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Analysis of Biology and Resource Management of Crab (*Portunus pelagicus*) in Betahwalang Village

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Crab is a fishery commodity with significant economic value and market demand. This encourages an increase in fishing activities, which, without a management strategy, will lead to a decrease in the crab population in the waters. Betahwalang Village is one of the villages in Bonang District, Demak Regency as the center of crab management. The objective of this study was to determine

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the biological aspects of crabs to determine their growth patterns, as well as the fisheries aspects and management strategies for crab resources (*Portunus pelagicus*) in Betahwalang Village. The study was carried out from November to December 2023 in Betahwalang Village, Demak Regency. The research method was descriptive. The sampling method was random sampling. The frequency distribution, width and weight relationship, sex ratio, Gonad Maturity Level (TKG), and the size of the first time caught and mature (Lc and Lm) were all considered in the data analysis. The results showed that measurements were taken on 423 crabs. The growth pattern of width and weight was pos/neg allometric. The crab sex ratio was divided into 246 males (58%) and 177 females (42%). The first catch size (Lc) was 114.5 mm.

Keywords: Weight; Lc; Width; Lm; sex ratio; crab; TKG.

1. BACKGROUND

Indonesia has a huge potential for fish resources because it is one of the world's largest maritime countries. This potential makes the fisheries sector one of the key development milestones in the economic development of the country [1]. Capture fisheries activities are considered to have a significant economic impact on most of the population around the coast. This is evidenced by the increased production of fishermen's catches. However, the existence of capture fisheries in Indonesia is dominated by small-scale capture fisheries businesses [2-4]. Crab (*Portunus pelagicus*) is one of the aquatic biotas that has economic value and high market demand. It was reported that the export volume of crab and crab in 2022 was 6,800 tons [5]. This has resulted in increased utilization, which is expected to disrupt the population of crab resources. According to the Decree of the Minister of Marine Affairs and Fisheries No. 19 of 2022, the Java Sea waters have an estimated crab potential of 23,508 tons, with an allowable catch of 16,456 tons and a utilization rate of 0.7. Crab (*Portunus pelagicus*) is a major commodity in Demak Waters, particularly in Betahwalang Village.

According to Maulana *et al.* [6] Crabs are in high demand, both domestically and internationally. Crabs have a high economic value. In early 2020, the selling price ranged from IDR 50,000 to IDR 80,000/kg. The high market demand has resulted in increased utilization. High levels of fishing have both direct and indirect effects, both short and long-term. Continuous fishing has an impact on the population size of the main catch fish species, as well as bycatch and habitat. An appropriate management strategy is required to maintain a balanced crab population [7-13]. Crab-catching activities include several provisions. This is stated in the Minister of Marine Affairs and Fisheries Regulation No. 12 of 2020, Article 8 paragraph (1), which states that the crabs must not be in spawning condition, have a carapace width of more than 10 cm, or weigh more than 60 grams/crab.

Demak Regency has a large fishery potential, one of which is crab. There is one village that is the center of crab in Demak Regency, namely Betahwalang Village. Betahwalang Village has 522 crab fishermen [14]. Demak Regency has two fish marketing centers, namely TPI Morodemak and TPI Wedung. Fisheries production at the Demak Regency Fish Auction Site in 2019 was 3,568 tons, with a production value of 51,851,903 [15]. The data do not include crab commodities. This is not recorded because the crab was not landed at the fish auction site. According to Triyanti *et al.* [16] crab catches are marketed directly to intermediary traders. Crab is processed to become export fishery products.

