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Size at First Capture and Growth Parameters of the Blue Swimming Crab (*Portunus pelagicus*, Linnaeus 1758) in Rembang Waters, Central Java, Indonesia

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ABSTRACT

Indonesia, as a maritime country, holds a significant economic value in the blue swimming crab (BSC) resources, catering to both domestic needs and international exports. Rembang Regency, Central Java Province, a key BSC production center in Indonesia, faces challenges related to the sustainability of its BSC resources. This study aimed to analyze the biological aspects of BSC, including the size at first capture, size at first maturity, and growth parameters, to inform sustainable management practices. The study was conducted from November 2023 to February 2024 in the waters of Rembang. BSC samples were collected using a random sampling method. Data collected included carapace width (mm), weight (grams), and gonad maturity stage. Analysis was performed using Microsoft Excel and FiSAT II software. A total of 786 BSC samples were obtained. The carapace width of the samples ranged from 72 to 150mm. The calculated size at first capture (Lc) for male and female BSCs was 104.1 and 104.6mm, respectively. The size at first maturity (Lm) was determined to be 116.5mm. The relationship between carapace width and weight for male and female BSCs was described by the equations $W = 0.000039CW^{3.096}$ and $W = 0.00022CW^{2.716}$, respectively. The growth equations for male and female BSCs were $CWt = 161.18(1 - e^{(-1.3(t+0.076))})$ and $CWt = 154.88(1 - e^{(-0.64(t+0.161))})$. Over the four-month study period, it was evident that BSCs of unfit size and egg-bearing females were being captured. Therefore, continuous monitoring and sustainable management practices are necessary to ensure the long-term viability of BSC resources.

INTRODUCTION

Indonesia, as an archipelagic maritime country, has an ocean area that is two-thirds larger than its landmass **(Darusman, 2018)**. This extensive marine environment is rich in resources, including diverse fish species and other aquatic biota. In the northern region of Central Java in the Rembang waters, the marine resources are substantial because of its coastal area constituting 35% of the total region **(Ameriyani, 2014)**. Among the valuable fisheries in Rembang is the blue swimming crab (BSC), evidenced by its increasing production: 37,066kg in 2020, 140,641kg in 2021, and 419,264kg in 2022, according to the Central Bureau of Statistics of Rembang Regency. The BSCs caught are typically distributed to middlemen and canning factories, serving both domestic and international markets.

The BSC (*Portunus pelagicus*) belongs to the Portunidae family and is a swimming crab because of its last pair of legs, which are modified into flat, paddle-like appendages **(Anbarasu *et al*., 2021)**. BSCs are found from Japan, Korea, China, Indonesia, and the Malacca Strait to parts of northern Australia **(Bagheri *et al*., 2020)**. Their habitat ranges from estuaries to waters with salinity levels of 30–40ppt, and they inhabit sandy or muddy substrates and algal areas at depths of 50–65 meters **(Afzaal *et al*., 2016)**.

BSCs have significant economic value, leading to large export volumes. In 2020, Indonesia exported 27,792 tonnes of BSCs valued at USD 472,962,123 **(Triyanti *et al*., 2021)**. According to the Minister of Marine Affairs and Fisheries Decree Number 19 of 2022, the potential yield of BSC resources in the Fisheries Management Area of the Republic of Indonesia 712 (WPPNRI 712), which includes Rembang waters, Central Java Province, is 23,508 tonnes per year. Its utilization rate of 0.7 indicates a fully exploited status that requires careful monitoring **(Suman *et al*., 2016)**.

Rembang is a major BSC production center in Indonesia. Continuous fishing activities by local fishermen impact the BSC stock. Research by **Simanjuntak *et al*. (2019)** indicated that BSCs caught in Rembang waters had carapace sizes ≤ 10cm. Additionally, female BSCs often get caught while laying eggs, contributing to the capture of undersized crabs. This finding aligns with **Putra *et al*. (2020)**, who reported that gonadally mature BSCs in Rembang are predominantly around 10cm in size.

Monitoring the size at first capture, growth, and reproductive conditions of BSCs is crucial for sustainable resource management. This study aimed to determine the size at first capture, size at first maturity, and growth parameters of BSCs in Rembang waters.

MATERIALS AND METHODS

The research material used was BSC caught by fisherman, which was caught by bubu fishing. BSC sampling was conducted twice monthly over four consecutive months: November and December 2023, and January and February 2024. The sampling took place in the waters of Rembang, Central Java (Fig. 1). Tools used included millimeter blocks with 1mm accuracy to measure carapace width, digital analytical scales for weight measurement, stationery for data recording, and FiSAT II software for data analysis. The material used comprised BCS samples caught by fishermen. The random sampling method was employed, ensuring each element had an equal chance of selection from the population **(Yulianto *et al*., 2020)**.

