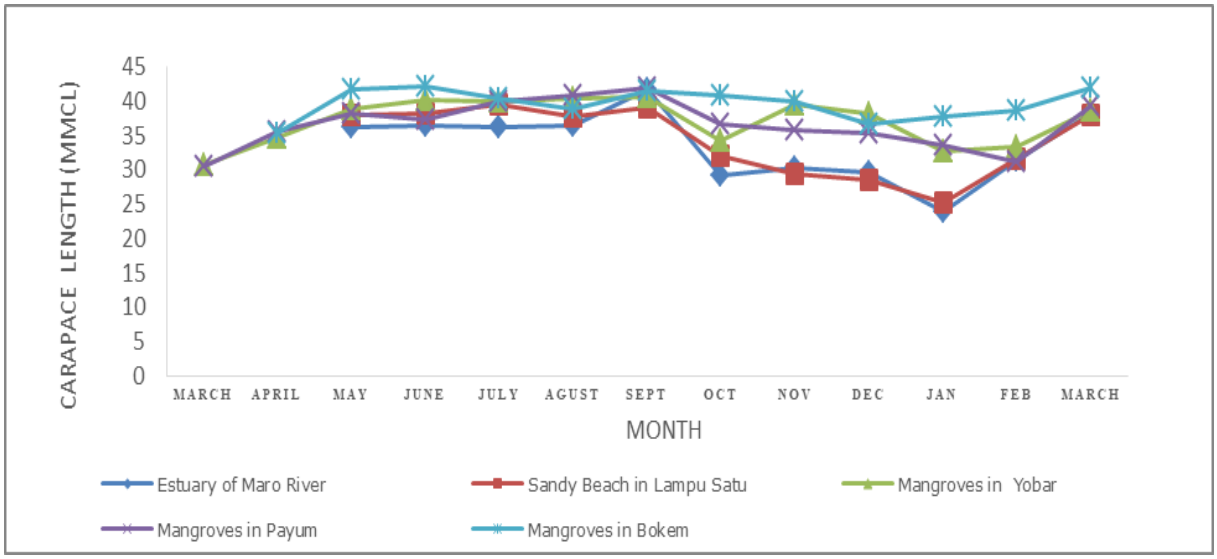

Figure 2. Distribution of carapace length of *Penaeus merguensis* in five habitats.

Table 1

Water temperature variations in five habitats

Month	*Habitat*				
	Estuary of the Maro River	*Sandy beach in Lampu Satu*	*Mangroves in Yobar*	*Sandy beaches in Payum*	*Mangroves in Bokem*
March	*	*	30.3	31.3	*
April	*	*	30	30	29.8
May	30.3	30.1	29.9	29.4	28.2
June	30.4	31	30.3	29.4	28.5
July	30.8	29.4	30.6	29.3	28.2
August	30	29.6	29,13	28.7	28.6
September	28.4	28.7	27.9	27.9	28.3
October	29.5	28.9	28.1	28	28.3
November	30.7	29	30.5	31.6	27.4
December	29.8	31.1	30.6	27.3	29.7
January	29.9	29.3	30.3	31.6	30.4
February	27.8	27.5	27.5	27.3	27.6
March	27.6	27.6	27.9	27.1	27.5

Note: * - data not available.

In April, the size of banana prawns changed from juvenile-size to sub adult-size in mangrove habitats in Yobar, sandy beaches in Payum, and mangroves in Bokem (Figure 2). This occurs when salinity increases by 23.2 to 24.6 psu, temperature decreases, and pH is approximately 6.8 (Tables 1, 2, and 3). The size continued to increase and reached the highest size (adult-size prawn) in June in the mangrove habitat in Bokem, in July in the sandy beach in Lampu Satu, and in September in the estuarial habitat, mangroves in Yobar and sandy beach in Payum.

Table 2

Water salinity variations among five different habitats

Month	*Habitat*				
	Estuary of the Maro River	*Sandy beach in Lampu Satu*	*Mangroves in Yobar*	*Sandy beaches in Payum*	*Mangroves in Bokem*
March	*	*	19.7	18.5	*
April	*	*	24.6	23.2	24.3
May	22	22.6	20.7	21.4	24
June	22.3	22	21.2	20.8	23
July	20.3	20.4	20.4	20.3	25
August	22.5	21.7	23.1	20.8	26
September	24	24.5	25	24.4	26.2
October	19	19	23	23.3	25.3
November	19	20	20.4	17	25
December	19.5	19	17	19.5	23.6
January	23.1	22	22.5	22.5	23.9
February	23	23.5	23.5	23	24
March	23	24	24	24	25

Note: * - data not available.