Blue swimming crab (Portunidae) is one of the crab family (brachyura) and swimming crab (Portunus pelagicus) is an economic value commodity that is important in Indonesia, because it serves as an export commodity that the demand increased year to year [17-20]. High commodity prices and the clear market crab encourage increased natural exploitation (wild catch) in the territorial waters of the North Coast of Java. Betahwalang waters is one small fishing crab area in Indonesia [21-24]. The purpose of this study is to know the distribution of blue swimming crab (Portunus pelagicus) in the Betahwalang waters and to determine the relationship of the carapace width and weight of crab [25-31]. This research was conducted from September to October 2016 in the Betahwalang waters, Demak. The data collection was done by contributing to the sea with the Betahwalang crab fishermen. Retrieval of research data includes width and length, as well as the data of the environmental parameters. Results of the analysis showed that the growth of crab, value b

was 2.518 which exhibits a allometric negative growth with the sex ratio was 1: 1.4. First caught crab size was 109 mm. The results showed that, 62.4% of crab in zone 1 was not included into the Minimum Legal Size, whereas in zone 2, 90.5% rajungan classified into the Minimum Legal Size. Anam A, Redjeki S, Hartati R (2018).

1.1 Formulation of the Problem

Fisheries resources are common property that can be used by anyone, but if they are used beyond their sustainable limits, they will be depleted in the future. Crab (*Portunus pelagicus*) is a fishery product with high potential and economic importance. King crab has a high nutritional value and a delicious meat flavor, so demand for both local and export markets is growing. The fishery resources in the form of crab that are exported, especially to the United States, reach 60% of the total catch of crab in Indonesia [32]. This encourages fishermen to capture more crabs, leading to overfishing.

A high utilization rate will have an impact on the status of the crab stock in the waters, particularly if the caught crabs are young, which can slow the rate of new stock replenishment [33-39]. The Ministry of Maritime Affairs and Fisheries of the Republic of Indonesia No.12/PERMEN-KP/2022Article 8 regulates the size of the crab (*Portunus pelagicus*) catch, which is allowed only if the carapace width is greater than 10 cm and the crab does not lay eggs.

1.2 Objective of the Study

Based on the explanation, objectives of the study are:

1. Analyzing the biology of crab (*Portunus pelagicus*) in Demak Waters.
2. Analyzing the resource management of crab (*Portunus pelagicus*) in Demak Waters.

2. LIMITATION OF THE STUDY

The study was carried out to determine the potential and biological aspects, which will be used to help determine the regulation of sustainable crab resource use in Demak Regency waters. The limitations of this study are:

Biological aspects include species identification, mantle weight and length, length frequency distribution, first capture size (Lc), first mature gonad size (Lm), gonad maturity level, and sex ratio of crabs in Betahwalang Village.

1. Aspects of fisheries include trawl gear, fishing fleet, fishing season, fishing area,
2. Efforts to manage crab (*Portunus pelagicus*) fisheries resources.

2.1 Research Significances

This research is very important if it is used as information and study material for fisheries practitioners, particularly those in the fishing industry so that they do not only focus on profit maximization but also maintain resource sustainability to make optimal catches. Research on the management of crab fisheries (*Portunus pelagicus*) in Betahwalang Village can provide the following benefits:

2.2 For Academic Purposes

The findings of this study can be used as references for future research into crab fisheries management on the North Coast of Java.

2.3 For Practical Purposes

This study is expected to be resources for capture fisheries practitioners in general, and *Portunus pelagicus* species in particular.

For the Government: To be references for the Central and Local Governments, particularly those that use crab fisheries landed in Demak Regency.

2.4 Time and Place of the Study

The study was conducted from October to December 2023 in Betahwalang Village, Bonang District, Demak Regency, Central Java Province. Crab observations were conducted on several fishermen trawls in Betahwalang Village. Betahwalang village was chosen because it had the largest crab management center in Demak Regency. According to information, crab catching in Demak Regency occurred outside of TPI or directly to collectors rather than landing at PPP Morodemak.

2.5 Type and Source of Data

Primary Data: The primary data collected in this study were obtained in the following instruments:

1. Field observations including the research location, fishing gear, fishing fleet, and measurement of crab.

2. In-depth interviews with relevant respondents including trawl gear operation techniques, fishing seasons and areas, catches, operating costs, income, and number of fishing trips.
3. Field documentation.

Secondary Data: Secondary data in this study include:

1. Production data and value of fisheries production in Demak Regency in 2018-2022,
2. The number of fishing fleets in Demak Regency in 2018-2022,
3. The number of fishing gear in Demak Regency in 2018-2022,
4. Fishery management plan in Demak Regency.