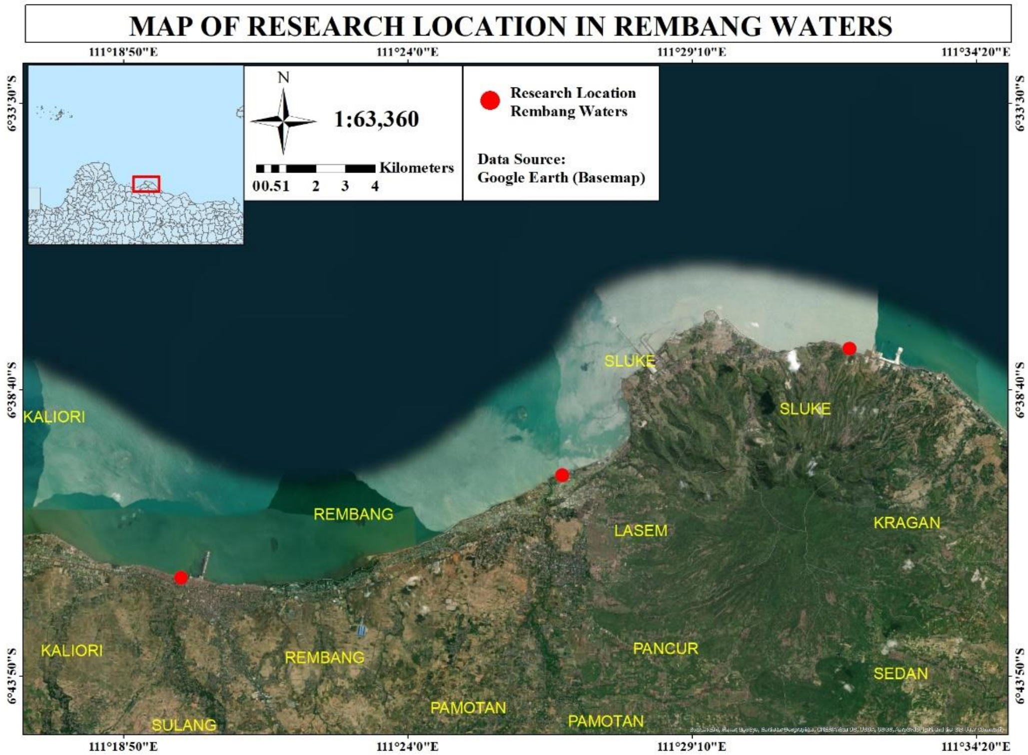


Fig 1. Location of sampling

Data analysis

The size at first capture was determined by plotting the cumulative frequency of BSC caught against their carapace widths. The intersection point between the curve and the 50% cumulative frequency represents the length at which 50% of the crabs are caught **(Khasanah *et al*., 2020)**.

Gonad maturity level was analyzed visually by opening the BSC carapace and examining the gonad morphology. The size at first maturity in BSCs can be estimated using the Spearman-Karber method **(Saputra *et al*., 2021)** with the following formula:

$$\text{Log}\, lm = xk + \frac{d}{2} - d\sum pi$$

Where, $d = xi + 1$ for $i = 1, 2, 3$ ..., $k - i$; xi = logarithm of the center class of the carapace width group; l = 1, 2, ..., k; xk = logarithm of the middle value of carapace width where the crab is 100% gonadally mature (or where $pi = 1$); pi = proportion of gonadally mature BSCs in the i-th carapace width group ($pi = \frac{ri}{ni}$); ni = number of crabs in the i-th carapace width group; ri = number of gonadally mature BSCs in the i-th carapace width group.

The growth pattern of BSCs was analyzed by examining the relationship between carapace width and weight using the following equation **(Saputra *et al*., 2021)**:

$$W = a \cdot CWb$$

Where, W = individual weight (g); CW = carapace width (mm); a = intercept; b = slope. After determining the value of b, a statistical test was conducted with the following hypotheses: $H0 : b = 3$ (isometric growth pattern); $H1 : b \neq 3$ (allometric growth pattern). The hypothesis was tested by comparing the calculated t-value with the t-table value. If the calculated t-value was greater than the t-table value, $H1$ was accepted; otherwise, $H0$ was accepted.

Growth parameters, including asymptotic carapace width ($CW\infty$), growth coefficient (K) and the age of the BSC when its carapace width is zero ($t0$) , were estimated using the ELEFAN I program in FiSAT II software. Growth parameters were modeled using the von Bertalanffy growth model **(Saputra *et al*., 2021)** as follows:

$$CW(t) = CW\infty\left(1 - e - K(t - t0)\right)$$

The value of $t0$ was determined using Pauly's empirical equation **(Saputra, 2009)**:

$$log\ (-t0) = 0.3952 - 0.2752\ (log\ CW\infty) - 1.038\ (log\ K)$$

Where, $CW(t)$= crab carapace width at age t (years); $CW\infty$ = asymptotic carapace width (mm); K = parameter describing the speed of reaching $CW\infty$; t = age of the crab; $t0$ = age of the crab at carapace width zero; e = natural number.

RESULTS

Carapace width size composition

A total of 786 BSCs were sampled during the study, consisting of 400 males and 386 females. The highest number of samples was collected in January. The carapace width of the BSC samples ranged from 72 to 150mm, indicating the presence of crabs smaller than 100mm (< 10cm). Figs. (2, 3) show the classification of BSC carapace width.

