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The Reveal of Growth Pattern and Condition Factors of Blue Swimming Crabs (*Portunus pelagicus*) in Coastal-Estuary Ecosystem of Labuhanbatu Regency, North Sumatera

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ABSTRACT
The blue swimming crab, *Portunus pelagicus* as one of the potential crabs from Portunidae family that have high economic value in Labuhanbatu regency. This study aimed to reveal the information on condition factors and growth pattern of *P. pelagicus* population in the coastal -estuary ecosystem of Labuhanbatu regency. This study was conducted from November 2021 to January 2022, using the purposive random sample method in determining the sampling points. In collecting the samples of *P. pelagicus*, the sapling process used fish traps called *bubu* with fresh fish as bait. Results showed that the growth pattern of *P. pelagicus* was allometric negative, in which values for males and females were 1.15 and 2.27, respectively. Furthermore, the results of the correlation analysis between the physic-chemical of waters to abundance of *P. pelagicus* indicated that positive correlation for water temperature (0.835), dissolved oxygen (DO) (0.778), and salinity (0.726) had an effect on the presence of *P. pelagicus* population.

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1. INTRODUCTION

Indonesia is one of the crab-producing countries in Southeast Asia (Hargiyatno *et al.*, 2013). one species crab from the Portunidae family that found in Indonesia is swimming crabs (*Portunus pelagicus*) (WoRMS, 2022). This species is live in the mangrove ecosystem, in which this ecosystem has the main ecological (as species supported on food chain), and economic functions (as food source of human) (Kamal, 2011; Usman, 2022). *P. pelagicus* in Indonesia is popularly known as *rajungan*. The local people in the coast of Labuhanbatu Regency call it *renjong* (one of which is the Sei Berombang community). In Situbondo Regency, East Java, it is known as *kepiting terang bulan* (Dewi *et al.*, 2017). Furthermore, in the international market, it is called the swimming crab (Makahinda *et al.*, 2018).

Ihsan (2018) and Sunarto *et al.* (2010) informed that the swimming crabs (*P. pelagicus*) are the prima donna because their selling price can reach 200,000 IDR/kg in the Sei Berombang (personal communication with Mr. Harisman-2021). China is one of the potential markets for exporting the swimming crabs and other crabs from Indonesia. Concerning the nutritional content per 100 g, the meat of these crabs contains protein (16-17 g), carbohydrates (14.1 g), phosphorus (1.1 mg), calcium (210 mg), iron (200 SI), and vitamins A & B1 (0.05 mg) (Hadijah *et al.*, 2021). In addition, their shells also contain high minerals, chitin, cytosine, and carotenoids which are used as raw materials for making food, cosmetics, medicine, and others.

Related to their distribution, swimming crabs are spread in the Indo-West Pacific Ocean (the waters of China, Japan (Okinawa and Kyushu), and Indonesia), the Malacca Strait, the Indian Ocean, East & Southeast Asia (e.g., Singapore, the Philippines, Japan, Korea, China, and the Bay of Bengal), Turkey, Lebanon, Sicily, Syria, Cyprus, Australia, and the northern Antarctic region (Hadijah *et al.*, 2021), specifically the coastal waters or mangroves ecosystem. Ghufran (2012) and Sipayung *et al.* (2021) revealed that the mangrove ecosystem as the main litter producer that produces detritus and support to increase the nutrient water quality and crabs' population which become the key species whose functions as a mangrove litter decomposer. This information showed that the abundance of mangrove litter gets a positive value direction for crab abundance. According to Alberts-hubatsch *et al*. (2016), the distribution of crustaceans has random and clustered patterns. The most suitable habitats for them are the bottom of sandy and muddy waters and mangrove forests.

