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The Implementation of Size Limit Regulation on the Swimming Blue Crab (*Portunus pelagicus*) Catches in Indonesia: To Maintain Resource Sustainability

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ABSTRACT

The policy regulating the minimum size of crabs (*Portunus* spp.) that can be caught in Indonesia has not yet been thoroughly assessed in various regions, which is crucial for promoting sustainable fishing and protecting the marine environment. In Kendal waters, Central Java—a fishing area frequently visited by local fishermen—detailed information on the captured crabs, including species, sex distribution, size, and the proportion of crabs meeting the catch criteria, is lacking. Understanding the natural stock's genetic information can help policymakers design fishing operations and conservation management policies to maintain genetic diversity. The study was conducted from September to October 2023, with crab samples collected from collapsible traps at 10 fishing grounds in Kendal waters. The crabs were identified, measured for carapace width, weighed, and sexed. Descriptive analysis was used to understand the distribution of carapace width and weight at the study sites. Simple regression analysis was applied to assess correlations between variables. The findings revealed that the crabs captured in Kendal waters were predominantly the blue swimming crabs (*Portunus pelagicus*) and crucifix crabs (*Charybdis feriata*), with the blue swimming crabs accounting for 87.79%. The observations indicated an imbalance in the sex ratio, and the growth of crabs in Kendal waters was positively allometric—meaning the body weight grew at a faster rate than the carapace width. The size distribution of crabs was generally smaller during the east monsoon, and the first-caught crabs were larger than the legal size requirement. Most of the captured crabs (90%) fell within the eligible size classification.

INTRODUCTION

Portunus pelagicus, known as the blue swimming crab (BSC) is classified under the Brachyura classification of the Phylum Arthropoda **(Romimohtarto & Juwana, 2007)**. This group is identified by its unique physical characteristics, featuring a significant width, with primary blue coloration and white spots on male crabs. At the same time, females display a greenish-brown coloration with white spots **(Ng, 1998)**. As

residents of the ocean floor, BSCs actively move closer to the water surface in search of food, earning them the nickname blue swimming crab.

Data from the **Ministry of Marine Affairs and Fisheries (2023)** indicates that Indonesia's blue swimming crab production in 2022 reached 583,815 tons, with a value of IDR 27 trillion. Blue swimming crab production in 2022 in Central Java Province amounted to 1,708 tons with a value of IDR 75 billion, representing a 46.35% increase from 2021. In countries including the United States, South Korea, Japan, Australia, and Taiwan, BSC is considered a favorite food, making them valuable export targets with a profitable market value **(Anam *et al.*, 2018)**. BSC production processes are still tied to harvesting from marine waters **(Hamid, 2015)**. While most of Indonesia's capture marine fisheries (80%) are consumed domestically, around 90% of BSC products are exported, mainly in cans **(Wiloso *et al.*, 2022)**.

Understanding fish size, a key component of biological resource information, is crucial for fisheries management **(Lane & Stephenson, 1995; Morgan, 2018)**. Stock assessment models use size data to monitor the condition of fish populations **(Beverton & Holt, 1959; Hordyk *et al.*, 2015; Prince *et al.*, 2015)**. Additionally, fish size plays a key role in determining the selectivity of fishing gear, promoting the use of resource-friendly equipment **(ManLennan, 1992)**. Examples of fisheries that apply size selectivity for sustainable management include the southern Australian rock lobster fishery **(Linnane *et al.*, 2011)**, various fisheries in Turkish waters **(Yildiz & Ulman, 2020)**, and the blue swimming crab (BSC) fishery in southern Australia **(Xiao & Kumar, 2004)**. Conservation efforts for BSC vary by region, reflecting local environmental conditions and socio-economic factors.

The Kendal waters are known for catching BSC in the Java Sea. Fishermen in Kendal mostly utilize traps to catch BSC **(Sudarmo *et al.*, 2023)**. Trap groups as fishing gear have the greatest potential in catching BSC because traps tend to be more selective, and their primary purpose is focused on catching BSC **(Zarochman & Prabawa, 2013)**. **Hufiadi (2017)** conducted a study related to the specificity of fishing gear in utilizing BSC in the waters of the Java Sea, focusing on research areas in Cirebon, Indonesia. The specificity of various types of BSC fishing gear in Cirebon is determined through the measurement of the carapace width of the BSC caught by each gear. The study involved the evaluation of the specificity of fishing gear such as collapsible traps, lift nets, and trawls used in BSC fishing. The results of the study indicate that collapsible traps demonstrate the highest selectivity efficiency in catching BSC.

Until now, Indonesia's management of BSC resources has been conducted by establishing a minimum size limit for crabs that can be harvested (Legal Minimum Size), as stipulated in Minister of Marine Affairs and Fisheries of Indonesia Regulation Number 16/PermanKP/2022 on August 12, 2022. This policy dictates that only BSC weighing

more than 60 grams per individual and not carrying eggs can be caught, with a carapace width of 10cm. This policy aims to ensure the sustainability of the blue swimming crab population in Indonesian waters. Despite the implementation of this policy, an assessment of its effectiveness in various regions of Indonesia has yet to be fully realized.