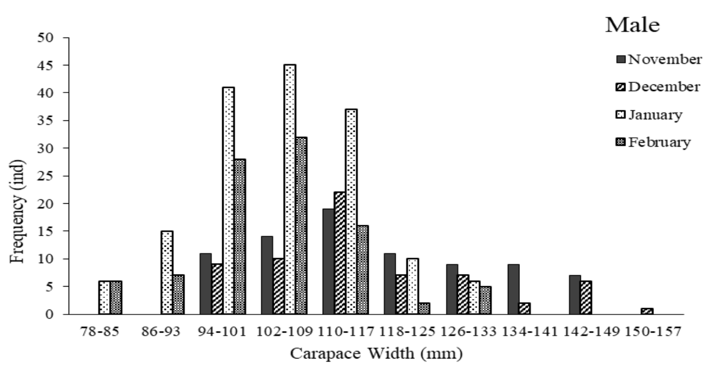


Fig. 2. Histogram of carapace width of male BSCs from Rembang Regency, Central Java Province

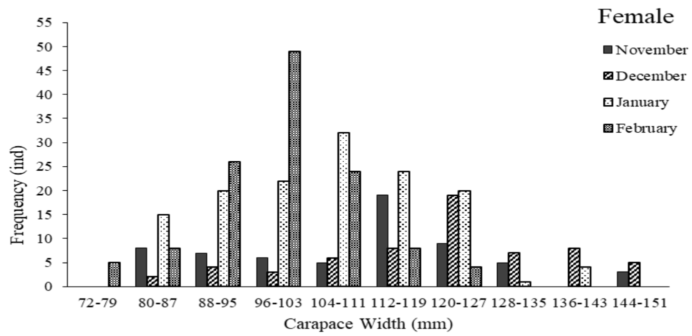


Fig. 3. Histogram of carapace width of female BSCs from Rembang Regency, Central Java Province

The size distribution of male BSC carapace widths varied across the months: in November and December, sizes were 110–117mm, while in January and February, sizes were 102–109mm. For female BSCs, the sizes were 112–119mm in November, 120–127mm in December, 104–111mm in January, and 96–103mm in February.

Size at first capture (Lc_{50})

Analysis of the size at first capture (Lc_{50}) for male and female BSCs (Figs. 4, 5) revealed a slight difference between the sexes. The Lc_{50} for males was 104.1mm, and for females, it was 104.6mm. This difference in Lc_{50} values between male and female BSCs was not significant.

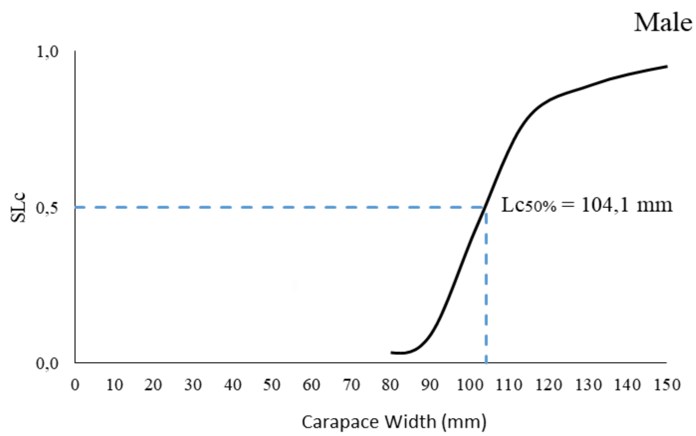


Fig. 4. Male BSC Lc_{50} curve from Rembang Regency, Central Java Province

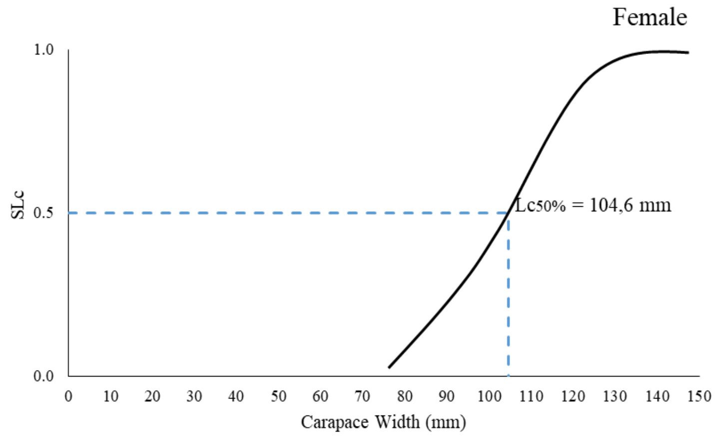


Fig. 5. Female BSC Lc_{50} curve from Rembang Regency, Central Java Province

Size at first maturity (Lm_{50})

The study classified female BSCs into immature (Stages 1 and 2) and mature (Stages 3 and 4) stages, showing that immature BSCs were more dominant (Fig. 7). Immature and mature gonads are depicted in Fig. (6).

(a) **(b)**

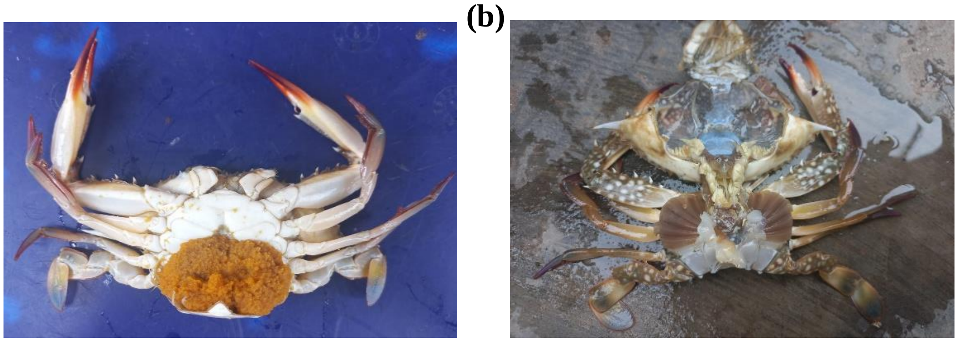


Fig. 6. (a) Immature BSC and **(b)** mature BSC from Rembang Regency, Central Java Province