2.6 Sampling Method

The sampling method used in this study was random sampling. Crab sampling is done randomly without restrictions, adjusting the conditions in the field. Simple Random Sampling is a sampling method where each member of the population has an equal chance of being selected as a sample. Random sampling is expected to be representative of the estimated population [40]. The research sample consisted of 423 crabs, including female and male crabs.

2.7 Data Analysis

Analysis of Biological Aspects: Morphological observations of male and female crabs can be seen physically through colour, shape, and size.

Correlation between Length and Weight: The analysis of the correlation between carapace width and crab weight aims to determine the type of crab (*Portunus pelagicus*) growth in Betahwalang Village. The width of the carapace was measured using a term thrust with an accuracy of 0.05 mm, which was taken from the longest lateral spines on the crab's sides. The weight of the crab body was measured using digital scales with an accuracy of 0.01 grams. According to Effendie [41] the analysis of length-weight correlation using the following formula:

$$W=aLb \quad (3.1)$$

Where:

W : Weight
L : Width of the carapace
a : Constant/intercept
b : Tangential angle/slope

The growth pattern of crab (*Portunus pelagicus*) can be known based on the value of b. The hypothesis tests the value of b = 3 or b ≠ 3 with the t-test, as follow:

H0: b = 3, where the relationship between carapace width and crab weight is isometric H1: b ≠3, where the relationship between carapace width and crab weight is allometric

Sex Ratio: Sex determination can be known physically, here are the differences between male and female crabs:

According to Effendi [41] the determination of sex ratio uses the following equation:

p = Number of male crabs / Number of female crabs (3.2)

Furthermore, it is analyzed with the Chi-Square test (3.3)

Where;

X2 : a value for the random variable
Fi : frequency of male and female crabs observed
fh : expected frequency which is the frequency of male crabs added to females divided by two. X2 table value with 95% confidence level and degrees of freedom (db) = 1 (one) with hypothesis:
H0 : There was no significant difference between the number of male and female crabs caught.
H1 : There was a significant difference between the number of male and female crabs caught. If, X2count < X2table = H0 accepted, Hi rejected X2count > X2table = H0 rejected, Hi accepted.

Table 1. Differences between male and female crabs No. Differences Male crab Female crab

No.	Differences	Male crab	Female crab
1.	Dorsal color	Blue	Brownish green
2.	Abdominal shape	Triangular, more conical	Rounded
3.	Habitat	Shallower waters	Deeper waters

Deeper waters Source: Novitasari et al., [42].

Gonad Maturity Level (TKG): The gonad maturity level in crab was determined through direct observations of crab samples. Observations of gonad morphology changes in crabs. Visually observing the morphology of the

crab's reproductive organs (plasma and thelicum), which the center part of the crab's body. According to Hamid 2015 and Munthe and Dimenta 2022, the morphological classifications of the maturity level of crab gonads are:

Size at First Capture (Lc) and Size at First Gonad Maturity (Lm)

The size of the first fish caught is determined by calculating the value of the middle size of the fish caught. The method for determining the size of the first caught fish is:

1. Creating fish length intervals, mid-length values and calculating the frequency of each length class;
2. Calculating the cumulative percentage of each length class; and
3. The size value of the first time a fish was caught (Lc50%) was obtained by plotting the cumulative percentage with the median length of the fish.

According to Wiadnyana *et al.* [43] the calculation of the average length of the first time capture (Lc) is based on the equation of Sparre & Venema [44].

$$L50\% = \frac{s1}{s2}$$

Where:

SL: logistic curve
S1, S2: the constant in the logistic curve formula that produces the average size of the first capture. Estimates of the size at first gonad maturity (Lm) were separated by sex and trawl gear. The size at first gonad maturity of crab was calculated using the SpearmanKarber method (Udupa, 1986) using formula

$$m = X_k + \frac{x}{2} - \{x \sum pi\}$$

The confidence interval was 95%, so:

$$m = anti\ log\left[m2 \pm 1{,}96\sqrt{x^2 \sum\left\{\frac{p1-qi}{ni-1}\right\}}\right]$$

Where:

m : logarithm of crab length at first gonad maturity,
Xk : logarithm of median of the last length class at first gonad maturity
X : difference of logarithm of length increases in the median pi
: proportion of gonadally mature crabs in the length class of i
ni : number of crabs in the length class of i
qi : 1 – pi
M : the average length of the crab when it first matures.