In the order of classification, the swimming crabs (*P. pelagicus*) belong to the aquatic organims of crustaceans in Portunidae family (Putri *et al*., 2021) from the *Malacostraea* class and the *Decapoda* order (Ernawati *et al*., 2014; Sahib, 2012). According to Setiyowati (2016), swimming crabs (*P. pelagicus*) are a hard-skinned biota that often undergoes moulting. Their morphology is characterized by 10 pieces (5 pairs) of legs: the first pair of legs have claws (cheliped) as a means of catching/holding food, the other four pairs of legs function as walking legs, and the last leg is fan-shaped (flat) as the paddle leg. These crabs have 9 thorns on the left and right eyes with the last thorn being the benchmark for the width of the carapace/shell. High market demand and economic value and minimum knowledge possessed by the local community about the regulations that have been set have caused the swimming crab (*P. pelagicus*) to become an overexploited capture fisheries commodity around coastal-estuary of Labuhanbatu regency. Pratiwi & Dimenta (2021) inform that waters condition affects to the *Scylla serrata* (Crab) population. It is feared that habitat destruction and high activity of catching will have an impact on the conditions and growth patterns of swimming crabs (*P. pelagicus*) in their natural environment around the Estuary-Coastal waters of Labuhanbatu regency. Based on this analysis, it is necessary to conduct a study to find out the growth patterns and condition factors currently experienced by swimming crabs (*P. pelagicus*) in Estuary-Coastal waters of Labuhanbatu regency North Sumatra Province

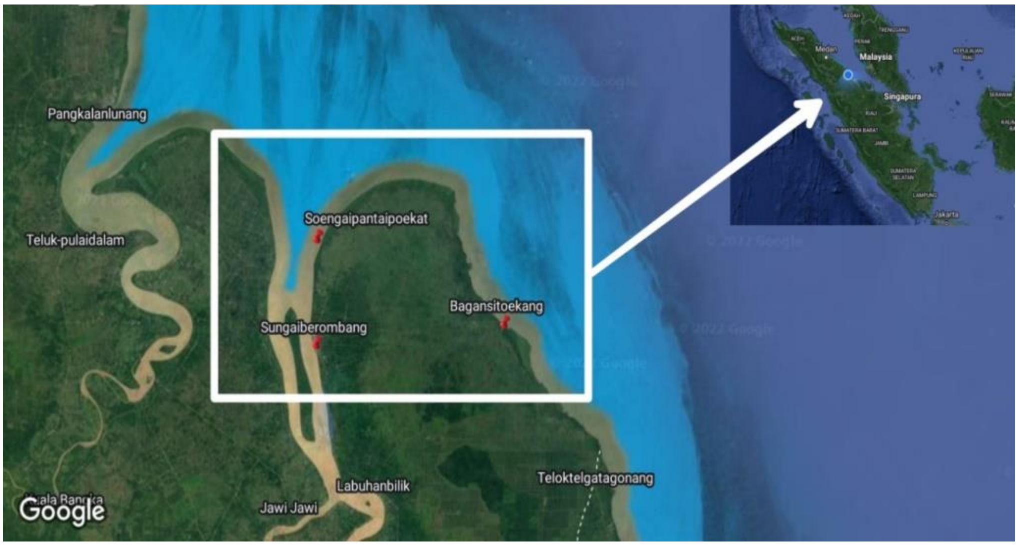

Figure 1. Research Locations

2. METHOD

Time and Place

This study was conducted in the mangrove forest area of Berombang estuary ecosystem, Panai Hilir district, Labuhan Batu regency. It was carried out for three months, starting from November 2021 to January 2022. In addition, the collection of the samples of blue swimming crabs (*P*. *pelagicus*) was performed at the three station points. These points were determined using the purposive random sampling method with 2 types of categories: natural zones and utilization zones. Detailed descriptions of the three station points are presented in the following,

Station	Location	Ordinate point	Description
1	Sei Berombang	2°35'33.43" N, 100°6'22.66" E	mangrove vegetation
2	Poekat	2°41'18.35" N, 100°8'15.67" E	The location around the mouth of Sei Berombang which widely used as a fishing location, and Nypa sp. as the vegetation
3	Bagan Sitoekang	2°35'43.61" N, 100°16'43.35" E	The location around found Nypa sp. & Mangrove vegetation

The tools used during the research process were digital scales with an accuracy of 0.1 grams, millimeter paper, caliper/ruler (30 cm), fishing gear for catching swimming crabs (in the form of *bubu*), glass jars, Styrofoam boxes, and stationery (i.e., books, pens, and markers). Meanwhile, the materials used were tissue, plastic bags, data books, and 70% alcohol to preserve the samples of swimming crabs (*P. pelagicus*).

