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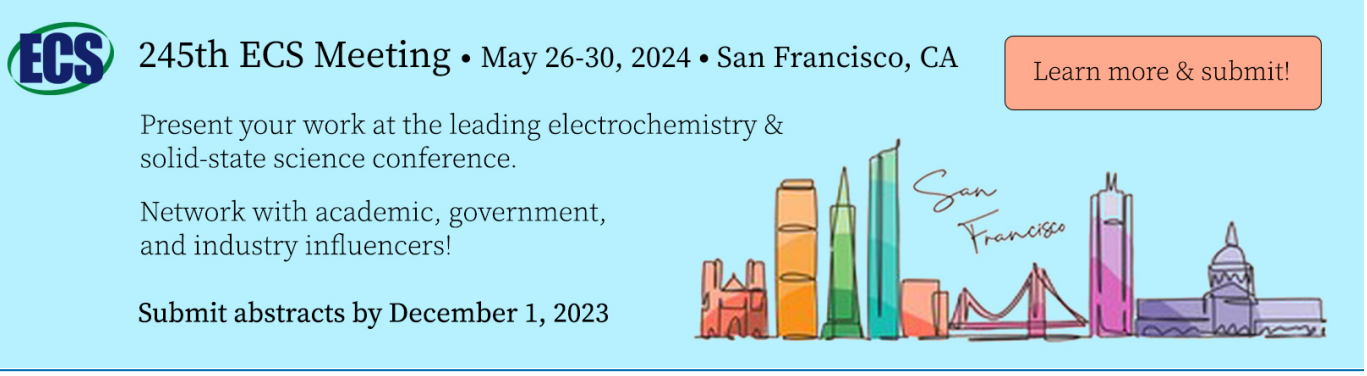

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Seasonal comparison of catch abundance and size of blue swimming crab (*Portunus pelagicus*) in Rembang, Central Java

R P Utomo[1], **P Maulana**[1], **M W Taqiyuddin**[1*]

[1] Indonesian Blue Swimming Crab Association (Asosiasi Pengelolaan Rajungan Indonesia-APRI), Surabaya, Indonesia

*E-mail: rajunganindonesia@gmail.com

Abstract. Considering the blue swimming crab (*Portunus pelagicus*) was exported as pasteurized crab meat, the quality of fresh meat (stock and size) could have been influenced by the season and needed to be considered. This study aimed to analyse the effect of the season on the crab's abundance and size in Rembang Water, Central Java. The study period includes four seasons, namely west monsoon, first transition, east monsoon, and second transition from July 2021 to June 2022. The crab samples from the fishermen were analysed in term of the fishing trips, weight, and carapace width at the fishing ground location. Descriptive statistics and univariate one-way ANOVA was used to analyze the data. The average abundance, weight, and size of crabs caught in Rembang waters during the year were 1,8 kilograms per trip a day (one-day fishing). The abundance of crabs in the west monsoons was greater than in the east monsoons. The pattern of crabs caught was higher at the beginning of the west monsoon (December–January), then it decreased in February until the start of the first transition (March), then gradually increased in April before decreasing again in June until the end of the second transition (October). The ANOVA test showed that the size of crabs in every season had significant differences. It was clearly shown on the boxplot that the catch in the west monsoon and the first transition was smaller than the east monsoon and second transition. These results can provide insightful information for fishers, managers, and policy makers as a basis for developing sustainable fisheries management.

Keywords: blue swimming crab, catch, season, size

1. Introduction

The blue swimming crab (*Portunus pelagicus*) is one of the marine commodities that have high economic value in the world market [1]. Blue swimming crab is exported in the form of pasteurized crab meat, so the quality of fresh crab meat needs to be considered. The standard of crab meat that is used as raw material for pasteurized products (pasteurized crab meat) is meat of excellent quality or first grade [2]. The quality of the meat can be improved by catching crabs of large sizes and by proper handling.