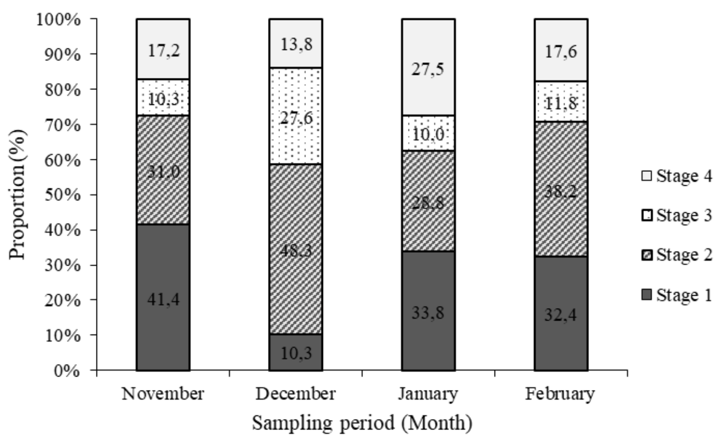


Fig. 7. Percentage of gonad maturity level of BCS from Rembang Regency, Central Java Province

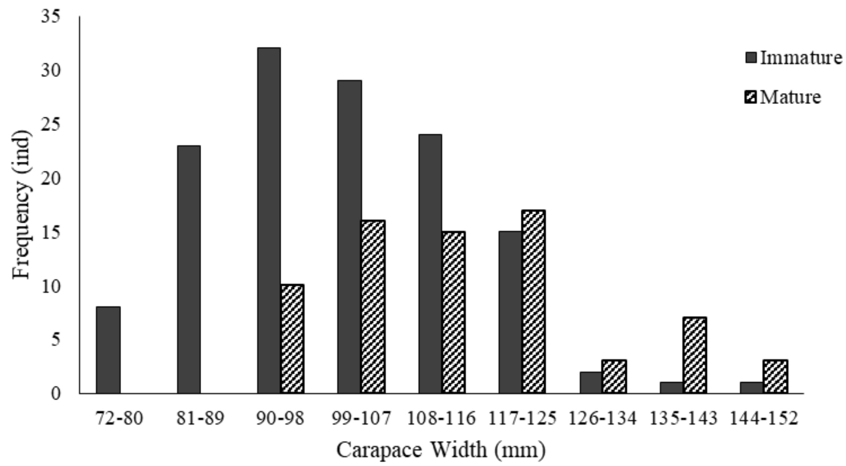


Fig. 8. Size distribution of mature and immature BSCs from Rembang Regency, Central Java Province

In November, immature BSCs dominated with a total percentage of 72.4%, including 41.4% in stage 1 and 31% in stage 2. In December, gonadal mature BSCs were more prevalent, with a total percentage of 41.4%, comprising 27.6% in stage 3 and 13.8% in stage 4. Female BSCs reached gonadal maturity at a carapace width of 90–98mm. The highest distribution of mature females was in the carapace width of 117–125mm, with 17 individuals (Fig. 8). The analysis of size at first maturity (Lm_{50}) indicated a carapace width of 116.5mm (Fig. 9).

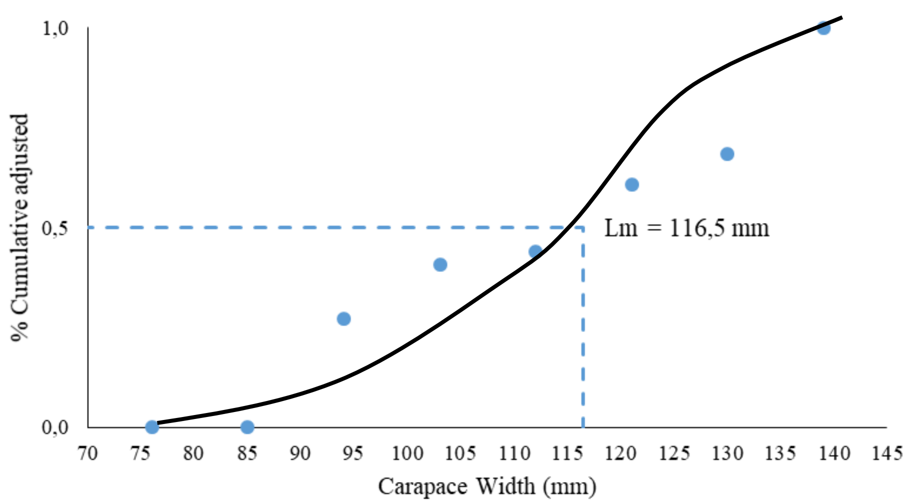


Fig. 9. Lm_{50} curve of BSC from Rembang Regency, Central Java Province

Relationship between carapace width and weight

The relationship between carapace width and weight is illustrated in Figs. (10, 11). This analysis demonstrates the growth patterns of male and female BSCs. The relationship equations for male and female BSCs were $W = 0.000039CW^{3.096}$ and $W = 0.00022CW^{2.716}$, respectively. The growth pattern, based on the b value, was isometric for males (b = 3.096) and showed negative allometry for females (b = 2.716). The t-test analysis confirmed these results: for males, t-value < t-table, indicating isometric growth, while for females, t-value > t-table, indicating negative allometric growth. This suggests that male BSCs were more plump than female BSCs.