Evaluating the effectiveness of this regulation requires comprehensive monitoring of the size and condition of the captured BSC. However, limited information is currently available regarding the implementation of this regulation, particularly concerning size limitations for BSC. Furthermore, information regarding the proportion of BSCs that comply with the legal size can serve as a basis for designing BSC fishery management strategies. This research aims to evaluate the catch results of blue swimming crabs related to their distribution, the relationship between the width and weight of BSC, and the percentage of BSC deemed suitable for capture in the Kendal Waters.

MATERIALS AND METHODS

We conducted the study in the northern side of Kendal waters, a designated BSC fishing ground in the Java Sea (Fig. 1). Data collection occurred during the seasonal transition from the dry to the wet season, specifically from September to October 2023. We followed the fishing operations of BSC fishermen using collapsible traps (Fig. 2), randomly determining the gear placement locations based on their fishing operations. The study was conducted in unique 10 fishing locations, ensuring that each location was distinct.

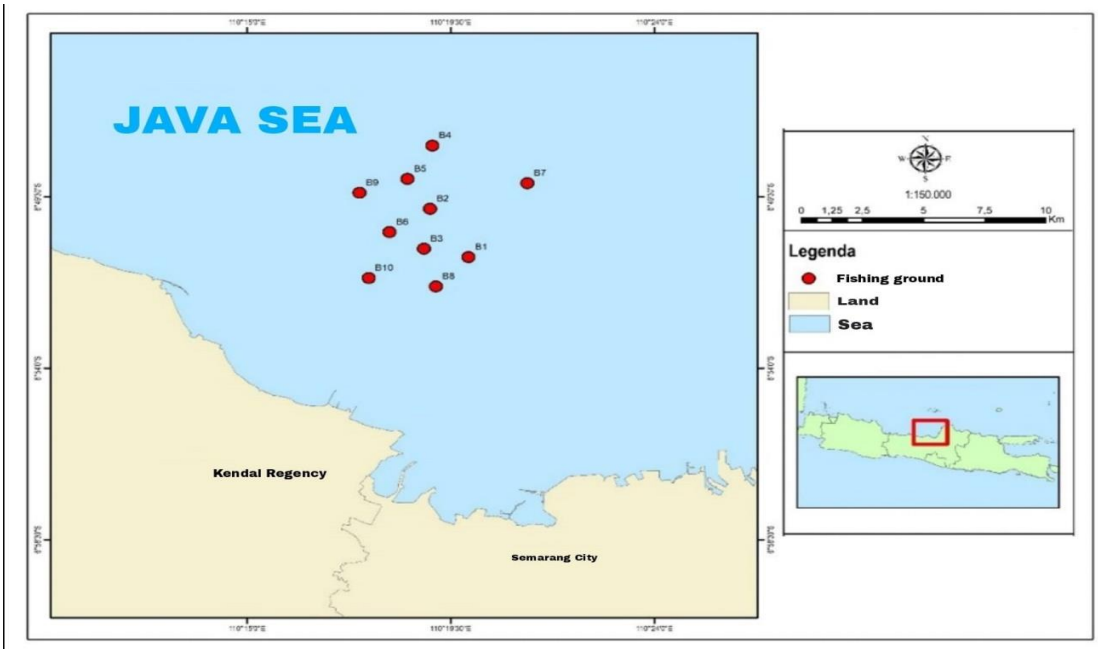
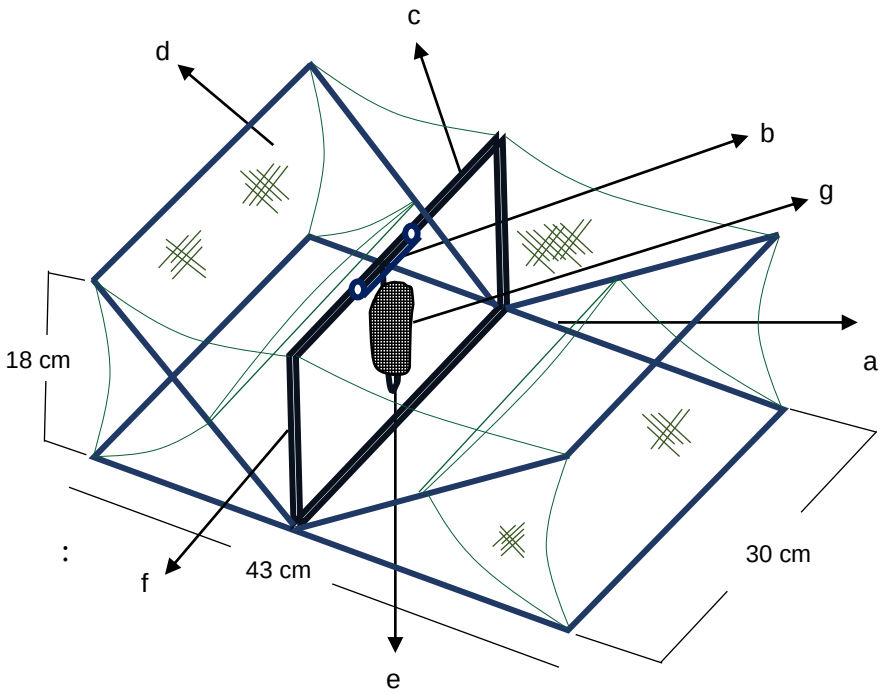