The abundance of large crabs is influenced by the crab fishing season. Catching crabs intensively throughout the year is carried out due to the increasing demand for foreign and domestic markets and the price of crabs, which have a high selling value. The main export destination country for Indonesian blue swimming is America, followed by other countries in Asia such as Singapore, Malaysia, China,

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Japan, and others [3]. The high demand for the export market is supplied by wild-caught crabs. One of the factors that affect the catch of crabs in nature is seasonal conditions.

Blue swimming crab behavior is influenced by several natural factors, namely life development, eating habits, the influence of the lunar cycle, reproduction, and the influence of oceanographic parameters [4]. Fishermen had a local knowledge regarding the fishing season and peak season of crab catches by observing the weather, ocean currents, and winds so that the determination of the west and east monsoons can be made. The climate in the Java Sea follows a seasonal pattern where the dry season lasts from June to September while the rainy season lasts from November to March. In waters that are seasonally influenced by rainfall, salinity is one of the important factors in changing the distribution and abundance of fauna. In more detail, it is explained that the wind pattern in the Java Sea follows the monsoon wind pattern that develops in Indonesia, where during the west monsoon (December–February) and east monsoon (June–August) the wind blows harder with speeds ranging from 0.96–7.11 m/s. The peak of this season occurs in January (west monsoon) and August (east monsoon), with speeds reaching 7.11 m/s and 6.79 m/s, respectively. Surface salinity in the waters of the Java Sea ranges from 31 to 34 (psu), where minimum salinity is found in May, and maximum salinity occurs in September. In the east monsoon (June–July), the surface salinity tends to be higher than during the west monsoon (December–February). This is presumably due to the input of water masses from the east of the Java Sea. Salinity in the southern part (north coast of Java waters, Madura, and Situbondo) has a value that tends to be higher throughout the year compared to other parts of the Java Sea [5].

Therefore, it is necessary to conduct further research related to the relationship between the abundance of crabs and seasonal variation so that the size distribution of the crabs throughout the year in response to the seasonal pattern can be predicted in the future. This study aimed to analyse the effect of the season and on the crab's abundance and size in Rembang Water, Central Java. These results can provide insightful information for fishers, managers, and policy makers as a basis for developing sustainable fisheries management.

2. Research Methodology

2.1 Data collection

The research was conducted from July 2021 to June 2022 in the waters of Rembang, Central Java (Figure 1). The study period includes the four seasons, which are the west monsoon (December-February), the first transition (March-May), the east monsoon (June-August), and the second transition (September-November). The west season occurs in December, January, and February, while the east season occurs in June, July, and August. The Indonesian wind is influenced by the seasons, so this wind system is called season winds or monsoon winds [6]. Primary data in the form of average carapace width (mm) and weight (grams) of the total catch from July 2021 to June 2022 was obtained through the biological data collection of crab catches by fishermen at the collector's place (landing location) in the form of carapace width (mm) using a 30 cm ruler and weight (grams) using a fleco i2000 scale. The data collection is carried out throughout the season on the catches of local fishermen or collectors who go on one-day fishing trips. During one-day fishing trips, setting the trammel net was done once a day. Then the data will be measured at each landing site. Secondary data is in the form of determining the pattern of fishing seasons and is obtained from journals, surveys of fishermen, and direct observations in the field. Supporting references in the form of seasonal pattern data are obtained from libraries and reports from various related agencies.