Table 3

Variations in water pH across five habitats

Month	*Habitat*				
	Estuary of the Maro River	*Sandy beach in Lampu Satu*	*Mangroves in Yobar*	*Sandy beaches in Payum*	*Mangroves in Bokem*
March	*	*	6.9	6.8	*
April	*	*	6.8	7	6.7
May	6.8	7.1	7.3	7.2	7.4
June	6.8	6.8	7.2	7.3	7.4
July	7.1	6.9	7.3	7.1	7.2
August	7.1	6.9	7.4	7.0	7.3
September	7.4	7.3	7.1	7.0	7.3
October	6.9	7.2	7.1	7.3	7.1
November	6.7	7	7	7.1	7.1
December	6.9	7	7	6.9	7.1
January	6.8	7.2	7	7	7.2
February	7.1	7.2	7.3	7.2	7.4
March	7.2	7.2	7.4	7.1	7.3

Note: * - data not available.

In October, as illustrated in Figure 2, a reduction in size occurred compared to the previous month. This decrease was accompanied by a decline in salinity, dropping to 19 psu in estuarial habitats and sandy beaches in Lampu Satu. In other habitats, although experiencing a decrease, salinity remained above 23-25.3 psu. Furthermore, size continued to decline in some habitats, rebounding in February for estuarial habitats, sandy beaches in Lampu Satu, and mangroves in Yobar, in March for sandy beaches in Payum, and in January for mangroves in Bokem. The size increase observed in February and March was associated with a temperature decrease across all habitats (27-27.9^{o}C), and a salinity increase (23-25 psu), along with a pH level above 7.

The allowable capture size varied each month, as depicted in Figure 2. The highest number was recorded in the mangrove habitat in Bokem, lasting for up to eight months, while the lowest was observed in the estuarine habitat, lasting only one month.

According to the t-test results presented in Table 4, the regression coefficient b exhibits a significant effect in all habitats, with $b \neq 3$, indicating the presence of an allometric growth. This relationship yielded $b<3$, with negative allometry in the length-weight relationship equation. Additionally, the correlation coefficient between males and females in all habitats ranges from 0.66 to 0.98.

Table 4

The length-weight equation and the results of the statistical test

Habitats	Male				Female			
	Length-weight relationship equation	*t-test*	*t-table*	*Correlation coefficient*	*Length-weight relationship equation*	*t-test*	*t-table*	*Correlation coefficient*
Estuary of the Maro River	$0.00029\ L^{2.295}$	7.50	1.97	0.74	$0.00035\ L^{2.274}$	13.81	1.96	0.91
Sandy Beach in Lampu Satu	$0.00204\ L^{1.909}$	14.05	1.97	0.73	$0.000114\ L^{2.504}$	12.39	1.96	0.90
Mangroves in Yobar	$0.00956\ L^{1.599}$	25.47	1.97	0.98	$0.0002\ L^{2.398}$	8.76	1.96	0.87
Sandy Beach in Payum	$0.00409\ L^{1.766}$	16.03	1.97	0.71	$0.0000435\ L^{2.697}$	7.28	1.96	0.89
Mangroves in Bokem	$0.00251\ L^{1.865}$	12.67	1.97	0.66	$0.000056\ L^{2.653}$	5.86	1.95	0.81

Discussion

Size distribution of banana prawn. Following size distribution data, the size can be divided into small (juvenile), sub-adult, and adult. The sizes can be related to the fishing gear used, namely the beach seine with a mesh size of 1 inch (25.4 mm); thus, sizes below were missed (Lantang et al 2023). Related to size, Hargiyatno et al (2015) have divided the CL of banana prawns in Dolak Island, Merauke District, as: juvenile, <32 mm CL, subadult, <38.7 mm CL, and adult, >38.7 mm CL.