Fig. 1. Research location

Collapsible traps were set on the main line, with a branch line connecting them. The distance between the branch lines was 3 meters. The setting of traps was conducted in 1 to 1.5 hours for the 120 traps.



Where
a : funnel e : bait hook
b : hinge f : hatch
c : galvanized frame g : bait of fish pieces
d : net polyethylene wall

Fig. 2. Collapsible traps used in Kendal waters

These data included species type and biological aspects such as sex, weight, quantity, and carapace width. The BSC was measured after landing by weighing their weight using digital scales, measuring carapace width and length using a vernier caliper, and observing gender by examining the shape of the crab's abdomen.

Species and sex identification are described in **Ng (1998)**. Species composition is the proportion of the number of individuals to the total number of crab individuals caught with the equation:

$$C = \frac{ni}{N} X\ 100\ \%$$

Where, C represented the composition of crab species; *ni* represented the number of individuals within each species; and N represented the total number of individuals across all species.

In the sex ratio of BSC, a comparison was made between the number of male and female crabs obtained from identical catching locations. The method for calculating the sex ratio of the blue swimming crabs utilized the following formula:

$$\text{The sex ratio} = \frac{\Sigma \text{ Male}}{\Sigma \text{ Female}}$$

The length of blue swimming crabs was determined by measuring the carapace width (CW, cm), while the weight was determined by the total weight of each individual (W, gr). Size distribution was compared with the recommended legal size. Using the following equation, the percentage of legally acceptable blue swimming crabs was calculated:

$$\text{Proportion of legal size} = \frac{n(Lsize)}{N} \text{ X } 100\%$$

Where, the proportion of the legal size represents the percentage of legally acceptable BSC; L size denotes the number of individuals exceeding the legal size of BSC as per the regulation; and N represents the total number of samples.

The length-weight ratio was analyzed using the equations from **King (1995)**:

$$W = aL^b$$

Where, W represented the individual weight; L denoted the carapace width (CW); and a and b represented the regression constants.

The measurement of the length at first captured (Lc) is one method of calculating the selectivity of fishing gear based on fish size. Lc is defined as $CW_{50\%,}$ which is 50% cumulative frequency, and the estimation of the CW when 50% of the fish are caught. The following formula is used to calculate Lc based on the logistic equation:

$$SL_{est} = \frac{1}{1 + \exp[S1 - S2.L]}$$

$$\ln\left(\frac{1}{SL}\right) - 1 = S1 - S2 * L$$

$$L_{50\%} = \frac{S1}{S2}$$

Where, SL = logistic curve; L = carapace width; S1 = intercept; S2 = slope. S1 and S2 are constants in the logistic curve formula.

RESULTS

1. Species composition

In ten fishing efforts, the total number of successfully captured BSC was 254 individuals, comprising two varieties. These varieties include the blue swimming crab (*Portunus pelagicus*) and the crucifix crab (*Charibydis feriatus*) as shown in Fig. (3). *Portununs pelagicus* contributed 88% of the total 223 individual crabs caught (Fig. 4) They exhibit variations in color and shell contours compared to crabs living on coral reefs. This crab's carapace is more dominant than its abdomen, with the abdomen forming a triangular shape folded ventrally from the shell. Around the crab's eye area are nine spines on the left and right sides. The foremost spine, positioned anteriorly, is larger than the seven spines behind it. Meanwhile, the ninth spine, located on the side of the shell, is the largest of all

(a) (b)

Fig. 3. The captured crabs: (a) The crucifix crabs (*Charibydis feriatus*); (b) The blue swimming crabs (*Portunus pelagicus*)