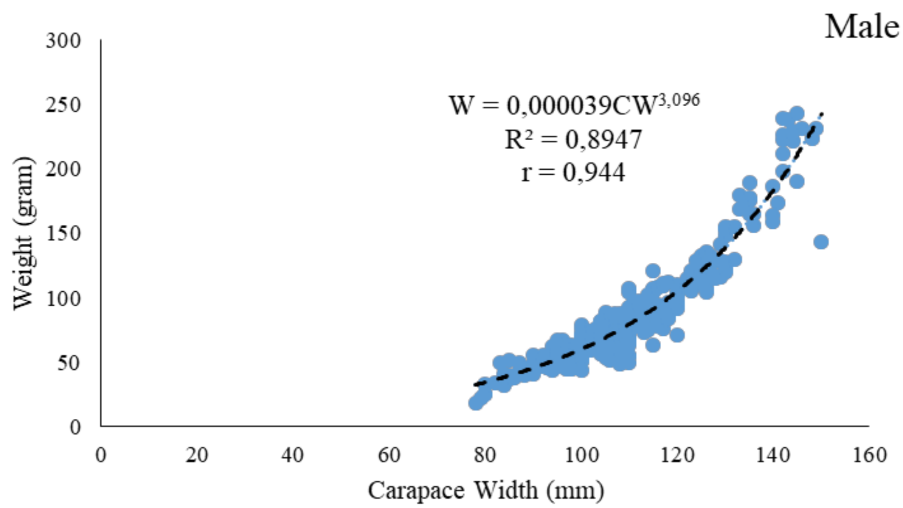


Fig. 10. Relationship curve between carapace width and weight of male BSC from Rembang Regency, Central Java Province

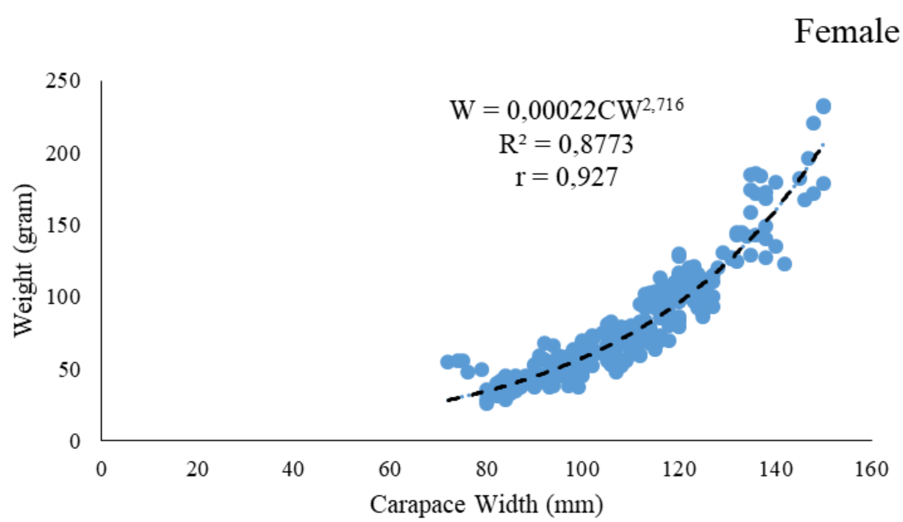
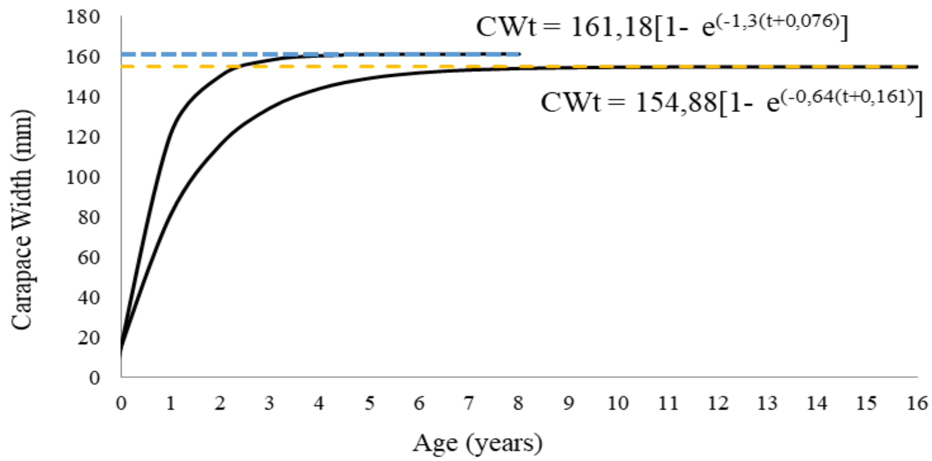


Fig. 11. Relationship curve between carapace width and weight of female BSC from Rembang Regency, Central Java Province

Growth parameters

Using the von Bertalanffy growth model and FiSAT II software, the estimated growth parameters yielded a CW_∞ value of 161.18mm for male BSCs and 154.88mm for female BSCs. The K values were 1.3 for males and 0.64 for females. The growth equations derived were $CW_t = 161.18(1 - e^{(-1.3(t+0.076)})$ for males and $CW_t = 154.88(1 - e^{(-0.64(t+0.161)})$ for females. These equations described the relationship between carapace width and age (Fig. 12). The growth curves indicated that male BSCs reach their asymptotic carapace width in approximately 8 years, whereas females take up to 16 years to reach their maximum size. This suggests that male BSCs grow faster than female BSCs, because the K value of male BSCs is greater.