3. RESULTS AND DISCUSSION

3.1 General Condition of Demak Regency

Demak Regency is one of the coastal areas in Central Java. The total area of Demak Regency is 897.43 km2. Demak Regency consists of 14 districts with 243 villages and 6 sub-districts. Geographically, Demak Regency is located at the coordinates of 6º 43'26' - 7º 09' 43' South latitude (LS) and 110º 27' 58' - 110º 48' 47' East longitude (BT).

Administratively, Demak Regency is bordered by:

North: Jepara Regency and the Java Sea
South: Semarang Regency and Grobogan Regency
West: Semarang City
East : Kudus Regency and Grobogan Regency

Demak Regency has 14 districts, four of which are in the North Coast of Java waters, including Karang Tengah, Sayung, Wedung, and Bonang. These districts are the center of fishing activity. Demak Regency is divided into two categories: marine fishing and inland fishing. Demak Regency has a type C fishing port, which is the Morodemak Beach Fishing Port (PPP).

Demak Regency has two fish auction centers, TPI Morodemak and TPI Wedung. Fisheries production in Demak Regency includes both inland and marine fisheries. Inland fishery products are obtained from inland waters such as rivers or lakes, whereas marine fishery products are obtained by fishing in open water. The landing of marine fisheries catches is divided into two categories: inside and outside the TPI. Crocodile catch includes catches landed outside of TPI.

3.2 Frequency Distribution of Crab

Based on the research, it was found that the species caught using trawls in Betahwalang Village is *Portunus pelagicus*. This species of crab has different frequency distribution. The

following crab frequency distribution data is presented in Fig.1.

According to the frequency distribution analysis, the number of crabs caught by fishermen ranged from 80 to 86mm, with the largest size caught being 108-114mm, followed by 129 to 135mm.

Fig. 2 shows the frequency distribution of crabs by weight class, with the largest weight class size reaching up to 257 gr in 423 crab samples. Crabs dominated had a size range of 80 to 102 gr and up to 123 crabs. While weighing between 241 and 263 grams, only one crab was caught.

3.3 Correlation between Width and Weight of the Carapace

The crab caught in Betahwalang Village was determined by measuring 423 samples. The correlation between carapace width and crab weight can be seen in Fig. 3.

Table 2. Gonad maturity level in crab

Gonad Maturity Level	Female	Male
TKG I	Macroscopically, there are no visible signs of gonadal changes.	Macroscopically, there are no visible signs of gonadal changes.
TKG II Gonad Immature	White gonad color tends to be translucent, eggs measure up to 0.14 mm in diameter.	Clear gonad color tending to grey.
TKG III Gonad Maturing	Light orange or yellow gonad color, no spread in the liver area and eggs measure up to 0.15-0.21 mm in diameter.	Light yellow gonad color.
TKG IV Gonad Mature	Bright orange gonads color and spread to the liver area, making the eggs measures 0.22-0.40 mm in diameter.	Bright orange gonad color.

Source: Hamid (2015) in Munthe and Dimenta (2022).