Figure 2. Gears for Catching Swimming Crabs (*P. pelagicus*)

Research Procedure

The sampling process was carried out using a rectangular *bubu*. At each station, 30 units of *bubu* were distributed with three repetitions. The time of sampling was static or steady ("static" means the location of the *bubu* does not move) at high or low tide with the position of the trap against the movement of water currents. By following the habits of local fishermen in catching swimming crabs, the researchers used small fresh fish as bait because of being able to attract the attention of the crabs to enter the *bubu*. Sampling was carried out once a month with a sampling time that was adjusted to the activities of local fishermen.

The measurement of the swimming crabs (*P. pelagicus*) obtained from fishermen and collectors was conducted on the spot. It was to not reduce the weight content of the crab. In this process, the researchers measured carapace length (from anterior to posterior) and carapace width (between lateral spines on both left and right sides of the crab body) to the nearest millimeter. In addition, the measurement of crab body weight was also to the nearest gram. The collected data were used to determine the growth pattern of the carapace width-weight relationship and the condition factor of the swimming crabs (*P. pelagicus*).

Figure 3. Ventral Abdomen Morphology of Female (a) and Male (b) Swimming Crabs (*P. pelagicus*)

In identifying which one is male and female swimming crabs (*P. pelagicus*), we referred to the fact that the body of the male crab is larger with longer claws compared to the female crab which has a smaller body size and shorter claws. Another difference can also be seen in the color of the carapace or shell of the crab. As shown in the Figure 4, the male crab has a bluish carapace with white spots, while the female has a greenish carapace with slightly gloomy white spots (Dewi, 2015).

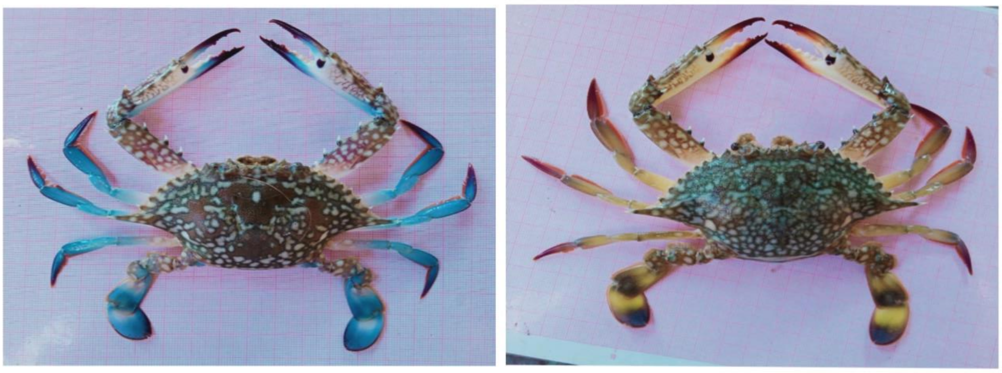

Figure 4. Dorsal Carapace Morphology of Female (Right) and Male (Left) Swimming Crabs (*P. pelagicus*)

Data Analysis

Growth Pattern

Analyzing growth of correlation width and weight aimed to determine the growth pattern of *P. pelagicus* in nature. To find the relationship between width and total weight, the researchers used a certain equation. The value of *b* was used to calculate the growth rate of the analyzed parameters. The hypotheses in this study were as follows. If the value of *b* equals 3, the growth pattern is isometric (the pattern of width growth is the same as the growth of weight). In addition, if the value of *b* is > 3, the growth pattern is positively allometric (weight growth is faster than width growth). Furthermore, if the value of *b* is < 3, the growth pattern is negatively allometric (width growth is faster than weight growth) (Mustofa *et al*., 2021). The formula employed in this study referred to Hargiyatno *et al.* (2013) and Yudha *et al.* (2015) who had conducted studies analyzing the length-weight relationship using the King equation (1995), as follows.

$$\mathbf{W = aL^{b} \text{ or } LnW = Lna + bLnL}$$

Where:
W = the average weight of the swimming crabs (gr); L = the average carapace width of the swimming crabs (cm); a = constant; b = exponential value between 2-5.