Fig, 12. Relationship curve between carapace width and age of BSC from Rembang Regency, Central Java Province

DISCUSSION

Based on the analysis of BSC carapace width, the size at first capture was determined. The catch was predominantly BSCs larger than 100mm (> 10cm), though some were smaller than 100mm (< 10cm). This is not in compliance with the Regulation of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia No. 7 of 2024, which stipulates that BSCs should only be caught if they have a carapace width above 10cm. The Lc_{50} values for male and female BSCs are similar, at 104.1 and 104.6mm, respectively, with female BSCs having a slightly larger size at first capture. These values are close to those reported by **Anam *et al*. (2018)** for BSCs in Betahlawang Demak (109mm). Additionally, they are lower than those reported by **Ningrum *et al*. (2015)** (122mm). Differences in Lc50 across different waters likely reflect variations in water depth and habitat **(Suman *et al*., 2019)**. The Lc50 values in this study are greater than half the L_∞ values (161.18mm for males and 154.88mm for females), indicating that BSCs are of catchable size **(Soukotta *et al*., 2022)**.

The study shows that BSCs reach gonadal maturity at a carapace width of 90–98mm, with the majority of gonadally mature BSCs having a carapace width of 117–125mm. The size at first maturity for crabs in this study was 115mm, larger than the Lm_{50} value reported for Pati Waters (107mm) **(Ernawati *et al*., 2014)** but smaller than that reported for Betahlawang Waters, Demak (141.51mm) **(Maulana *et al*., 2021)**. Factors influencing the size at maturity include food availability, predation, temperature and salinity variations, fishing pressure, and types of fishing gear used **(Hamid *et al*., 2016)**. The Lc_{50} value in this study is smaller than the Lm_{50} value, indicating that the BSC resource utilization in Rembang waters is suboptimal and may lead to recruitment overfishing if not managed properly **(Panggabean *et al*., 2018; Kanedi *et al*., 2020)**. Indeed, captured BSCs were predominately immature, which indicates overfishing due to fewer adult BSCs being caught **(Saranga *et al*., 2019)**. Hence, capture intensity needs to be limited to avoid catching many immature crabs, which impedes their ability to reproduce **(Saputra *et al*., 2009)**.

BSCs spawn throughout the year, as indicated by the presence of gonadally mature female crabs (Stage 3 and 4), with the peak indicated by a higher percentage of egg-bearing females **(Kembaren & Surahman, 2018)**. Female BSC spawning can be known based on gonad maturity, where the spawning season is thought to coincide with the gonad maturity season **(Pane *et al*., 2017)**. Based on the results of the BSC gonad maturity stage percentage (Fig. 7), the peak spawning in this study was observed in December and January, which means that BSCs will migrate from the estuary area to high salinity waters for spawning. The results of this research are in consistent with **Romimohtarto and Juwana (2005)**, who reported the peak of the BSC spawning season occurs in the western season in December, the first transitional season in March, the eastern season in July and the second transitional season in September. In contrast to findings from the northern Java Sea, peak spawning in Pati was reported in October **(Ernawati *et al.*, 2014)**, while in the waters of East Lampung, it occurred in May and September **(Zairion *et al.*, 2014)**. These differences in spawning seasons are attributed to the varying environmental conditions specific to each region **(Hermanto *et al*., 2019)**.

The relationship between carapace width and weight for male BSCs was represented by the equation $W = 0.000039CW^{3.096}$, with a b value of 3.096. For female BSCs, the equation was $W = 0.00022CW^{2.716}$, with a b value of 2.716. The b value for males indicates isometric growth ($b \approx 3$), meaning that width and weight increase proportionally **(Qamariyah *et al*., 2023)**. For females, the b value suggests negative allometric growth ($b < 3$), indicating that width increases faster than weight **(Philips *et al*., 2022)**. This can be influenced by reproductive activities, as female BSCs molt when mating, leading to faster carapace width growth and subsequent weight gain due to nutritional needs for spawning **(Tharieq *et al*., 2020)**. Males generally have a larger b value than females, meaning they weigh more at the same size **(Wahyu *et al*., 2020)**.

The coefficient of determination (R^2) was 0.8947 for males and 0.8773 for females, indicating that 89.47 and 87.73% of carapace width variations in males and females, respectively, can be explained by weight, with the remaining variance due to other factors **(Setiawan *et al*., 2019)**. An R^2 value close to 1 suggests a strong correlation between carapace width and weight **(Nuringtyas *et al*., 2019)**. The regression model's standard deviation was 0.099 **(Ndiyae *et al*., 2015)**. The correlation coefficient (r) values were 0.944 for males and 0.927 for females, indicating a very close relationship between body length and weight **(Bidawi *et al*, 2017)**.

The analysis of growth parameters yielded asymptotic widths ($CW\infty$) of 161.18mm for males and 154.88mm for females. The K value for males was 1.3, with a theoretical age (t_0) of 0.076, while for females, the K value was 0.64, with a t_0 of 0.161. The K value indicates the growth rate, with values greater than 1 indicating faster growth for males and values less than 1 indicating slower growth for females, which indicates that BSCs take a long time to reach the asymptotic width **(Lubis *et al*., 2022)**. Furthermore, male BSCs grow faster than female BSCs. Differences in growth rates between male and female BSCs may be due to energy allocation for gonadal development in females **(Kembaren *et al*., 2012; Hamid *et al*., 2015)**.

The growth curve (Fig, 10) shows that both male and female BSCs experience rapid growth when young, which slows as they approach their maximum carapace width (asymptotic width). This pattern aligns with **Yesilyurt *et al*. (2022)**, who found that young BSCs grow quickly initially, with growth slowing in later phases. The growth rate (K) is related to species age and mortality, as species with high K values tend to have higher mortality rates and vice versa **(Beverton & Holt, 1959; Saputra, 2009)**.