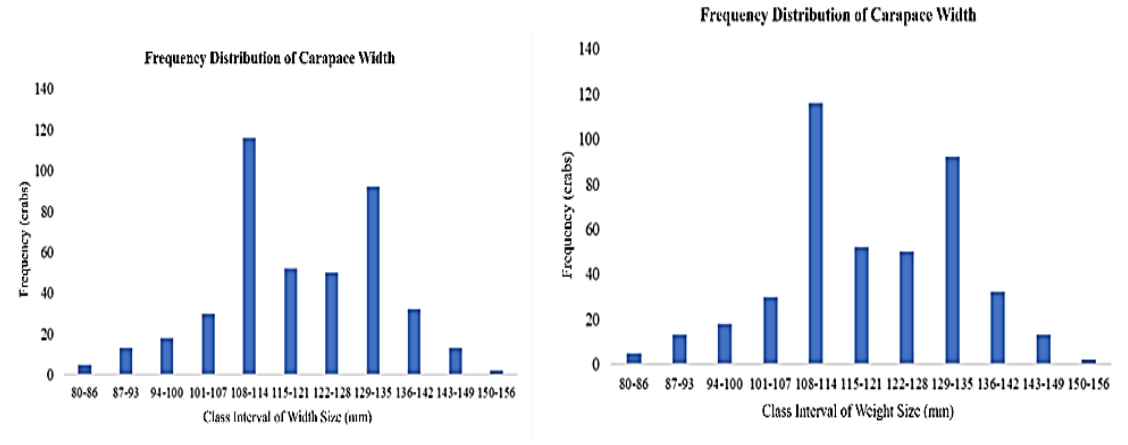

Fig. 1 and 2. Frequency distribution of crab

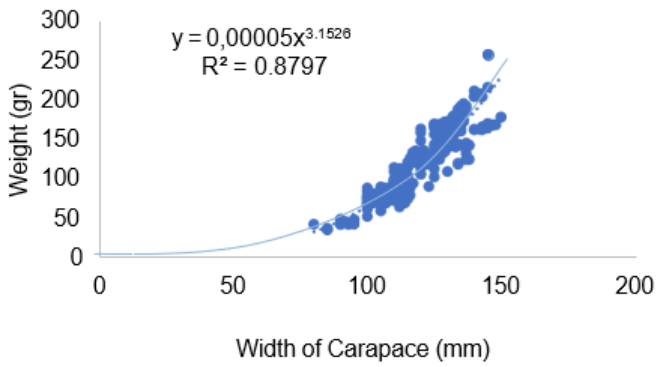

Fig. 3. Graph of the Correlation between Width and Weight of the Crab (*Portunus pelagicus*).

The correlation between carapace width and weight of crab showed the growth pattern of crab.

Analysis of the relationship between the width and weight of the crab obtained the equation W = 3.1472L3.1526 with a b value of 3.1526. The value of b > 3 indicated that crabs that landed in Betahwalang Village had a positive allometric growth pattern. Positive allometry indicated that the crab's weight gain was faster than its length gain.

3.4 Sex Ration

A research sample of 423 crabs was obtained. The sex composition was 246 male crabs and 177 female crabs. The sex of the crab was directly determined by its outer morphology. Body color, abdominal shape, and length were all indicators of sex differences. The differences between male and female crabs can be seen in Fig. 4.

Based on the results of field research, the composition of crabs was dominated by male crabs. There were 246 male crabs (58%) and 177 female crabs (42%).

3.5 Analysis of Gonad Maturity Level

The gonad maturity level is an analysis that is used to provide information about the number and size of species when they have reached the reproductive or spawning period, as well as mature gonads [45]. Crab gonad maturity is determined by opening the crab carapace. The percentage of gonad maturity level can be seen in the Fig. 6.

Gonad maturity in female crabs causes significant variations that are influenced by seasonal changes. This study examined the composition of Gonad Maturity Levels (TKG) in female crabs, finding 26 in TKG 1 (virgin), 22 in TKG 2 (immature), 72 in TKG 3 (maturing), and 57 in TKG 4 (mature gonads). The level of gonad maturity in female crabs is dominated by TKG 3, which is believed to be related to the migration pattern of female crabs in their reproductive cycle. Female crabs reached TKG 1 (virgin) in the carapace width range of 80-116 mm; TKG 2 (immature) in the carapace width range of 105-134 mm; TKG 3 (maturing) in the carapace width range of 100-145 mm; and TKG 4 in the carapace width range of 105-150 mm.