Condition Factors

The condition factors can be seen in the weight of *P. pelagicus* in numbers. Factor analysis for each sample was carried out using the relative weight (Wr) and condition factor coefficients. To calculate the relative weight (Wr), the researchers used the following equation.

$$\mathbf{Wr = W / Ws \times 100}$$

Where: Wr = relative weight gained; W = weight of each sample; Ws = predicted standard weight of the same sample because it is calculated from the combined length-weight regression through the distance between species.

For the factor analysis of the condition of the swimming crabs (*P. pelagicus*), the researchers employed the equation that had been used by Effendi (2002) and King (1995), as follows.

$$\mathbf{Kt = 100\ W / L^{3}}$$

Where:
Kt = condition factor; W = the average weight of the crab (gr); L = the average carapace width of the crab (cm); 3 = the length coefficient to ensure that the value of K tends to come near to the value of 1.

3. RESULTS AND DISCUSSION

Growth Patterns

The results of the analysis of the growth patterns of swimming crabs (*P. pelagicus*) in the waters of the Berombang river estuary were differentiated based on the sex ratio. The obtained *b* value of the relationship between length and weight of male swimming crabs (*P. pelagicus*) was 1.1552, while that of the female was 2.2727. These findings indicated that the growth pattern of female swimming crabs is greater than that of males. The relationship between the length and weight of the male swimming crabs (*P. pelagicus*) can be seen in Figure 4, while that of females can be seen in Figure 5.e

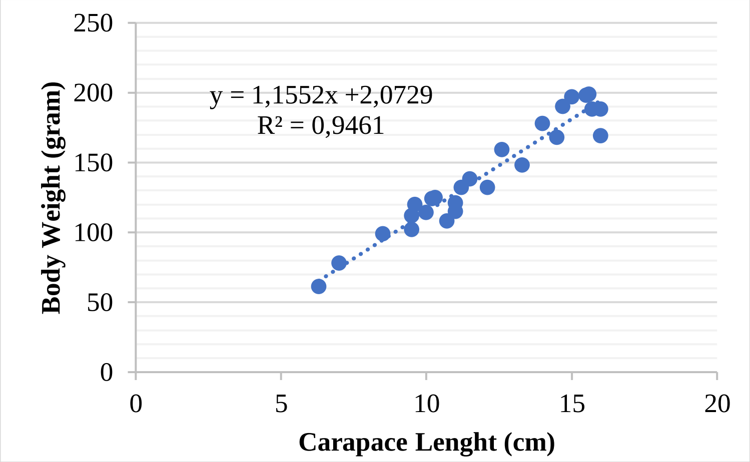

Figure 5. The relationship between the length and weight of the male swimming crabs (*Portunuspelagicus*)

The analysis of male swimming crabs (*P. pelagicus*) showed that the *b* value was < 3 (i.e., 1.1552), meaning that the growth pattern was negatively allometric. Similarly, the results of the analysis of female swimming crabs (*P. pelagicus*) presented that the *b* value was < 3 (i.e., 2.2727), concluding that the growth pattern is negatively allometric. In other words, from the results of this study, the *b* value in swimming crabs (*P. pelagicus*) in the waters of the Berombang river estuary indicated that, at these three stations, the constant value of male and female swimming crabs (*P. pelagicus*) had the same value, namely b < 3 (negatively allometric growth pattern). For this reason, it can be stated that the growth of carapace width in swimming crabs (*P. pelagicus*) is faster than the growth in weight of the crabs.