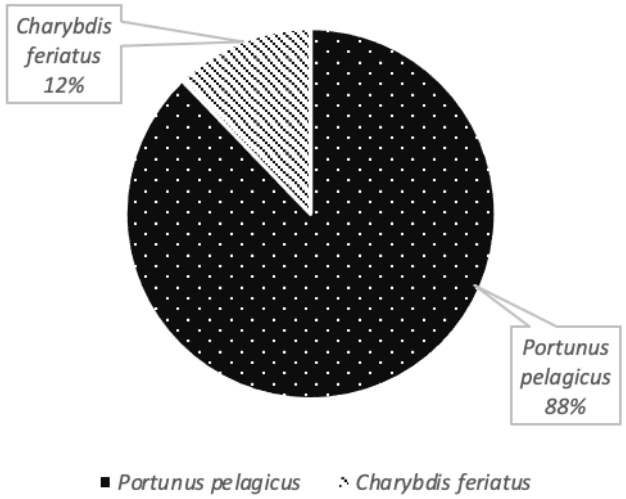


Fig. 4. The percentage of captured crabs based on types in the Kendal waters

2. Sex ratio of the blue swimming crabs

The difference in the shape of the abdomen and color of the male and female blue swimming crabs (*Portunus pelagicus*) is shown in Fig. (5). Some visual identification of the sex of the blue swimming crabs can be observed through the configuration of their abdomens. The male blue swimming crabs have tapered and narrow abdomens toward the front, while females display wider and semi-oval-shaped abdomens. This differentiation of sexes is not only limited to morphology but also their skin pigmentation; male crabs exhibit a dominant blue color with white spots, unlike females, which have a base color of dirty green or brown with dull white spots. According to their gender, the number of male blue swimming crabs caught was 93 individuals or 41.70%, and the number of female blue swimming crabs caught was 130 individuals or 58.30% (Fig. 6), with the ratio between male and female is 1:1.39. Whereas in Rembang Waters, both in Java Sea, the ratio was 1:1.18 **(Putra *et al*., 2020)**.

Fig. 5. The difference in the abdomen and color of male (right) and female (left) BSC (*Portunus pelagicus*)

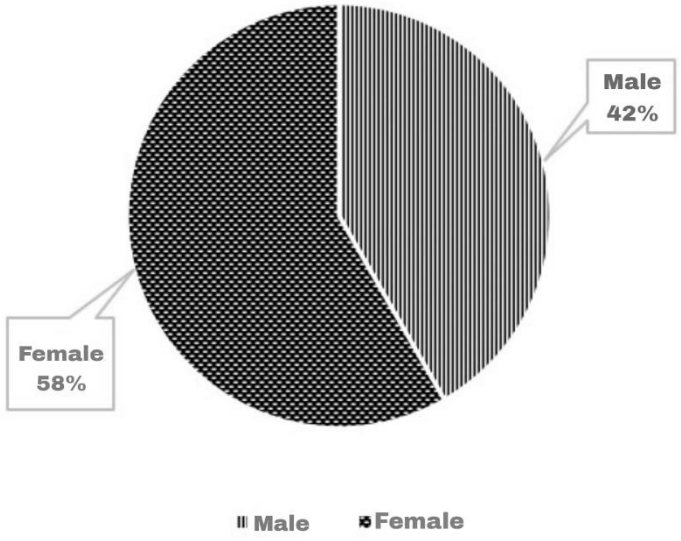


Fig. 6. Comparison of BSC (*Portunus pelagicus*) based on gender

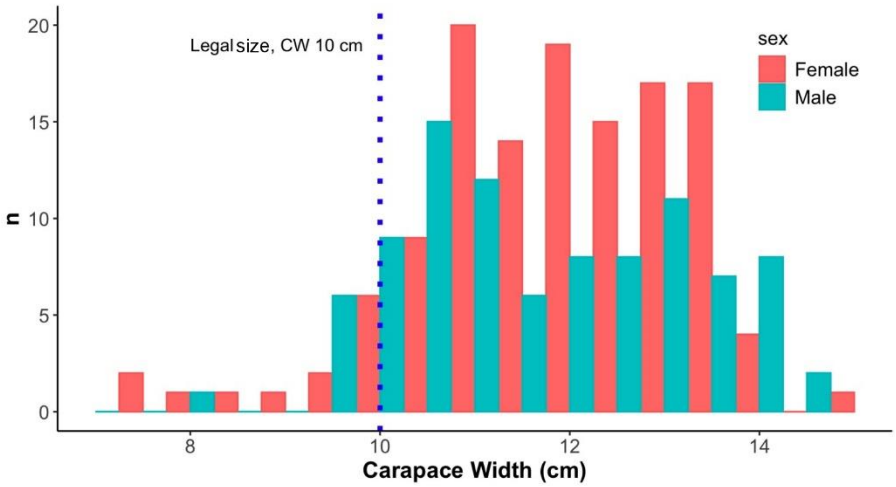
3. The size distribution

During the observation in this study, a total of 223 individual BSCs were identified and measured, with 93 of them being male and the remaining 130 individuals being