3.6 Size of First Capture Crab (Lc)

The size of the first catch was determined by the frequency distribution of crab length, which was based on the total length class of the crab. The size of the first crab caught can be seen in the graph bellow:

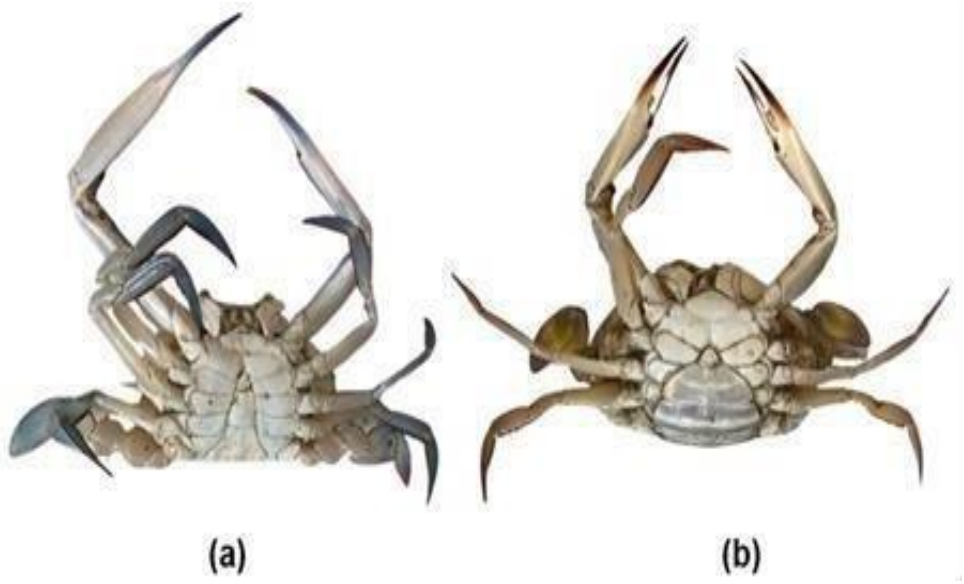

Fig. 4. Sex Differences (a) Male and (b) Female

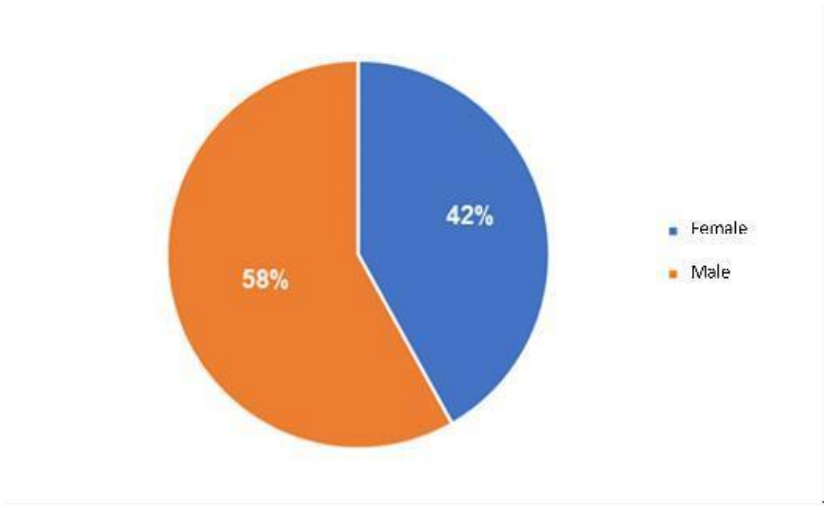

Fig. 5. Graph of Crab's Sex Ratio Percentage (Portunus pelagicus)