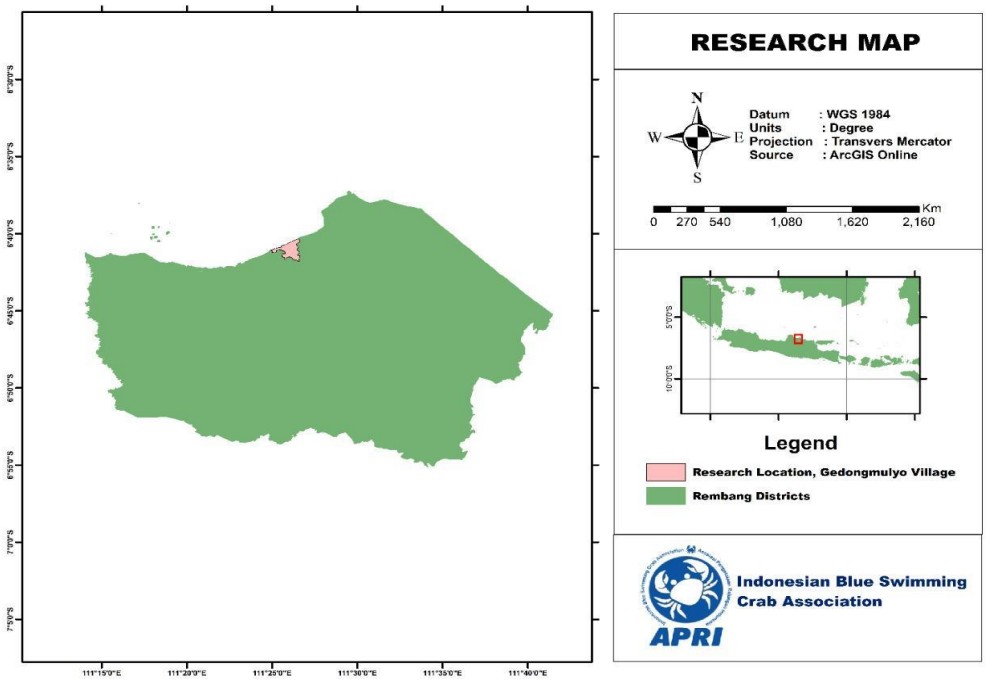

Figure 1. Map of blue swimming crab catching areas in Rembang Regency, Central Java.

Blue swimming crabs in Rembang were mainly caught by the trammel net (Figure 2). The net is made of nylon monofilament with a mesh width of 3 inches. According to [7], the parts of a trammel net fishing gear consist of a net body, ris rope, srampat, main rope, sign buoy, buoy, weights, and additional weights. Trammel net construction consists of two layers of outer net made of nylon multifilament and one layer of inner net made of monofilament nylon. The thread diameter and mesh size of the inner layer are smaller than those of the outer layer. [8] added that the use of trammel nets provides an opportunity to restore the fertility of fishery biological resources that are under exploitation pressure so that the crabs in nature are maintained.

Figure 2. Trammel nets used by fishermen in Rembang Regency, Central Java.

The boats used for daily fishing are boats with a length of 6-7 meters and a width of 2-2.7 meters and use a 20-27 PK engine (Figure 3).

Figure 3. Boats used by fishermen in Rembang Regency, Central Java.

The operation of the fishing gear is carried out from morning to noon, with a net soaking time of 2-3 hours and a setting once a day. The crab fishing area is located between 2-20 miles from the coastline at a depth of 7-30 meters.

2.2 Data analysis

The abundance of blue swimming crab in Rembang waters was analyzed using catch per unit effort (CPUE) by using the fishing power index per fishing gear. The data were aggregated on a monthly and yearly basis. Based on the monthly standardized gear operations (trips per month) and landings per month (kg per month), the monthly CPUE (kg per trip per month) of the gear was generated [9].