The dominance of juveniles in March was related to the migration of small sizes that entered the habitat from the spawning activities in the previous month (Vance & Rothlisberg 2020). The pattern observed aligns with the findings of Hargiyatno et al (2015), which reported an increase in small-sized prawns from January to April, attributed to spawning. This indicates that juvenile prawns are evenly distributed in March across various habitats, including mangrove forests in Yobar and the sandy beach of Payum. This is due to low salinity, as observed in the sandy beach habitat at Payum, with a salinity below 20 psu. However, the temperature was relatively high, reaching 31.3°C, and the pH was low, below 7. Nevertheless, salinity is the more important parameter compared to temperature and pH for banana prawn (Lantang et al 2023). Low salinity will enhance the survival of juveniles, being necessary for their growth (Vance & Rothlisberg 2020). With the discovery of sub-adult sizes in April, the pattern observed in the research by Hargiyatno et al (2015) has undergone changes. This shift may be attributed to an increase in water salinity exceeding 23.2 psu in certain habitats compared to the previous month, while the temperature decreased below 30.3°C, with the pH remaining low. This suggests that sub-adults require higher salinity, explaining their absence in the previous month (Lantang et al 2023). Sub-adult prawns constitute a segment of the juvenile population from the previous month that has developed and was observed in April in some habitats. Mature prawns, also found in some habitats, originate from the sub-adult stage in the previous month and mature to adulthood between July and August, especially in sandy coastal habitats in Payum and mangroves in Bokem (Vance & Rothlisberg 2020). Additionally, adult prawns migrate in search of environmental factors suitable for their life stage (Niamaimandi et al 2010; Duggan et al 2019; Vance & Rothlisberg 2020), as in the mangrove habitat in Bokem, with salinity ranging from 23 to 26.2 psu, aligning with the requirements of banana prawns. Consequently, in this habitat, more adult prawns were found than juvenile and sub-adult prawns (Vance & Rothlisberg 2020).

The smallest (juvenile) prawns were predominantly caught in the estuary habitats of the Maro River and on the sandy beach at Lampu Satu. This suggests that these habitats serve as nurseries for juvenile prawns (Lantang et al 2023). This information is necessary to determine the location of spawning and breeding of prawn (Razek et al

2022). This corresponds to low salinity in this habitat. Additionally, after several months of data collection, adult prawns were observed in waters adjacent to this habitat. However, in the subsequent month, there was a decrease in size, with juveniles dominating. This suggests that adult prawns move to the area adjacent to this habitat for spawning (Vance & Rothlisberg 2020). Prawn larvae from such spawning sites migrate to shallow waters where they develop into juveniles (Vance & Rothlisberg 2020). Juvenile habitats are typically different from spawning areas, causing juveniles to migrate towards estuaries (Rodríguez-Climent et al 2017). In September, the most significant size increase was observed, with the peak presence of adult prawns in estuaries, mangroves in Yobar, and sandy beaches in Payum. These prawns represent a population of sub-adults from the previous month that have matured into adults (Duggan et al 2019; Vance & Rothlisberg 2020). This study revealed a peak in adult prawns occurring earlier in September, in contrast to the findings of Hargiyatno et al (2015), who reported it in October. The changes were attributed to increased salinity in all habitats above 24 psu, a decrease in temperature below 29°C, and an increase in pH above 7 in all habitats (Duggan et al 2019). Salinity is a crucial parameter in determining the movement and life stage of banana prawns (Hargiyatno et al 2015; Amanat et al 2021). The decrease in size on the estuarine and sandy beaches of Lampu Satu in October was caused by the influx of juvenile prawn populations in these two habitats because of increased fresh water supply (Duggan et al 2019; Vance & Rothlisberg 2020). According to the data for that month, salinity decreased to 20 psu, except for the mangrove habitat in Bokem, which had a salinity of 25 psu. Consequently, adult prawns were found in that habitat. The temperature was similar to that of the previous month, as well as the pH, except in estuarine habitats with lower pH. The juvenile prawn came from the spawning in the previous month (September), with the discovery of adult prawns in estuarine habitats and surrounding areas (Vance & Rothlisberg 2020).