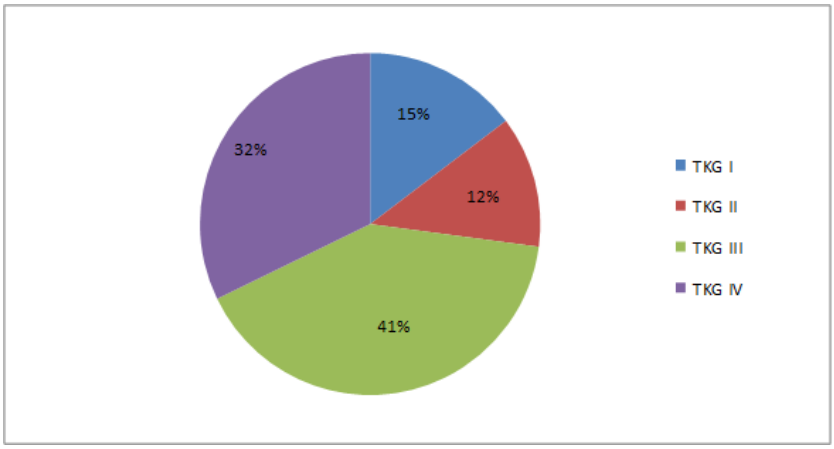

Fig. 6. Graph of Crab's TKG Percentage (*Portunus pelagicus*)

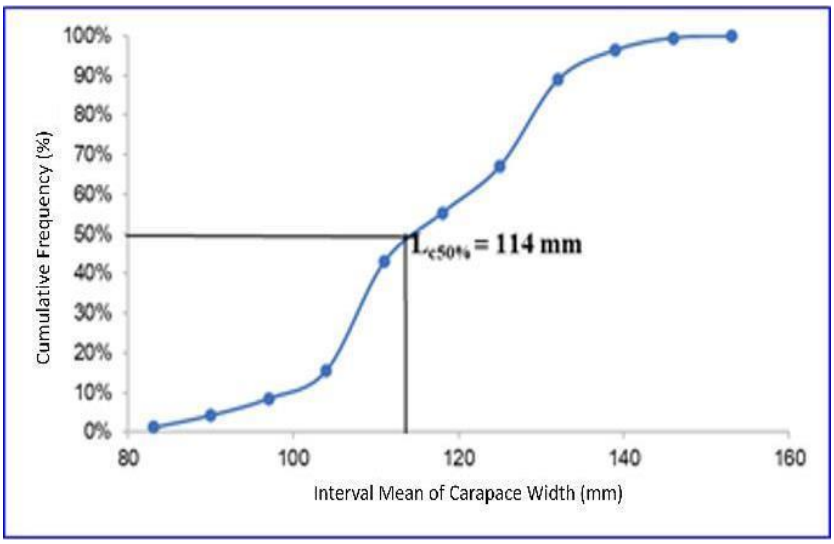

Fig. 7. Size of First Captured Crab (Lc)

According to the findings, the first crab caught in Betahwalang Waters measured 114 mm (11.4 cm), which was close to the width of the crab carapace that can be caught.

3.7 Crab Resource Management

3.7.1 Indicator of caught crab proportion (Juvenile)

The indicator of the size of the first time caught was an improvement action plan implemented from the first to the third years to restore the proportion of juvenile crabs caught. From the fourth to the tenth years, the improvement plan included: (1) enacting regulations on mesh size and catchable size and releasing crabs that did not meet size standards back into the waters; (2) socialization and focus group discussions on mesh size and catchable size; and (3) monitoring the implementation of regulations. From the eleventh to the fifteenth years, it was expected to be good.

3.8 Indicator for Stakeholder Participation

Stakeholder participation in crab resource management will maximize effectiveness. From the first to third years, an improvement plan for counseling and community capacity building in the management of sustainable crab resources in Betahwalang Village is implemented, and counseling must be carried out by all elements, both institutional and local, continuously to ensure that crab resource management remains sustainable. Next year, greater stakeholder participation is expected than this year.

4. CONCLUSION AND SUGGESTION

4.1 Conclusion

Based on the discussion, it can be concluded that:

The results showed that measurements were taken on 423 crabs. The growth pattern of width and weight of crab showed pos/neg allometric. Male crabs had a sex ratio of 58% while female crabs had a ratio of 42%. The size of the first capture (Lc) was 114.5 mm.

Management can be done because there was still a size of carapace width below the standard and the capture of crabs in the state of laying eggs, so that the need for resource management both biologically and socially through socialization and supervision.

4.2 Suggestion

Based on the conclusions, the researcher would like to contribute some suggestions as follows:

1. The researchers recommend that fishermen be socialized and educated about the importance of maintaining crab stocks to ensure their sustainability.
2. More research into crab resource management is needed to strengthen and prove the hypothesis made in this study.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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