The variance in crab size was identified in each season (west monsoon, first transition, east monsoon, and second transition) using boxplots and ANOVA test statistics and SPSS version 25 software. The data are the average carapace width (mm) and weight (grams) from July 2021 to June 2022, assumed to be independent of each other or not related to each other (because the data were obtained from data collection and not the result of treatment between seasons), as evidenced by the assumption of normality and homogeneity of variance before entering into the ANOVA analysis. One-way ANOVA as a comparative test statistic in this study proves the research hypothesis, which is formulated as follows:

First Hypothesis

H_0 : average carapace width (mm) of blue swimming crab caught by fishermen in the waters of Rembang, Central Java, between west monsoon = first transition = east monsoon = second transition

H_1 : average carapace width (mm) of blue swimming crab caught by fishermen in the waters of Rembang, Central Java, between west monsoon ≠ first transition ≠ east monsoon ≠ second transition

Second Hypothesis

H_0 : average weight (gram) of blue swimming crab caught by fishermen in the waters of Rembang, Central Java, between west monsoon = first transition = east monsoon = second transition

H_1 : average weight (gram) of blue swimming crab caught by fishermen in the waters of Rembang, Central Java between west monsoon ≠ first transition ≠ east monsoon ≠ second transition

The provision of ANOVA analysis in proving the hypothesis used the significance value with an error level (α = 5%). If the significance value is more than (>) the error level (α = 5%) then H0 is accepted, while if the significance value is less than (<) the error level (α = 5%) then H0 is rejected (H1 is accepted) which means there is a difference between both observation samples [10]. After the formulated hypothesis is proven, it is necessary to do a Post Hoc test to find out which season the difference occurs. The provisions of the Post Hoc test were declared to be different if the significance value was smaller (<) than the error level (α = 5%) and were seen based on the dominance of the difference in the average carapace width and crab weight in the seasons which proved significant.

3. Results and Discussion

3.1. Catch abundance of blue swimming crab.

The total crab catches obtained at the research location from July 2021 to June 2022 were 14,441 crabs with an average weight of 124.7 grams and a size of 121.5 mm. The data collection was carried out at local collectors, and the crabs were sampled before the steaming process at the mini plant. The results of the Catch Per Unit Effort (CPUE) analysis are shown in Figure 4.

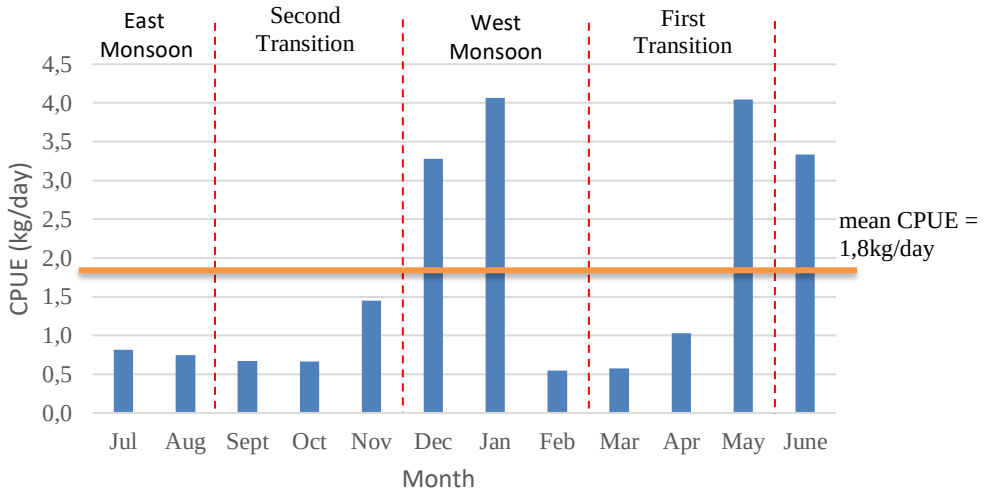

Figure 4. Catch abundance of blue swimming crab in four seasons at Rembang waters, Central Java.

The average abundance, weight, and size of crabs caught in Rembang waters during the year were 1,8 kilograms per trip per day (one-day fishing). The pattern of crabs caught was higher at the beginning of the west monsoon (December–January), then it decreased in February until the start of the first transition (March), then gradually increased in April before decreasing again in June until the end of the second transition (October). Landing data in Rembang shows that the highest crab catch occurred in January 2022 at 1,789.1 kg and the lowest in February 2022 at 166.75 kg, which is the west monsoon.