The decrease in size continued until January. However, on the sandy beach in Payum, it occurred until February, and in the mangrove habitat in Bokem, it ended in December. The discovery of the smallest size (<32 mm CL) in estuarial habitats and sandy beaches in Lampu Satu indicates that these areas serve as nursery grounds, and the juvenile size resulted from prawn larvae grown and developed in those specific locations (Lantang et al 2023). Additionally, the data indicates that the transition from juvenile to sub-adult prawns in estuarial habitats and sandy beaches in Lampu Satu takes about five months, from October to February, and is correlated with salinity (Duggan et al 2019; Vance & Rothlisberg 2020). There are some causes for the abundance of juvenile prawns in estuarial areas and areas adjacent to this habitat. Firstly, the presence of food-rich estuarial waters is notable, characterized by the abundant availability of plankton, detritus, mollusks, and microorganisms (Taylor et al 2017; Stewart et al 2020). Juvenile prawns require good nutrition for early growth and development in estuarial areas (Ab Lah et al 2017; Bityutskaya et al 2021). Secondly, these areas were characterized by the mixing of fresh water from rivers and seawater, resulting in low salinity conditions that are conducive for juvenile prawn growth (Taylor et al 2017; Pickens et al 2021). Thirdly, this environment provides protection from predators, as prawns in this phase are highly vulnerable to predation by fish or other organisms (Barbier 2016; Lorencová & Horsák 2019; Penning et al 2021). The presence of mangroves and mud, as identified in this study, makes these areas favorable for juvenile prawns (Atkinson et al 2016; Rabaoui et al 2017; Blankespoor et al 2017; Lantang et al 2023). In addition, water flow from the river in the estuarial region helps circulate food for prawns, such as microalgae (Duggan et al 2019; Rozirwan et al 2022). This process is essential for distributing the food supply evenly across various locations. The increase in size observed in February and March at the estuary habitats, sandy beaches in Lampu Satu, and mangroves in Yobar was attributed to the rise in salinity. Consequently, the input of fresh water began to decrease (Vance & Rothlisberg 2020). This also occurs in sandy coastal habitats in Payum in March and mangroves in Bokem in January. In addition, the temperature in January was consistently below 28°C with an average pH, which supports the growth of banana prawns (Vance & Rothlisberg 2020).

In relation to the permissible size for capture, fishing prawns in the estuarial habitat of the Maro River can only be done in September, with the discovery of adult prawns in the area adjacent to this habitat, as shown in Figure 2. In other months, the area was dominated by juveniles and sub-adults. However, the adult prawn in question, migrating in September, is the prawn that will spawn, so it is necessary to consider this aspect for resource sustainability (Vance & Rothlisberg 2020; Tirtadanu et al 2022). A sub-adult prawn is a young prawn that has not spawned, so it is not allowed to be arrested (Hargiyatno et al 2015). Therefore, only mature prawns measuring more than 38.7 mm CL are suitable for capture (Hargiyatno et al 2015). This size was also observed on the sandy beach at Lampu Satu in July and September. The size of adult prawns found in this habitat was related to the spawning season (Hargiyatno et al 2015). The prawns move closer to coastal areas to spawn, as also observed in estuarine habitats (Vance & Rothlisberg 2020). Therefore, both habitats were not recommended for fishing areas, as the smallest sizes, including juveniles, were predominantly found in these habitats (Figure 2). In other habitats, the sizes of adult prawns were found in the mangroves of Yobar in May, June, July, August, September, and November, while in the sandy coastal habitat of Payum, they were found in July, August, September, and March. In the mangrove habitat in Bokem, adult prawns were found in May, June, July, August, September, October, November, and March. This information serves as a reference for determining the location and timing of prawn fishing, enabling the optimization of utilization without compromising resource sustainability.

Growth pattern of banana prawn. According to Table 4, growth patterns of males and females were negative allometric in each habitat. This pattern suggests that the body growth was imbalanced, with the length increasing more quickly than the weight (Selvia & Lestari 2019; Putra et al 2020; Widiani et al 2021; Fauziah et al 2022; Masoumi et al 2023). This growth pattern can occur due to the unavailability of sufficient food in the waters (Niamaimandi et al 2010; Lantang and Merly 2017; Aye et al 2019;). Food availability and good quality water can lead to an increase in weight (Vance & Rothlisberg 2020). In relation to food availability, research by Lantang & Pakidi (2015) has analyzed the food of banana prawns, namely phytoplankton, and found that the brightness of the water is very low in the coastal waters of the Merauke District. Thus, phytoplankton growth is not supported. Therefore, there are certain seasons when the brightness decreases, causing banana prawns, especially juveniles and sub-adults, to not obtain sufficient food. In some habitats, such as estuaries and sandy beaches in Lampu Satu, juvenile and sub-adult prawns were predominantly found. The initial growth in prawns involves an increase in length before weight gain occurs, this being supported by appropriate temperatures (Vance & Rothlisberg 2020). This phenomenon occurs because the development of exoskeleton (carapace) is faster during this phase (Mohanty 2002). After the structure becomes strong, weight gain begins. This was explained by Vance & Rothlisberg (2020), noting that some studies report young prawns that grow to a length of 15 mm CL in two months or about 1.75 mm CL per week.

