

## THE POPULATION BIOLOGY OF BLUE SWIMMING CRAB *Portunus pelagicus* (Linnaeus, 1758) DURING OVERFISHING CONDITIONS IN EAST LAMPUNG WATERS

### Biologi Populasi Rajungan *Portunus pelagicus* (Linnaeus, 1758) Saat Kondisi Tangkap Lebih di Perairan Lampung Timur

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#### ABSTRACT

Blue swimming crab (BSC) is one of Lampung's main export fisheries commodities. The catch of BSC by fishermen in East Lampung waters is becoming more intensive and increasing from year to year, so it is a concern that it will threaten the sustainability of the stock. This research aimed to analyze the biology of several populations of BSC in East Lampung waters during overfishing conditions. Population biology data on BSC analyzed included growth rate, size at first caught, recruitment patterns, sex ratio, fishing mortality, exploitation level, and a potential spawning ratio. The analyzed data originated from BSC caught by crab net fishermen in East Lampung landed at TPI Kuala Penet and TPI Muara Gading Mas for 1 year (August 2019-June 2020), totaling 35,322 samples consisting of 20,586 males and 14,736 females. The research showed that the level of crab utilization had an E value of 0.71 per year. In these overfishing conditions, it was known that the growth of crabs in these waters was following the equation of  $CW_t = 191,6x[1 - e^{-130(t - (-0,073))}]$ . The carapace width of BSC caught for the first time ( $L_c$ ) was 119 mm (male) and 123 mm (female) with a sex ratio (M: F) that varied every month between 1:1 and 2:1. Recruitment occurred throughout the year. The SPR was slightly under 20% indicating that overfished conditions had caused the potential for the crab to spawn in an unsustainable condition.

**Keywords:** BSC, Overfishing, Population Biology

#### ABSTRAK

Rajungan merupakan salah satu sumber daya perikanan yang menjadi komoditas ekspor utama Provinsi Lampung, terutama ke Amerika Serikat. Penangkapan rajungan oleh nelayan di perairan Lampung Timur dari tahun ke tahun semakin intensif dan meningkat sehingga dikhawatirkan mengancam kelestarian stok. Penelitian ini bertujuan untuk menganalisis beberapa karakteristik biologi populasi rajungan di perairan Lampung Timur pada saat kondisi

tangkap lebih (*overfishing*). Data biologi populasi rajungan yang dianalisis meliputi laju pertumbuhan, ukuran rajungan pertama kali ditangkap, pola rekrutmen, rasio jenis kelamin, mortalitas akibat penangkapan dan tingkat eksploitasi, serta rasio potensi pemijahan. Data yang digunakan meliputi data rajungan hasil tangkapan nelayan jaring rajungan di Lampung Timur yang didaratkan di TPI Kuala Penet dan TPI Muara Gading Mas selama 1 tahun (Agustus 2019-Juni 2020) sebanyak 35.322 sampel yang terdiri dari 20.586 jantan dan 14.736 betina. Hasil penelitian menunjukkan bahwa tingkat pemanfaatan rajungan diduga sudah melebihi MSY dengan nilai E sebesar 0,71 per tahun. Pada kondisi tangkap lebih tersebut diketahui bahwa pertumbuhan rajungan di perairan tersebut mengikuti persamaan  $CW_t = 191,6x[1 - e^{-130(t - (-0,073))}]$ . Ukuran lebar karapas rajungan jantan yang ditangkap pertama kali ( $L_c$ ) adalah 119 mm dan rajungan betina 123 mm dengan rasio kelamin (J:B) yang bervariasi setiap bulan antara 1:1 hingga 2:1. Rekrutmen terjadi sepanjang tahun dengan satu musim puncak dan rasio potensi pemijahan (SPR) sebesar 19% yang mengindikasikan bahwa tingkat pemanfaatan rajungan yang berlebih (*overfishing*) tersebut telah menyebabkan potensi pemijahan rajungan dalam kondisi yang tidak berkelanjutan.