Given these findings, it is clear that the current state of BSCs in Rembang waters necessitates careful management of fishing practices. Effective BSC management in Rembang can include establishing BSC apartments as breeding grounds, enhancing monitoring of BSC fishing activities, banning the use of mini trawl fishing gear, and managing waste to protect the aquatic environment.

CONCLUSION

Since 26.7% of captured BSCs in Rembang Waters exhibit a carapace width of less than 100mm (< 10cm), which does not comply with the catchable size. The size at first capture (Lc_{50}) for both male and female BSCs is nearly identical, measuring 104.1 and 104.6mm, respectively. The size at first maturity (Lm) in this study is 116.5mm. The Lm_{50} value is greater than the Lc_{50} value, indicating that the exploitation of BSC resources in Rembang waters. The peak of BSC spawning occurs in December and January. The growth pattern analysis revealed that male BSCs exhibit isometric growth, while female BSCs exhibit negative allometric growth. Furthermore, male BSCs grow faster than female BSCs. Given these findings, it is clear that the current state of BSCs in Rembang waters necessitates careful management of fishing practices. Effective BSC management in Rembang can include establishing BSC apartments as breeding grounds, enhancing monitoring of BSC fishing activities and considering to prohibit the use of mini trawl fishing gear.

REFERENCES

Afzaal, Z.; Kalhoro, M. A.; Budzar, M. A.; Nadeem, A.; Saeed, F.; Haroon, A. and Ahmed, I. (2016). Stock Assessment of Blue Swimming Crab *Portunus pelagicus* (Linnaeus, 1758) from Pakistani Waters (Nothern, Arabian Sea). Pakistan J. Zool., 48(5): 1531-1541.

Ameriyani, P. (2014). Development Planning for the Marine Fisheries Sub-Sector in Five Sub-Districts of Rembang Regency. Economics Development Analysis Journal., 3(1): 225-234.

Anam, A., Redjeki, S. and Hartati, R. (2018)**.** Carapace Width Size Distribution and Weight of Crab (*Portunus pelagicus*) in Betahwalang Waters Demak. Journal of Marine Research., 7(4): 239-247.

Anbarasu, M.; Nazar, A. K. A.; Tamilmani, G.; Sakthivel, M. and Jayasingh, M. (2021)**.** External Morphological Abnormalities Encountered in a Wild Population of *Portunus pelagicus* (Brachyura, Portunidae). Crustaceana., 94(7): 887-895.

Bidawi, B. M.; Desrita, D. and Yunasfi, Y. (2017). Lenght-Weight Relationships and Condition Factor of Mudskipper (Family: Gobiidae) at The Mangrove Ecosystem of The Sembilan Island Village of Langkat Regency, North Sumatera. Journal of Aquatic, Coastal and Fisheries Sciences., 6(3): 228-234.

Darusman, Y. M. (2018)**.** Influence of the 1982 Convention on the International Law of the Sea on Indonesia's Marine Territory. Cita Hukum Journal., 6(2): 343-360.

Ernawati, T.; Boer, M. and Yonvitner. (2014). Population Biology of Blue Swimming Crab (*Portunus pelagicus*) XSD in The Surrounding Waters of Pati Region, Central Java. BAWAL., 6(1): 31-40.

Hamid, A. and Wardianto, Y. (2015). Population Dynamics of The Blue Swimming Crab (*Portunus pelagicus*, Linnaeus 1758) in Lasongko Bay, Central Buton, Indonesia. AACL Bioflux., 8(5): 729-739.

Hamid, A.; Batu, D. T. F.; Riani, E. and Wardiatno. (2016). Reproductive Biology of Blue Swimming Crab (*Portunus pelagicus* Linnaeus, 1758) in Lasongko Bay, Southeast Sulawesi-Indonesia. AACL Bioflux., 5(9): 1053-1066.

Hermanto, D. T.; Sulistiono and Riani, E. (2019). Study on Some Reproductive Aspects of Blue Swimming Crab (*Portunus pelagicus*) in Mayangan Waters, Subang, West Java. Biospecies., 12(1): 1-10.

Kanedi, M. M.; Maulita, M. and Rahardjo, P. (2020). Biological Aspects of Crab (*Portunus pelagicus*) in Coastal East Lampung Regency, Lampung Province. Buletin JSJ., 2(1): 49-56.

Kembaren, D. D. and Surahman, A. (2018)**.** Size Structure and Population Biology of Blue Swimming Crabs (*Portunus pelagicus* Linnaeus, 1758) In The Waters of Kepulauan Aru. Indonesian Journal of Fisheries Research., 24(1): 51-60.

Khasanah, A. N.; Saputra, S. W. and Taufani, W. T. (2020)**.** Population Dynamic of Indian Scad (*Decapterus russelli*) Based on Data in Tasikagung Fishing Port of Rembang. *IOP Conference Series: Earth and Envirnmental Science*, 530 (1): 1-11.

Lubis, F. and Rahmi, M. M. (2022). Growth Parameters of Blue Swimming Crab (*Portunus pelagicus*) in Asahan Waters, North Sumatera. Jornal of Aceh Aquatic Science., 6(1): 1-10.

Maulana, I.; Irwani and Redjeki, S. (2021). Morphometric Study and Gonad Maturity Level of Blue Swimming Crabs in Betahwalang Waters, Demak. Journal of Marine Research., 10(2): 175-183.