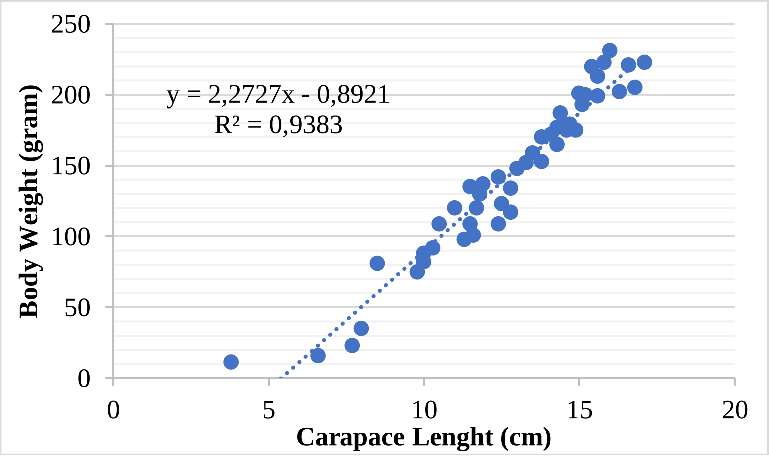

Figure 6. Relationship between the length and weight of the female swimming crabs (*Portunuspelagicus*)

According to (mustofa *et al.*, 2021), the growth pattern of males and females that are negatively allometric (b > 3) means that the growth of carapace width is faster than weight growth. This is in line with the results of studies conducted by Edi *et al*. (2018), Chandra *et al*. (2015), and Hidayah *et al*. (2019) who found that the growth rate in the waters of TelukAur is L∞ = 8.61 cm with K = 0.6/year and t = 0-0.08. In addition, Mustofa *et al*. (2021) also found that a total of *b* value in the waters of Tunggulsari, Rembang was 2.8575, which was negatively allometric. A study conducted by Wibowo *et al*. (2019) revealed that growth parameters in the waters of Rembang, Central Java indicated that male and female swimming crabs had *b* values of 2.438 and 2.209, respectively. Furthermore, a study by Widianingsih *et al*. (2019) presented that significant food availability had an effect on the low quality of the environmental carrying capacity of the abundance of swimming crabs (*P. pelagicus*). Dewi *et al*. (2017) added that the factors that influence the abundance of *P. pelagicus* are temperature and tides with a *p*-value of < 0.05.

Biological Parameter and Conditional Factors (Fulton)

The results of this study indicated that the condition factor of the three sampling stations of the swimming crabs (*P. pelagicus*) showed that the value of the relative weight (Wr) for the male crabs was 86.43-110.72 with an average of 100.25 ± 10.37, while that of females was 54.89-152.63 with an average of 101.0 ± 2.46. Meanwhile, the values of the Fulton condition factor (K) in the waters of the Berombang river estuary at 3 station points were

4.06-24.93 for male swimming crabs with an average of 12.94 ± 0.54 and 3.62-15.84 for females with an average of 11.92 ± 0.67. In general, there is no significant difference between the observed swimming crab condition factors at three different station points (not much different). Therefore, based on the value of these condition factors, it can be stated that *P. pelagicus* had the same level of body weight. The values of the Fulton condition factor (K) and the range of relative condition factor (Wr) at three station points can be seen in detail in Table 1.

Table 1. Biological Parameters Observed in Swimming Crabs (*P. pelagicus*)

Parameters	Male (n = 81)	Average	Female (n = 174)	Average
Carapace Width (cm)	6.30 – 16.34	11.97 ± 2.19	7.70 – 17.10	13.12 ± 1.25
Measured Crab Weight (W) (grams)	61.27 – 199.57	140.88 ± 11.12	23.35 – 231.20	149.63±10.13
Predicted Weight (Ws) (grams)	66.62 – 195.54	140.58 ± 3.55	42.39 – 259.89	149.05 ± 3.17
Relative Weight (Wr)	86.43 – 110.72	100.25 ± 10.37	54.89 – 152.63	101.95 ± 2.46
Fulton Condition Factor (K)	4.06 – 24.93	12.94 ± 0.54	3.62 – 15.84	11.92 ± 0.67
Coefficient of Determination (r^2)	0.9461	-	0.9383	-
Value of *b*	1.1552	-	2.2727	-

The results of the condition factor analysis indicated that the condition factors of the swimming crabs (*P. pelagicus*) studied at three station points, in general, belonged to the low category and were not much different from one another. Therefore, it can be concluded that the value of the Fulton (K) condition factor in the Berombang river estuary, Labuhanbatu Regency, is still relatively low. This is supported by the finding of Nurdin & Haser (2018) that condition factors in the mangrove ecosystem showed a greater level of *P. pelagicus* abundance. It refers to the value of the Fulton condition factor, in which if K is > 100, then the population condition in the waters is in a good category. However, if K is < 100, it means that the population condition in the waters is in a bad category (Napisah & Machrizal, 2021). In addition, Kembaren*et al*. (2012) stated that if the swimming crabs (*P. pelagicus*) had the K value of > 1, it means that the crabs had a short lifespan with a high risk of death.