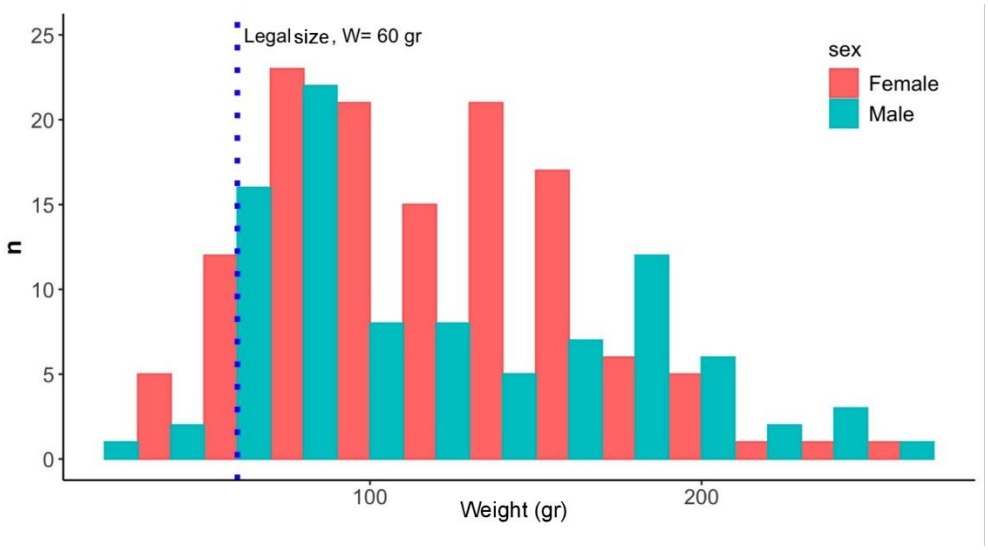
female. The findings of this study reveal that the carapace width of BSC found in the research area varied from 7.4 to 15.1cm, with an average value of 11.78cm. More specifically, the carapace width of the female blue swimming crabs ranged from 7.4 to 15.1cm, with an average of 11.85cm, while in the male blue swimming crabs, it ranged from 8.1 to 14.7cm, with an average of 11.68cm (Table 1 & Fig. 7a). Weight size was distributed from 22 to 260 grams with an average of 118 grams, with female crabs measuring 22 to 260 grams (average 116.36 grams) and males measuring 30 to 258 grams (average 119.77 grams) (Table 1 & Fig. 7b). The legal size of the carapace width and weight of the blue swimming crab caught had a proportion above 90% (Fig. 8). The female was wider in the carapace than the male; this was found in Tiworo Strait where the carapace female was 11.06cm and the male was 10.76cm **(Cardin *et al*., 2023)**.

Table 1. Size and gender of BSC during the research

Variable	Total catch		Minimum size		Maximum size		Average	
	Female	Male	Female	Male	Female	Male	Female	Male
Carapace width (cm)	130	93	7.4	8.1	15.1	14.7	11.85	11.68
Weight (gram)	130	93	22	30	260	258	116.36	119.77



(a)



(b)

Fig. 7. The size distribution of the of BSC based on carapace (a) width, and (b) weight

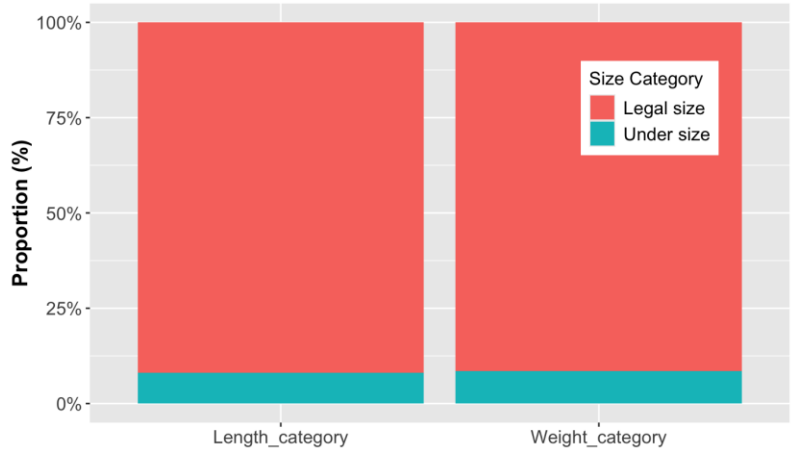


Fig. 8. Legal size proportion based on carapace width and weight

4. Carapace width and weight relationship

Regression analysis reveals the pattern of carapace width distribution in male and female BSC concerning their weight (Fig. 9). The trend observed in the graph indicates that for the same size, male BSC are generally heavier than the female. The graph illustrates that as carapace width increases, the weight of BSC also increases. From the analysis conducted on the relationship between carapace width and crab weight, it was found that the coefficient b for male crabs was 3.61, while for female crabs it was 3.30 (Fig. 9 & Table 2). This finding indicates that in the Kendal waters, both male and female blue swimming crabs experience positive allometric growth (with b values above 3), indicating that crab weight growth occurs faster than carapace width growth.