**Kata Kunci:** Biologi Populasi, Rajungan, Tangkap Lebih

## INTRODUCTION

The swimming crab (*Portunus pelagicus*) is an important commercial fishery commodity in Indonesia (Hutajulu *et al.*, 2019; Ihsan *et al.*, 2020; Yudha *et al.*, 2023) and is one of Indonesia's main export commodities sent to various continents, such as Asia, Europe, America, Africa, and Australia (Nugroho *et al.*, 2023) with the export volume of crabs and swimming crabs in 2023 reaching 29,371 tons and equivalent to 447.7 million USD. Swimming crab producers are spread across several provinces in Indonesia, one of which is Lampung Province. Swimming crabs are one of Lampung's leading export commodities in 2020 with a catch of 1,482.84 tons or worth IDR 353.02 billion (BKIPM Lampung, 2021) and swimming crab fishing is the main source of livelihood for fishing communities in the eastern coastal areas of Lampung Province (Cendrakasih *et al.*, 2023). Fishing for crabs by fishermen from East Lampung takes place in the Indonesian Marine Fisheries Authority (WPPNRI) 712, which encompasses the coastal waters of East Lampung, part of the Java Sea. WPPNRI 712 is a highly productive fishing area with the largest fleet among other WPPNRI, accounting for 40% of total national production (KKP, 2019).

The east coast of Lampung Province is among the top five producers of crabs in Indonesia (Hidayani 2018; Tirtadanu & Chodrijah 2019; Yudha *et al.*, 2023), making crab fishing a primary livelihood for these fishermen. Fishing efforts generate significant multiplier effects. The production and trade of *P. pelagicus* are economically, socially, and environmentally significant for the lives of many fishermen and the community (Cendrakasih *et al.*, 2022). Household income on the east coast of Lampung Province, particularly in Muara Gading Mas Village and Kuala Seputih Village, comes from capture fisheries, as the majority of the population in these villages works as fishermen.

The fishing gear used by East Lampung fishermen to catch blue swimming crabs is bottom gillnets and folding traps (Nugroho *et al.*, 2023; Yudha *et al.*, 2023). Pane *et al.* (2017) stated that the capture of juvenile blue swimming crabs can be prevented by using sufficiently large mesh sizes. The mesh size is considered a measure of the gear's selectivity, allowing juvenile blue swimming crabs to escape capture. The use of appropriate mesh sizes also affects the first catch size ( $L_{c50}$ ). A larger first catch size indicates that the captured blue swimming crabs have spawned at least once in their lifetime.

Furthermore, Zairion *et al.*, (2014) reported that crab exploitation on the coast of East Lampung occurs in almost all habitats and continues year-round. According to Wardiatno &

Zairion (2011), East Lampung crab production has tended to increase in the last decade, but there has been a decline in catch per trip and smaller crab sizes in recent years. This is suspected to be due to overfishing and declining stock productivity, which can disrupt the sustainability of the crab fishery (Zairion *et al.*, 2014).

The sustainability of crab stocks can be threatened if fishing controls are not implemented. Crab stock control can be achieved through a series of complex research stages, including studies of crab population biology, fishing rates, and the relationship between the two. The stock assessment conducted in this study involved estimating the spawning potential ratio (SPR) based on carapace width, which explains the decline in the SPR (spawning potential ratio) from 100% to X% due to fishing mortality (Brooks *et al.*, 2010). The SPR analytical model is generally used to analyze limited fisheries data.

In sustainable crab management, Lampung Province has three pilot management locations, one of which is in East Lampung Regency. The crabs caught by fishermen are landed at two fish landing sites (TPI): Kuala Penet TPI in Margasari Village and Muara Gading Mas TPI in Muara Gading Mas Village. High crab production is expected to result in a declining trend in individual size. Crab fishing not only affects individual size but also the stock status in the waters. Catches per unit of effort will decrease if the fleet used to capture the resource increases. Therefore, stakeholder commitment is needed to support the sustainability of crab resources related to food security and fisherman welfare. This study aims to assess the stock status of crabs in the waters based on carapace width to support sustainable crab management.

## METHODS

This research was conducted in the coastal waters of East Lampung, using data from crab catches landed at two fish landing sites: the Kuala Penet Fish Farm (Margasari Village) and the Muara Gading Mas Fish Farm (Muara Gading Mas Village), both located in Labuhan Maringgai District, East Lampung. Data collected over a one-year period (August 2019-June 2020) included 35,322 crab samples, consisting of 20,586 male and 14,736 female crabs. The collected crab biological data included weight, carapace width, and sex.