The Correlation Analysis of Physical-Chemical Properties of Waters on the Abundance of *P. pelagicus*

Pearson's correlation analysis is a statistical test that examines the relationship between the chemical & physical properties of the waters and the abundance values. In this study, the researchers applied this analysis in a computerized method using SPSS v. 22. Moreover, the set interval index values were 0.80-1.00 (very strong), 0.60-0.799 (strong), 0.40-0.599 (moderate), 0.20-0.399 (low), and 0.0-0.199 (very low). Furthermore, the measured water quality parameters were pH, salinity, temperature, and dissolved oxygen (DO). Measurement of the chemical and physical parameters of water from the Berombang river estuary was carried out at the Laboratory of the Faculty of Teacher Training and Education, Labuhanbatu University. It was conducted three times a month. The results of the correlation analysis of the relationship between chemical & physical factors and the abundance of *P. pelagicus*in the Berombang river estuary can be seen in Table 2.

The results of the correlation analysis presented that the temperature (one of the physical parameters) got the highest correlation value, meaning that it is the most influential factor in the abundance of swimming crabs (*P. pelagicus*) in the waters of the Berombang river estuary, Labuhanbatu Regency, with a value reaching 0.835. Meanwhile, in the chemical parameters, dissolved oxygen (DO) had the highest correlation value reaching 0.778, followed by salinity (0.726) and pH (0.368). For this reason, it can be concluded that the value of the physical-chemical properties in the waters of the Berombang river estuary is in the strong category with a positive value. This indicates an increase in the abundance of swimming crabs (*P. pelagicus*). From the results of the analysis, it can be concluded that water temperature is the most influential factor in the abundance of swimming crabs in the waters of the Berombang river estuary, Labuhanbatu Regency, North Sumatra, Indonesia.

Table 2. Results of Correlation (Pearson) between Environmental Parameters and Abundance of *P. pelagicus*

No.	Parameters	r^2
Physics		
1	Water Temperature	0.835
2	Water Brightness	0.529
Chemicals		
3	DO	0.778
4	pH	0.368
5	Salinity	0.726
6	Nitrate	0.529
7	Phosphate	0.531

Apart from that, the value for the dissolved oxygen (DO) in the waters of the Berombang river was 0.778. The content of dissolved oxygen in the water is an important requirement that must be met in order to meet the needs of fish and invertebrates in the waters. Dissolved oxygen is influenced by other factors, such as organic matter, pH, temperature, and salinity (Nikhlani & Sukarti, 2017).BA study conducted by Talpur (2012) showed that oxygen levels of less than 0.5 mg/L in the water were not sufficient for the larvae of swimming crabs and could cause death. Wilson (2011), Verberk *et al*. (2016), and Pedapoli & Ramudu (2014) stated that the oxygen content of 1-3 mg/L generally makes the activity of biota minimum. They added that if it is too low, it will be harmful to aquatic organisms. The recommended concentration is more than 3 mg/L. Susana (1988) and Agus (2015) said that the dissolved oxygen contained in the waters is usually used by plants for the photosynthesis process and marine animals for the formation of shells/molting.

In this study, the temperature in the waters of the Berombang river reached 0.835. Temperature plays a role in determining the location of organisms in the sea. An increase in temperature can have an impact on increasing the metabolic rate of aquatic biota. Temperature can also affect the diversity of swimming crab growth sizes (Mainassy, 2017). According to Castro & Huber (2016), optimum temperature stability at each stage of life can affect the success rate of swimming crab life. Furthermore, according to Ikhwanuddin *et al*. (2012), the optimum temperature for swimming crabs is 28-30°C. Additionally, according to Santoso *et al*. (2016) and Zaidin *et al*. (2013), the temperature of 28-29°C is still suitable for swimming crab life and may affect the diversity of organisms, the gas solubility in water, and swimming crab metabolism processes. Juwana (1997) and Castro & Huber (2016) explained that high temperatures can cause expeditions to occur more quickly and extreme temperature changes can interfere with swimming crab growth.