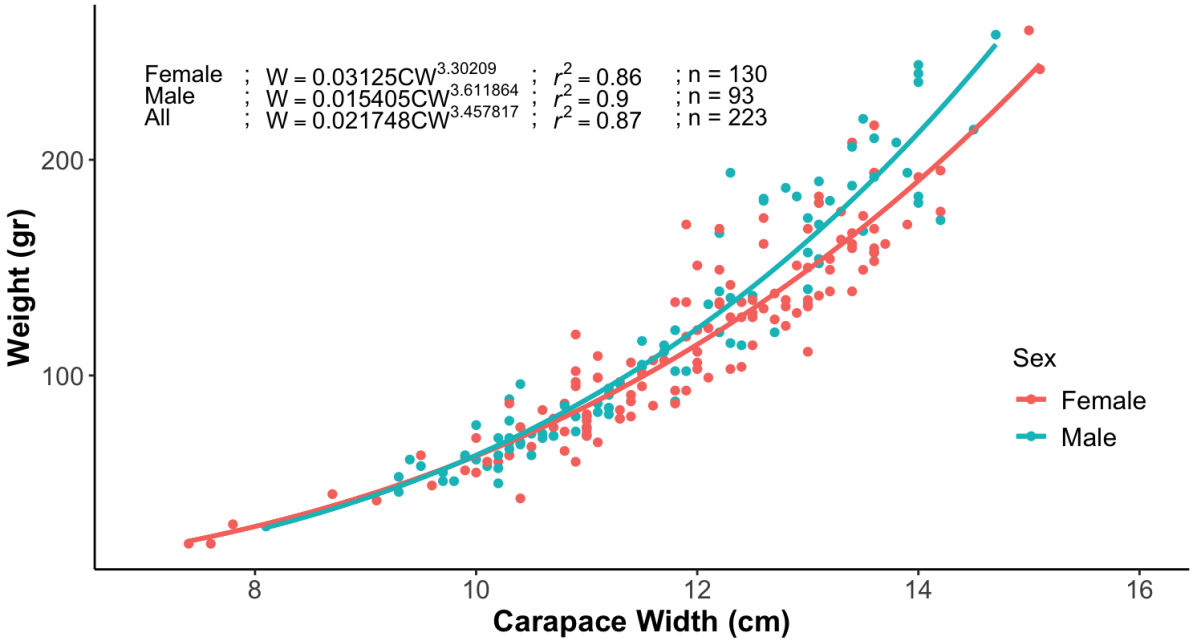


Fig. 9. The distribution of carapace width sizes of male and female BSC in correlation with their weight sizes

Table 2. The regression analysis results of carapace width and weight of captured BSC

Gender	The parameter for the relationship between carapace width and crab weight				
	n	a	b	r	Growth characteristic
Male	93	0,0133	3,6709	0,923	Positive allometric
Female	130	0,0403	3,1974	0,886	Positive allometric

Unlike the increase in the BSC population, some studies reveal characteristics of negative allometric growth, where the increase in width tends to be more significant than the increase in mass. Examples include the research by **Muhsoni and Abida (2009)** in the Bangkalan Waters, the study by **Setiyowati (2016)** in the Jepara Waters, and the research by **Anam *et al*. (2018)** in the Betahwalang Waters. The allometric relationships between the characters of this set suggest that most relationships are positive and highly significant in the Red Sea **(El-Kasheif *et al*., 2021)**. Positive allometric growth was observed for male *Portunus pelagicus*, with a negative allometric growth for females **(Haputhantri *et al*., 2021)**.

Meanwhile, according to the study by **Safira *et al*. (2019)**, BSC can also exhibit isometric growth patterns, where the increase in width is proportional to the increase in

weight, such as crabs found in the southern part of Madura Island, Cirebon, and Lancang Island. Differences in growth characteristics were evident between the male and female blue swimming crabs, as revealed by **Suryakomara (2013)**. This can be attributed to higher feeding activity levels in male crabs than in females. Furthermore, consumption activity in female crabs decreases due to additional energy requirements allocated to support gonad development. As a result, female crabs utilize materials such as calcium in the eggshell formation process.

5. Carapace width at first capture

Carapace width first caught (Lc) is identical to $CW_{50\%}$ in gear selectivity. Based on the calculation results, the mean carapace width at first captures (Lc) of BSC was 11.9cm (Fig. 10). The Lc size is larger compared to this species' fishing legal size.