The low catch abundance was observed in February which can be caused by seasonal conditions where the peak of the west monsoons often related to high frequency and intensity of rainfall, strong currents, and high waves. This condition were dangerous and not safe for fishers to go to sea for fishing several days to catch crabs. This causes the small crabs caught in February to make the landing data low. If the average catch per season is taken, the highest catch was in the west monsoons at 900.72 kg and the smallest in the east monsoons at 210.62 kg. Based on these results, it can be seen that the abundance of crabs in the west monsoons is greater than in the east monsoons. [11] conducted research on crab catches in the waters of Pangkep Regency, showing that production increased until it peaked in September and decreased after entering October to March, in contrast to what happened in Rembang waters. This result is because from October to March, the waters of Pangkep Regency are very bad

because the west wind blows very hard, causing the number of fishing trips to be very limited. This is similar to what happened in Rembang in February 2022, where many fishermen did not go to sea due to bad weather, causing limited trips.

3.2. Size differences in four seasons

The classification of the seasons in Rembang, based on surveys of fishermen and natural conditions, includes the west monsoon in December – February and the east monsoon in June – August, with the first and second transitional between the two monsoons. As [6], [5] stated, the seasonal pattern in the Java Sea follows the monsoon wind pattern in Indonesia, where the west monsoon occurs from December – February and the east monsoon in August. This is in accordance with what was conveyed by fishermen and natural conditions, although there are some differences in the duration of the east monsoon. The average weight of the blue swimming crabs in the east season is greater than in the west season, which is an indication that seasonal patterns affect the size of the blue swimming crabs caught. The results of research on the effect of fishing season abundance of blue swimming crabs conducted in Pangkajene, South Sulawesi by [9] show that blue swimming crabs seasonal catch was very short and fish catches are seasonally dynamic.

Table 1. Normality and homogeneity assumption test.

Criteria	Significance value	Description
Normality Assumption Test		
Average carapace width	0.200	Data is normally distributed
Average weight	0.200	Data is normally distributed
Homogeneity Assumption Test		
Average carapace width	0.105	Homogeneous variety
Average weight	0.104	Homogeneous variety

Table 1 shows the results of the normality and homogeneity tests for the average carapace width and crab weight, with the significance value of each observation both on the normality and homogeneity assumption tests exceeding the error level ($\alpha = 5\%$). Both the average carapace width and crab weight, are normally distributed, come from populations with the same or homogeneous variance, and have met the requirements for valid and accurate measurements [10].

3.2.1. The effect of seasonal patterns on the average carapace width of blue swimming crab catch.

Table 2 shows the significance of the average carapace width (mm) in the west monsoon, first transition, east monsoon, and second transition at 0,006, where the value is less than the error level ($\alpha = 5\%$) which indicates H0 is rejected. Thus, it is concluded that the average carapace width (mm) of blue swimming crabs caught by fishermen in the waters of Rembang, Central Java is different from each season.

Table 2. Seasonal pattern ANOVA test with crab carapace width.

	Criteria	Significance value	Description
Average carapace width	west monsoon, first transition, east monsoon, second transition	0.006	Significantly different

The results of the post hoc test (Table 3) show that the fishing crab catches in the waters of Rembang, Central Java have the largest average carapace width between the first transition, east monsoon, and second transition. The highest average of blue swimming crabs was obtained in October 2021 at 128.2 mm and the lowest in June 2022 at 112.2 mm.

Table 3. Post hoc test of crab carapace width based on seasonal patterns.

Criteria			Average difference	Significance
Average carapace width	first transition	east monsoon	10.948	0.015
		second transition	9.775	0.021

3.2.2. The effect of seasonal patterns on the average weight of blue swimming crab catch.

The significance value of the average weight (kg) of blue swimming crabs in the four seasonal patterns (west monsoon, first transition, east monsoon, and second transition) is 0.004, which is less than the error level ($\alpha = 5\%$) in other words H0 is rejected. Thus, it is concluded that the average weight (grams) of blue swimming crabs caught by fishermen in the waters of Rembang, Central Java in the east monsoon is different from the average weight (grams) of blue swimming crabs caught by fishermen in the west monsoon, first and second transition.