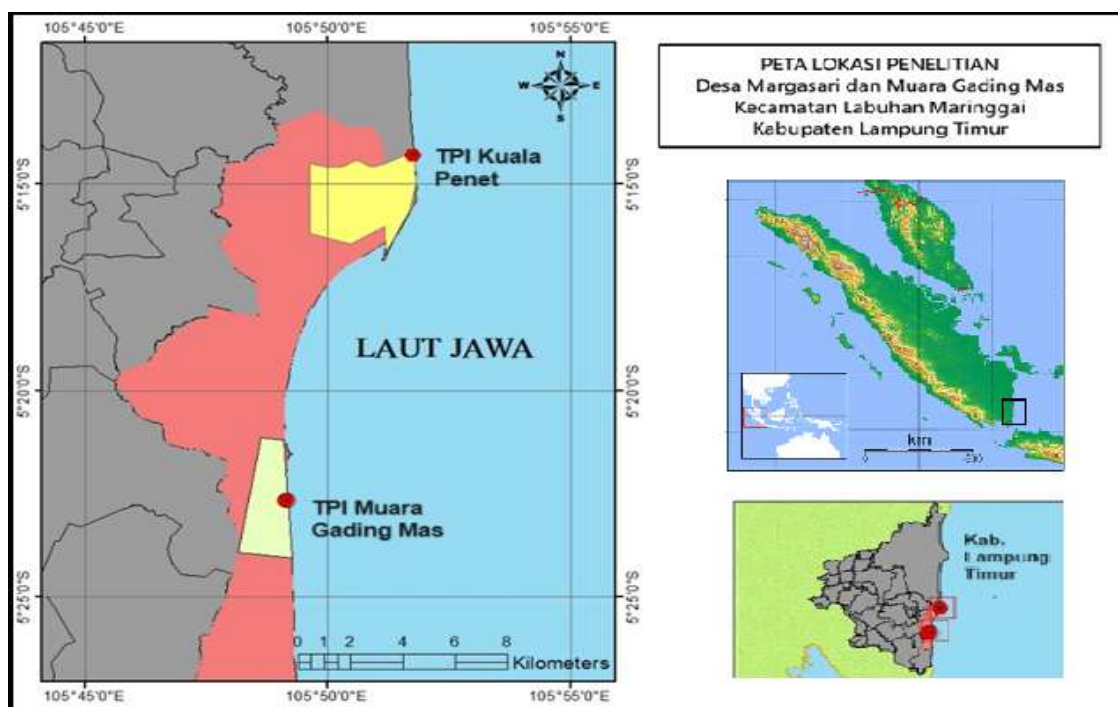


Figure 1. Research Location

The level of crab utilization was analyzed based on fishing mortality compared to total mortality, where total mortality includes both fishing mortality and natural mortality. The natural mortality rate can be estimated using the following equation (Pauly *et al.*, 1984):

$$\text{Log}(M) = -0.0066 - 0.279 \log(L_{\infty}) + 0.6543 \log(K) + 0.4634 \log(T)$$

Where:

- M = natural mortality
- K = growth coefficient
- T = average sea surface temperature.

The fishing mortality rate and exploitation rate were then analyzed using the following equations from Sparre & Venema (1992):

$$F = Z - M \text{ and } E = \frac{F}{Z}$$

Where:

- F = Fishing mortality
- Z = Total mortality
- M = Natural mortality
- E = exploitation rate.

The growth rate is calculated using the Von Bertalanffy equation as follows:

$$L_t = L_{\infty} \times [1 - e^{-Kt(t-t_0)}]$$

Where:

- $L_t$  = crab carapace width at age  $t$  (mm)
- $L_{\infty}$  = crab asymptotic carapace width (mm)
- K = growth rate
- $t_0$  = hypothetical age when carapace width = 0

The theoretical age of the crab when carapace width = 0 is estimated using the empirical equation by Pauly (1984) as follows:

$$\text{Log}(-t_0) = 0.3922 - 0.2575 (\log L_{\infty}) - 1.038 (\log K)$$

The size of the crab ( $L_c$ ) first captured was analyzed using the equation according to Boutson *et al.*, (2009) as follows:

$$SL_c = \frac{\exp(a+bL)}{1+\exp(a+bL)}$$

Where:

- $SL_c$  = size of crab first caught
- $\exp(a+bL)$  = crab with carapace width  $L$  caught
- $a$  and  $b$  = selectivity curve parameters ( $a < 0$  and  $b > 0$ )

The estimated spawning potential ratio was analyzed using the Barefoot Ecologist Toolbox on the web using the built-in model in R with the equation (Prince *et al.*, 2014):

$$SPR_t = \frac{\sum_{t=0}^t EP_t}{\sum_{t=0}^{t_{max}} EP_t} \text{ and } EP_t = (N_{t-1}^e - M)f_t$$