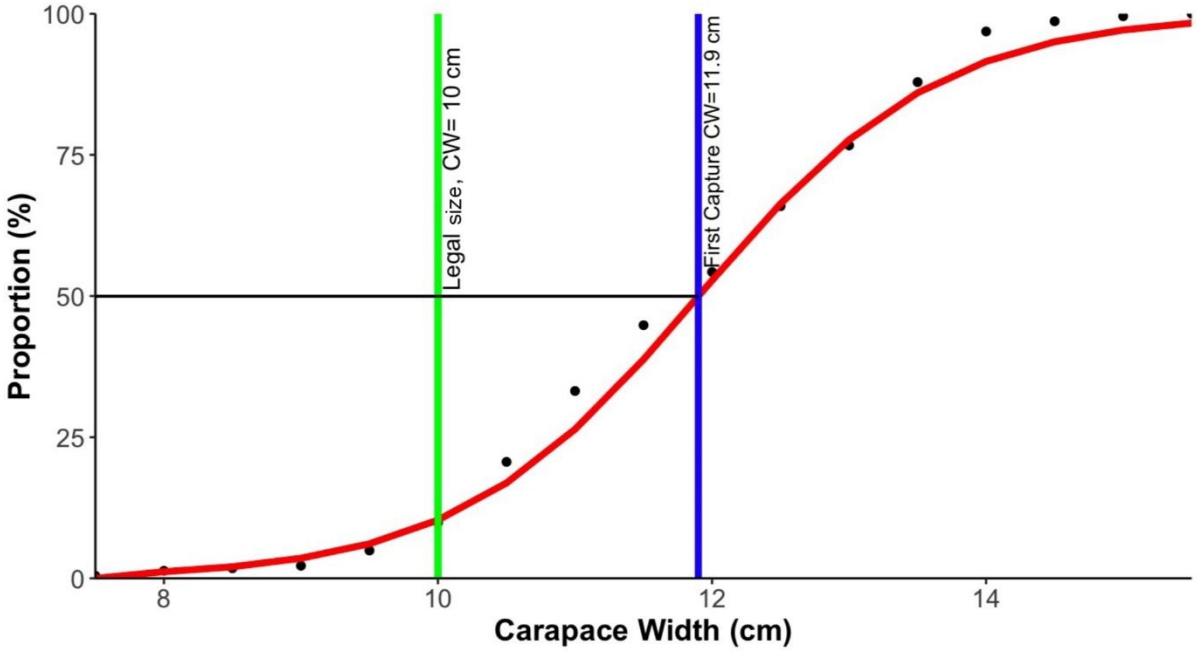


Fig. 10. Carapace width at first captured (Lc). Black dots indicate observed size selectivity, red line is the fit (estimated) of the size selectivity. The green horizontal line indicates legal size (10cm) and the blue horizontal line indicates L_{50} = 11.9cm

DISCUSSION

Blue swimming crabs (*Portunus pelagicus*) dominate the catch composition compared to other crab species in this area. This condition arises because the research location is situated in a fishing zone far from the coast, at depths ranging from 15 to 30 meters, where the seabed is a mixture of sand and mud. According to **Foka *et al.* (2004)**, BSCs are typically found in sandy-muddy seabeds and offshore waters. In contrast to this study, in the waters of the Gulf of Thailand, the *Charybdis affinis* dominated **(Jatigate &**

Sawusdee, 2022). Many things influence this difference, such as the characteristics of the waters and fishing pressure.

Observations regarding the sex distribution of BSC (*Portunus pelagicus*) reveal the presence of a larger number of female crabs than male crabs. This condition reflects an imbalance in the gender ratio of BSC, where the ideal balance should approach a 1:1 ratio **(Ningrum *et al*., 2015)**. This is similar to several studies conducted in Australia **(Sumpton *et al*., 1994; Xiao & Kumar, 2004)**, and in Bone **(Kembaren *et al*., 2012)**. According to the concept of stock balance, if the female population is significantly lower than the male population, reproductive capacity is reduced. In a broader sense, this can greatly affect the number of new individuals added to the stock system (recruitment), disrupting the population structure balance.

Several factors such as food availability, fishing areas, seasons, and migration patterns in Indonesian waters can influence the number of the male and female BSC **(Sara *et al*., 2002)**. Different sex ratios in catches can be influenced by breeding season, migration, and habitat preferences **(Josileen, 2011, Rahman *et al*., 2019)**. During mating periods occurring in March, July, September, and December, female BSC migrate to areas with higher salt concentrations, making deep-sea zones their primary habitat. According to research conducted by **Prasetyo *et al*. (2014)**, there is a tendency for an increase in the population of female BSC in deeper water areas, while male crabs are more commonly found in shallow waters. Consistent with this, findings by **Adam *et al*. (2006)** indicate that fishing areas located farther from the coastline generally yield catches with a higher proportion of female BSC, while areas closer to the shore tend to be inhabited more by male crabs.

Females were generally found to have a higher frequency distribution of carapace length than males. This is in contrast to several studies conducted in Queensland **(Sumpton *et al*., 1994: Kumar *et al*., 2003)** and several places in Indonesia, such as Cirebon, Demak, Rembang, Sumenep, Sampit, Pati, Brebes, Mayangan, and Bengkulu **(Sunarto, 2012; Ernawati, 2013; Maylandia *et al*., 2021)**. Several things, including differences in growth patterns, fishing areas, and fishing seasons, cause differences in carapace length frequencies.

In this study, the results of the length-weight relationship between male and female crabs were positive allometric ($b>3$; $R2=0.92$ and 0.886). Unlike the increase in the BSC population, some studies reveal characteristics of negative allometric growth, where the increase in width tends to be more significant than the increase in mass. Examples include the research by **Muhsoni and Abida (2009)** in the Bangkalan waters, the study by **Setiyowati (2016)** in the Jepara waters, and the research by **Anam *et al.* (2018)** in the Betahwalang waters. Meanwhile, according to the study by **Safira *et al*. (2019)**, BSC can also exhibit isometric growth patterns, where the increase in width is proportional to the

increase in weight, such as crabs found in the southern part of Madura Island, Cirebon, and Lancang Island. Differences in growth characteristics between male and female BSC, as revealed by **Suryakomara (2013)**, can be attributed to higher feeding activity levels in male crabs compared to females. Furthermore, consumption activity in female crabs decreases due to additional energy requirements allocated to support gonad development. As a result, materials such as calcium are utilized by female crabs in the eggshell formation process.