Based on the results of this study, the salinity in the waters of the Berombang river is 0.726 and the river is more dominated by female swimming crabs. Mangrove forests which are in the transition of fresh water and salt water are related to salinity (salt content) caused by the tides and sedimentation from the sea and rivers. The crustacean group generally can withstand high or low salt levels (Sipayung & Poedjirahajoe, 2021). According to Chande & Mgaya (2004), small swimming crabs have a salinity tolerance of 9-39%. Furthermore, according to Adam *et al*. (2016), the area with low salinity is dominantly inhabited by male swimming crabs. Conversely, the area with high salinity is dominantly inhabited by female swimming crabs for spawning.

The obtained pH correlation in the waters of the Berombang river is 0.368. According to the Decree of Indonesia's Ministry of Environment (2004), a good water pH for marine biota is 7-85. The pH value is related to oxygen levels. If the pH is low, the oxygen and alkalinity values are high and the carbon dioxide values are low (Mustofa *et al.*, 2021). The low pH value is caused by its location which is close to river mouths or estuaries. Aquatic organisms have different abilities to tolerate the pH of water. The condition that determines high or low pH varies, depending on several factors, such as the concentration of gases in carbonates and bicarbonates, the decomposition process of organic matter at the bottom of the water, and others. Some biotas are sensitive to changes in the pH of water. However, swimming crabs are not too affected by pH because DO is a very important component for swimming crab survival and growth (Safirti *et al.*, 2021; Pescod, 1973). Arief (2003) said that the pH of the soil in the mangrove area is one of the factors that influence the presence of macrozoobenthos. This is in line with a study conducted by Dimenta*et al*. (2020) that the dissolved oxygen (DO) and water pH in the Berombang river waters affect the distribution and abundance of macrozoobenthos which is classified as having a strong correlation with the dissolved oxygen (0.776) and pH (0.656). Apart from that, Syam *et al*. (2021) found a pH correlation with a very low value (0.179). Sipayung & Poedjirahajoe (2021) said that the crustacean group dominates macrozoobenthos species both in rivers and beaches.

According to Santoso*et al*. (2016), a good correlation value of water for the survival of the swimming crabs (*P. pelagicus*) is water quality at a temperature of 29-30°C, water salinity of 31-32 ppt, and pH level of 7.2-7.5. The results of a study conducted by Radifa *et al*. (2020) regarding the distribution pattern of swimming crabs in the coastal waters of East Lampung showed that the population of swimming crabs will increase from the coast to the offshore with temperatures ranging from 280 to 310°C. A study by Putri *et al*. (2021) revealed that salinity conditions in Batu Ampar waters ranged from 27 to 28%. It was in a low category but still good for the growth of juvenile swimming crabs, which was influenced by the entry of fresh water from several surrounding rivers due to tidal activity.

4. CONCLUSION

The values of the relative weight condition factor (Wr) in the waters of the Berombang river estuary, Labuhanbatu regency were 86.43-110.72 with an average of 100.25 ± 10.37 for male swimming crabs (*Portunus pelagicus*) and 54.89-152.63 with an average of 101.0 ± 2.46 for its female counterparts. Meanwhile, the values of the Fulton condition factor (K) were 4.06-24.93 with an average of 12.94 ± 0.54 for males and 3.62-15.84 with an average of 11.92 ± 0.67 for females. The growth pattern of male and female swimming crabs (*Portunus pelagicus*) was negatively allometric (b< 3), meaning that the carapace growth was faster than the weight growth of swimming crabs. In addition, the value for the physical-chemical parameters in waters of the Berombang river estuary is in the strong category with a positive value, as seen from the values of water temperature (0.835), dissolved oxygen (DO) (0.778), salinity (0.726), and pH (0.368). the result informs that the enviromental factor in Berombang river still suitable for *P. pelagicus* life.

5. ACKNOWLEDGMENT

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