Where:

- SPR<sub>t</sub> = proportion of reproductive potential at age t
- EP<sub>t</sub> = reproductive output at age t
- N<sub>t</sub> = number of individuals at age t with N<sub>0</sub> = 1,000
- M = natural mortality
- f<sub>t</sub> = average fecundity

## RESULTS

### Exploitation Rate

The analysis revealed that the annual crab mortality rate due to fishing (F) was 3.20, while the natural mortality rate was 1.31 (Table 1). An exploitation rate of 0.71 indicates that crab exploitation in East Lampung waters is excessive (overfishing), as the E value is greater than 0.5 (Sparre & Venema, 1999).

Table 1. Crab Mortality and Exploitation Rates in East Lampung Waters

Z (per year)	M (per year)	F (per year)	E (per year)
4.50	1.31	3.20	0.71

Note: Z = total mortality, M = natural mortality, F = fishing mortality, E = exploitation rate

### Abundance

The crab catch in the coastal waters of East Lampung fluctuates. Crab abundance increases from August to December, then decreases in January. Subsequently, crab abundance increases from January to April, then decreases until July. The highest crab abundance occurs in April, while the lowest occurs in August (Figure 2). Crab abundance throughout the year is dominated by the capture of male crabs.

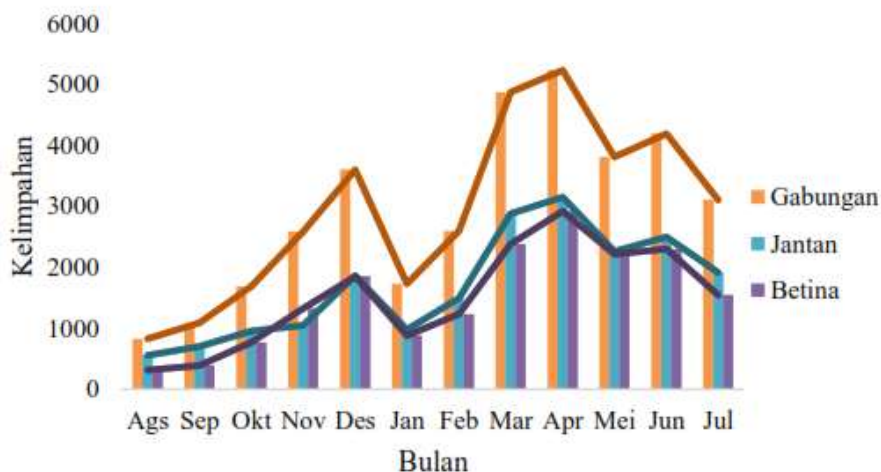


Figure 2. Fluctuations in Crab Abundance Caught by Fishermen on the Coast of East Lampung

### Carapace Width Distribution

The distribution of crab carapace width in the coastal waters of East Lampung is divided into 10 carapace width classes, with the highest frequency in the 120-129 mm class (Figure 3). The most common crab caught in the coastal waters of East Lampung during peak fishing conditions is a carapace width exceeding 100 mm, as stipulated in Article 4 of the Minister of Maritime Affairs and Fisheries Decree No. 56 of 2016. It is estimated that no more than 10% of crabs caught have carapace widths less than 100 mm. This variation in carapace width is thought to be due to differences in crab fishing areas. Adult crabs typically inhabit deeper waters, while smaller crabs are found in shallower waters (Panggabean *et al.*, 2018). Therefore, fishing in shallower areas will result in smaller crabs.