The carapace at first caught in this study was 11.9cm wide. This size is larger when compared to the size of the first-time mature gonads in the Java Sea waters **(Ernawati *et al.*, 2017; Abrenica *et al.*, 2021)**. This shows that the fishing gear used (the trap) shows high selectivity to catch BSC. Therefore, this fishery can be classified as a sustainable fishery, but it still needs to be carefully utilized to maintain the sustainability of BSC stock resources.

Percentage of legally acceptable BSC

The study researched the challenges of the crab industry in East Sumatra and North Java, Indonesia, which focused on reducing the average size of crabs. This study suggests a variety of management options to address these challenges, including implementing legal minimum sizes, prohibiting the take of mated females, equipment changes, time or area closures, and implementing effort controls **(Bahtiar *et al.*, 2016)**. There are new regulations in the management of lobster resources (*Panulirus* spp.), crabs (*Scylla* spp.), and blue swimming crabs (*Portunus* spp.) in the Indonesian waters. These regulations stipulate that the capture and/or export of BSC, for consumption purposes must meet certain criteria, where each crab caught or exported must have a minimum weight of 60 grams per individual and must not be in a gravid condition. Additionally, for cultivation purposes, the carapace width of blue swimming crabs must be at least 10cm **(Ministry of Marine Affairs and Fisheries, 2022)**. The international standard limit size carapace width is 10,2cm which can vary by region. This size limit is aimed at protecting BSC, and ensuring this sustainability.

The research results indicate that based on the weight of BSC, 9.87% of BSC (*Portunus pelagicus*) weigh below 60 grams. Meanwhile, based on the carapace width, 10.31% of BSC is measured below 10cm (Fig. 6). Approximately 90.13% of the BSC catches in the fishing grounds of Kendal Waters fall within the legally acceptable size category. This shows that most fishing gear complies with regulations, compared to gill nets and mini trawl **(Rahman *et al.*, 2019)**. The continued capture of BSC below 60 grams and/or below 10cm is suspected to be influenced by several factors such as fishing season, crab fishing areas, crab life cycle, and the scale of fishermen's activities **(Ihsan, 2018)**. These four factors are closely interrelated, depicting the life cycle of BSC involving their movement between coastal and offshore areas. In this cycle, crabs migrate

from offshore to coastal areas for nurturing, foraging, and experiencing growth stages, involving small-sized crabs. Another factor is the lack of selectivity of crab traps **(Novitasari *et al.*, 2023)**, as the openings used in the traps may still allow small-sized crabs to enter. By adopting sustainable fishing practices and management strategy we can help ensure the long-term health and sustainability of BSC and the marine ecosystem they inhabit.

In addition to Indonesia, Australia, specifically in its western and southern waters, also restricts the minimum size limit for BSC to 11cm, which is larger than the limit in Indonesian waters **(Xiao & Kumar, 2004)**. However, compliance with this regulation remains an issue, particularly within recreational fisheries **(Liandley & Quinn, 2023)**. This lack of compliance has contributed to the decline of the fishery, partly due to the exploitation of immature BSC that have not yet spawned **(Johnston *et al.*, 2011)**. In this study, the first caught size (Lc50 = 11.9cm) exceeded the size at first sexual maturity (10.6cm) **(Ernawati *et al.*, 2017)**, suggesting that the average size of the caught fish is already reproductively mature. This suggests that the reproductive process has already occurred for these individuals, reducing their risk of impacting egg production and, consequently, natural recruitment.

Even though most of the catch in controlled waters is legally acceptable, control over the use of fishing gear must continue to be carried out to maintain sustainability. Evaluation of the use of fishing gear is a practical step to support the implementation of ministerial decisions in the field and to ensure the sustainability of the BSC **(Rahman *et al.*, 2019)**. Additionally, it is also necessary to understand the life history characteristics of crabs for stock assessment and improving sustainable fisheries management **(Ervinia *et al.*, 2023)**.

CONCLUSION

Two blue swimming crabs, the BSC (*Portunus pelagicus*) and the crucifix crab (*Charibydis feriatus*), were successfully harvested from the Kendal Waters. BSC dominated the majority of the catch, reaching 87.79%. Observations of the BSC catch indicated gender imbalances and positive allometric growth characteristics in the BSC in the Kendal Waters, characterized by the rate of body mass growth of the crabs exceeding the increase in carapace width. The average size of the BSC caught and the size first caught was above the legal size required. Most BSC catch (90%) falls within the legally acceptable size range.

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