Ningrum, V. P.; Ghofar, A. and Ain, C. (2015). Some Biological Aspects of Blue Swimming Crab (*Portunus pelagicus*) in Betahwalang Waters and its Surroundings. Journal of Fisheries Science and Technology., 11(1): 62-71.

Nuringtyas, A. E.; Larasati, A. P.; Septiyan, F.; Mulyana, I.; Israwati, W.; Mourniaty, A. Z. A.; Nainggolan, W.; Suharti R. and Jabbar M. A. (2019). Biological Aspects of Belanak Fish (*Mugil cephalus*) in Banten Bay. Buletin JSJ., 1(2): 81-77.

Panggabean, A. S.; Pane, A. R. P. and Hasanah, A. (2018). Population Dynamics and Utilization Rate of Blue Swimming Crab (*Portunus pelagicus* Linnaeus, 1758) in Jakarta Bay Waters. Indonesian Journal of Fisheries Research., 24(1): 73-85.

Pane, A. R. P.; Widiyastuti, H. and Suman, A. (2017). Population Parameters and Exploitation Rate of Blue Swimming Crab (*Portunus pelagicus*) In The Asahan Waters, Malacca Strait. BAWAL., 9(2): 93-102.

Philips, H. A.; Redjeki, S. and Sabdono A. (2022). Morphometric Analysis of Crab (*Portunus pelagicus*) in the Waters of Keboromo Village, Pati Regency, Central Java. Journal of Marine Research., 11(3): 429-436.

Putra, M. J. H.; Subagiyo and Nuraini, R. A. T. (2020). Biology of Blue Swimming Crab from Morphometric Aspects and Sex Ratio Landed in the Waters of Rembang. Journal of Marine Research., 9(1): 65-74.

Romimohtarto, K. and Juwana, S. (2005). Marine Biology: The Science of Marine Biota. Djambatan. Jakarta, 540 pp.

Sabrah, M. M.; El-Refaii, A. and Ali, T. G. (2020). Reproductive Characteristics of The Blue Swimming Crab, Portunus pelagicus (Decapoda, Brachyura: Portunidae) from The Bitter Lakes, Suez Canal, Egypt. African Journal of Biological Sciences., 16(1): 79-91.

Saputra, W. S. (2009). Research-Based Population Dynamics. Diponegoro University Publishing Agency. Semarang, 203 pp.

Saputra, W. S.; Ghofar, A.; Sholichin, A. and Taufani, W. T. (2021). Textbook of Fish Population Dynamics. Diponegoro University Publishing Agency. Semarang, 298 pp.

Saranga, R.; Siman, S.; Kalesaran, J. and Arifin, M. Z. (2019). Size at First Capture, Size at First Gonadal Maturity and Status of *Selar boops* in Bitung Waters. Journal of Fisheries and Marine Research., 3(1): 67.

Simanjuntak, S. D.; Yudiati, E. and Subagiyo. (2019). Sex Ratio and Gonadal Maturity Blue Swimming Crab (*Portunus pelagicus*) Linnaeus, 1758 (Malacostraca: Portunidae) Landed in Pacar Village, Rembang Regency. Journal of Marine Research., 9(1): 1-8.

Suman, A.; Irianto, H. E.; Satria, F. and Amri, K. (2016). Potential and Utilization Level of Fish Resources in the State Fisheries Management Area of the Republic of Indonesia (WPP NRI) in 2015 and Management Options. Indonesian Journal of Fisheries Policy., 8(2): 97-110.

Soukotta, I. V. T.; Moniharapon, L. D.; Rahman and Hakubun, R. D. (2022). Size at First Catch ($Lc_{50\%}$) and Length Weight Relationship of Skipjack (*Katsuwonus pelanis*) in the Banda Sea. Island Sea Journal., 1(2): 12-18.

Tharieq, M. A.; Sunaryo and Santoso, A. (2020). Morphometric Aspects and Gonadal Maturity Level of Blue Swimming Crab (*Portunus pelagicus*) Linnaeus, 1758 (Malacostraca: Portunidae) in Betahwalang Demak Waters. Journal of Marine Research., 9(1): 25-34.

Triyanti, R.; Zamroni, A.; Huda, H. M. and Wijaya, R. A. (2021). Fishermen's Perceptions and Attitudes Toward Sustainable Management of Blue Swimming Crab (*Portunus pelagicus*). Journal of Sosek KP., 16 (1): 121-139.

Wahyu, R.; Taufiq, N. and Redjeki, S. (2020). Relationship between Carapace Width and Weight of Blue Swimming Crab *Portunus pelagicus*, Linnaeus, 1758 (Malacostraca: Portunidae) in Sambiroto Waters, Pati, Central Java. Journal of Marine Research., 9(1): 18-24.

Yulianto, E.; Sanjaya, F. and Setiadi, T. (2020). Online Exam Application Development Using Token Access and Simple Random Sampling Algorithm. Pasunand Journal of Research in Mathematics Learning and Education., 5(2): 143-158.

Yesilyurt, I. N.; Tureli, C. and Gundogdu, S. (2022). Growth Parameters of The Invasive Blue Swimming Crab (*Portunus segnis* Forskal, 1775) (Crustacea) in The North-Easter Mediterranean, Turkiye. Aquatic Research., 5(4): 285-294.

Zairion, Y. Wardiatno; Fahrudin, A. and Boer, M. (2014). Spatial Temporal Distribution of Portunus Pelagicus (*Portunus pelagicus*) Breeding Population In Coastal Waters of East Lampung. BAWAL., 6(2): 95-102.