Table 4. Seasonal pattern ANOVA test with crab weight.

Criteria		Significance value	Description
Average weight	west monsoon, first transition, east monsoon, second transition	0.004	Significantly different

The results of the post hoc test (Table 5) show that the fishing blue swimming crab catches in the waters of Rembang, Central Java have the largest average weight in almost all season patterns but the most dominating (based on the average difference) is between the second transition with the west monsoon and first transition. The highest average crab weight was produced in October 2021 at 150.4 grams which was included in the second transition (October), and the lowest in June 2022 at 91.96 grams in the first transition. This difference can be caused by many factors, such as fishing location, water depth, substrate, temperature, salinity, season, and fishing effort. In the east season, fishermen tend to move fishing grounds to a more central sea area because the weather is favorable, which causes the size of the crab caught to be larger.

Table 5. Blue swimming crab weight post hoc test based on seasonal patterns.

Criteria			Average difference	Significance
Average weight	east monsoon	west monsoon	30.340	0.038
		first transition	26.935	0.049
	second transition	west monsoon	39.320	0.017
		first transition	35.915	0.021

The boxplot of average weight (grams) and width (millimeters) of crabs every month for one year of observation is as shown in Figure 5 and 6.

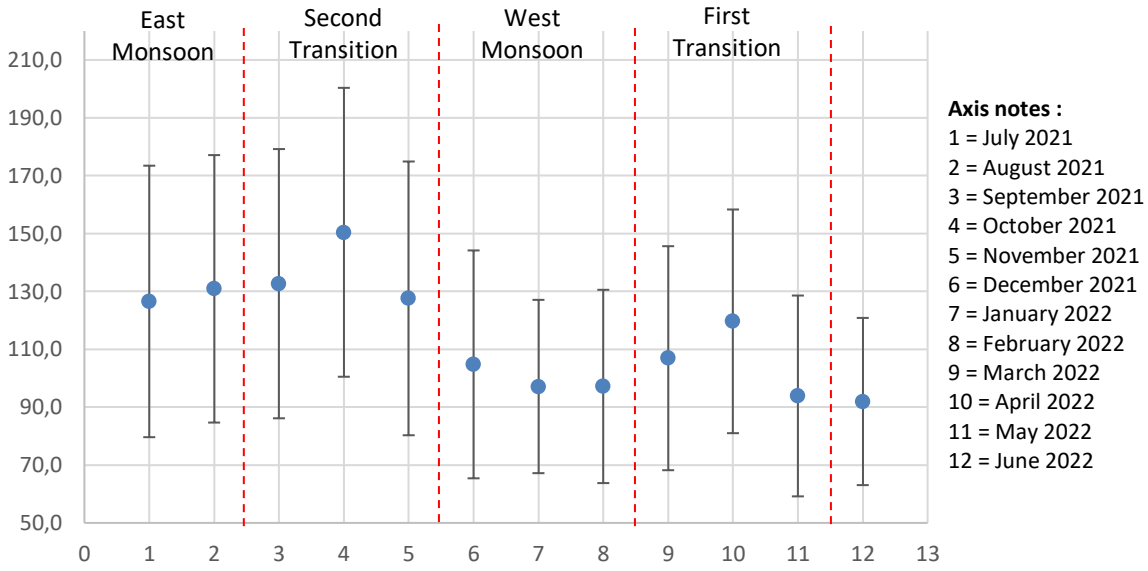

Figure 5. The average of crab weight (grams) in Rembang waters, Central Java.