Another factor influencing the growth pattern is the change in oceanographic parameters (Yu et al 2020; Samad et al 2022). Lantang & Merly (2017) report that the pH was below 7 in this region, similar to what was found in this study. Low pH affects the intestinal function and inhibits the absorption of proteins and carbohydrates, adversely affecting growth (Yu et al 2020). Vance & Rothlisberg (2020) clarified that a temperature and salinity combination of 28°C and 25 psu was ideal for improved biomass and production. The temperature in this study was above that value, although in February and March, temperature values were close, overall affecting the growth pattern. The situation is similar for water salinity, where a salinity of 25 psu was found only in September in mangrove habitats in Yobar and in July, November, and March in Bokem.

In addition, some studies also mention that the moulting process affects growth patterns (Sharawy et al 2019). This was important considering the size of prawns found in several habitats was typical for juveniles and sub-adults, which are in the moulting process. Prawns that have just moulted will experience faster growth in length than weight due to inactive behavior in foraging, with considerable energy expended (Bardera

et al 2019; Lemos & Weissman 2021). This condition can increase length, while the weight remains relatively the same or decreases. Prawns will experience a weight loss of approximately 10.76% of their total weight due to a reduced appetite, leading to insufficient nutritional intake and the shedding of the old carapace after moulting (Mohanty 2002). Negative allometric growth patterns in banana prawns were also observed in various regions, as reported by Safaie (2015), Saputra et al (2018), and Tirtadanu et al (2018). The same growth pattern was identified in other prawns, namely *Penaeus indicus*, as reported by Saputra et al (2019).

Analysis of correlation coefficients of the length-weight in banana prawns, according to Table 4, showed that the range of correlation values for males and females in all habitats was from 0.66 to 0.98. This indicates a moderate to very strong correlation (Lantang & Merly 2017).

Conclusions. The findings of this study reveal that juvenile prawns dominate in two habitats in March. This is related to the spawning season in the previous month, with juveniles entering these habitats. The end of the juvenile period, the influx of sub-adult prawn in some habitats, decreases in temperature, and weakening fresh water supplies were the causes of the increase in size in April. Prawns continue to grow into adults and peak in September and August in some habitats, supported by increased salinity. A decrease in size occurs from October to January. However, in the sandy coastal habitats of Payum, this decrease extends to February, while in the mangrove forests of Bokem, it persists to December. This phenomenon was attributed to the influx of fresh water, resulting in the migration of adult prawns that spawned in the previous month, being replaced by juveniles in areas adjacent to the estuary. However, adult prawns were still found in mangrove habitats in Bokem, associated with increased salinity. A decrease in fresh water supply, along with a reduction in temperature in all habitats and a pH above 7 cause an increase in prawn size in March. This signals that sub-adults and adults move more extensively in all habitats to replace juvenile prawns. Negative allometric growth patterns were observed in all habitats, for both males and females. In terms of the size that can be caught, more than 38.7 mm CL for an adult prawn, prawn fishing can only be conducted at specific times and in specific habitats.

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Authors:
Bonny Lantang, Graduated School, Department of Agricultural Science, Faculty of Agricultural, Hasanuddin University, Perintis Kemerdekaan KM. 10, 90245 Makassar, South Sulawesi, Indonesia, Department of Aquatic Resources Management, Faculty of Agricultural, Musamus University, Kamizaun Mopah Lama, 99608 Merauke, South Papua, Indonesia, e-mail: lantang@unmus.ac.id.
Najamuddin, Faculty of Marine Science and Fisheries, Hasanuddin University, Perintis Kemerdekaan KM. 10, 90245 Makassar, South Sulawesi, Indonesia, e-mail: najaunhas@gmail.com
Alfa Filep Petrus Nelwan, Faculty of Marine Science and Fisheries, Hasanuddin University, Perintis Kemerdekaan KM. 10, 90245 Makassar, South Sulawesi, Indonesia, e-mail: alfanelwan@fisheries.unhas.ac.id
Muhammad Farid Samawi, Faculty of Marine Science and Fisheries, Hasanuddin University, Perintis Kemerdekaan KM. 10, 90245 Makassar, South Sulawesi, Indonesia, e-mail: farids.unhas@gmail.com

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