Figure 5 shows that the average crab weight (grams) varied each month. The average weight of the crabs occurs in east monsoons, and the second transition decreased, and the higher one was in October 2021. Then decrease gradually in the west monsoon before increasing again in the first transition in April 2022.

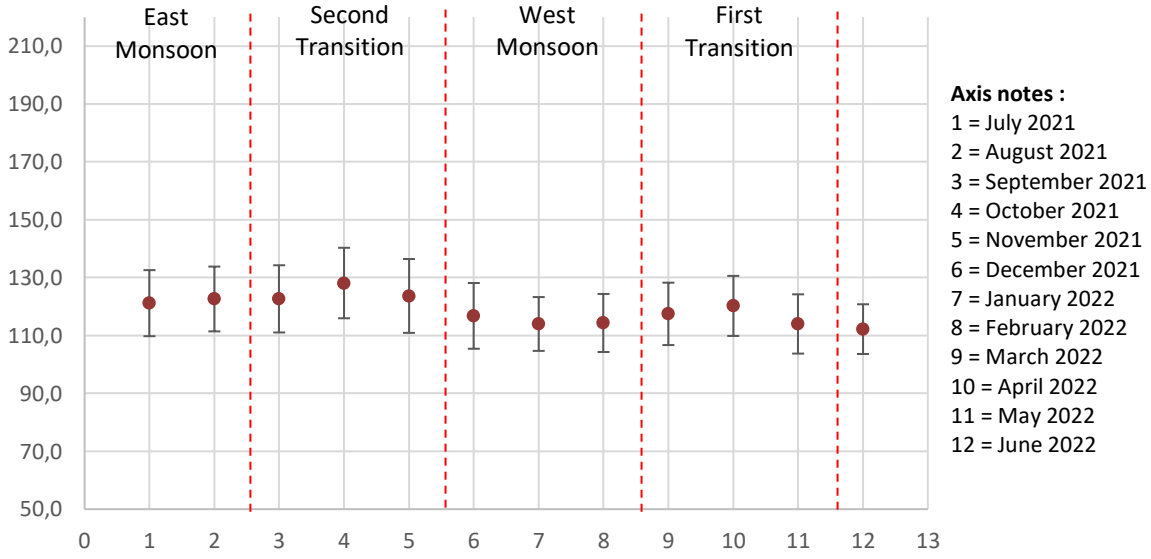

Figure 6. The average carapace width of crabs (millimeters) in Rembang waters, Central Java.

Similar to the average weight of the crab (grams) caught per month, Figure 6 shows that every month the average carapace width (millimeters) of the crab also changes. The average carapace width (millimeters) of the biggest width carapace of crabs caught occurred in October 2021, when that month was in the second transition. The smallest one was caught in June 2022 (first transition).

From Figure 5 and Figure 6 it can be concluded that the average weight and width of blue swimming crab have the same pattern; the size of the crab increase in October 2021, then decrease gradually and increase again on April 2022. Based on interviews with the fisherman, the transition season has the highest average weight and width because in the transition season, the sea was calm, so the fisherman

change the fishing ground into the central sea (>12 mil). Mature blue swimming crabs move forward to deep sea water in response to water salinity and temperature [12], [13].

4. Conclusion

This research shows that the abundance of crabs based on CPUE in the west monsoons is greater than in the east monsoons. The highest peak of the average size of crab weight and width was observed in the second transition season in October 2021. It is evident that the crabs caught by fishermen in the waters of Rembang, Central Java have differences in carapace width (mm) and weight (grams) in each monson, even in the transition season. The seasonal pattern influences the abundance and size of crabs in the waters of Rembang, Central Java. The west monsoon had a high abundance of crabs compared to the east monsoon but with a smaller average carapace width and weight.

5. Recommendation

It is necessary to conduct further research in other locations with different environmental parameter conditions to obtain more comprehensive data for Indonesian blue swimming crab. Relationships between environmental oceanography conditions and crab's distribution and abundance across seasons could be explored in the future.

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