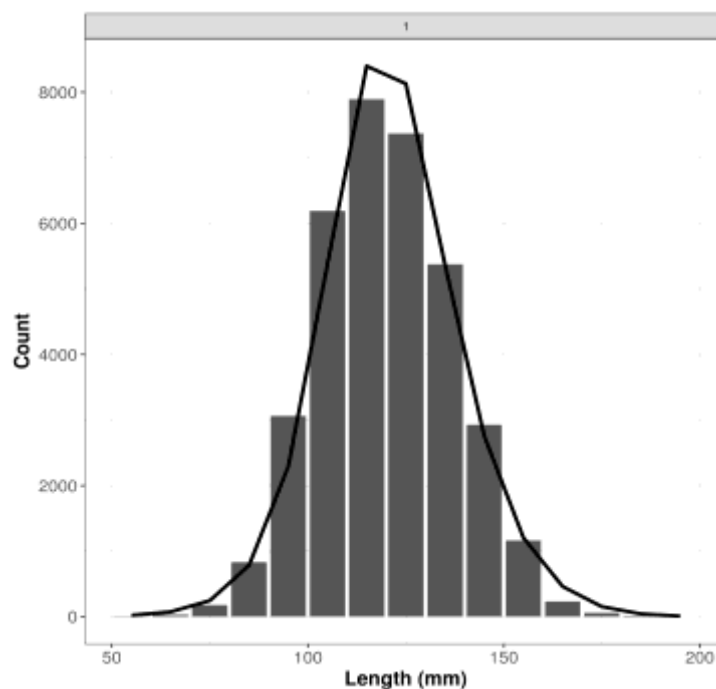


Figure 3. Distribution of Carapace Width of Swimming Crabs Caught During Overfishing Conditions in East Lampung Waters

The distribution of carapace width in this study is not significantly different from the study by Zairion (2014), which stated that the average carapace width of swimming crabs caught by fishermen in East Lampung waters was  $121.27 \pm 18.85$  mm. According to Zairion (2014), the average carapace width increases with depth, with the average carapace width at depths below 5 m being  $108.57 \pm 13.39$  mm; at depths of 5-10 m being  $127.51 \pm 13.85$  mm; and at depths above 10 m being  $145.54 \pm 12.57$  mm. In line with this study, most of the blue swimming crabs studied in this research had carapace widths between 120-129 mm, which were likely caught by blue swimming crab net fishermen operating at depths of 5-10 m.

### Von Bertalanffy Growth Parameters

The results of the von Bertalanffy growth parameter analysis in the coastal waters of East Lampung indicate that the maximum carapace width of blue swimming crabs is 191.6 mm. Based on the analysis, blue swimming crabs require approximately 8 to 9 months to reach their maximum carapace width (Table 2).

Table 2. Blue Swimming Crab Growth Parameters Under Overfishing Conditions in East Lampung Waters

$CW_{\infty}$ (mm)	K (year)	$t_0$ (year)	$t_{maks}$ (year)	Persamaan van Bertalanffy
191.6	1.30	-0.0727	0.74	$CW_t = 191.6 \times [1 - e^{-130(t - (-0.073))}]$

Note:  $CW_{\infty}$  = Theoretical maximum carapace width; K = growth coefficient,  $t_0$  = theoretical age at zero carapace width;  $t_{max}$  = age at maximum carapace width ( $CW_{max}$ )

### Sex Ratio

Under overfishing conditions, the sex ratio of male and female crabs in East Lampung waters varies monthly, with males exceeding females, particularly during August-September, when the proportion can double. According to Zairion (2015), variations in the number of individuals and total catch can affect the sex ratio. This theory states that if males outnumber females, competition between males for females will occur. Males can mate more than once during a single breeding season. Males can prevent each other from releasing sperm to regulate fertilization rates (Jivoff, 1997).

Table 3. Sex Ratio of Crabs in East Lampung Waters Under Overfishing Conditions

Month/Year	Number of Crabs		F:M Ratio
	Female	Male	
August 2019	268	559	1:2.1
September 2019	386	700	1:1.8
October 2019	733	954	1:1.3
November 2019	1,254	1,332	1:1.1
December 2019	1,740	1,865	1:1.1
January 2020	752	976	1:1.3
February 2020	1,103	1,491	1:1.4
March 2020	1,991	2,881	1:1.4
April 2020	2,080	3,151	1:1.5
May 2020	1,545	2,264	1:1.5
June 2020	1,692	2,500	1:1.5
July 2020	1,192	1,913	1:1.6

### The Relationship between $L_c$ and $L_m$

A situation where the proportion of first-catch size is smaller than the initial gonadal maturity size can threaten the sustainability of blue swimming crab stocks. The first-catch size must be greater than or equal to the first gonadal maturity size for blue swimming crab stocks to be sustainable (Ningrum *et al.*, 2015). Research results show that blue swimming crabs caught in East Lampung waters during overfishing conditions had a larger proportion of first-catch size ( $L_c$ ) compared to the first gonadal maturity size ( $L_m$ ) (Figure 4). This indicates that stock conditions are still good when blue swimming crabs larger than the first gonadal maturity size ( $L_m$ ) are considered mature and exploitable. Therefore, blue swimming crab fishing in the overfished coastal waters of East Lampung is thought to still provide opportunities for blue swimming crabs to reproduce and restore stocks.

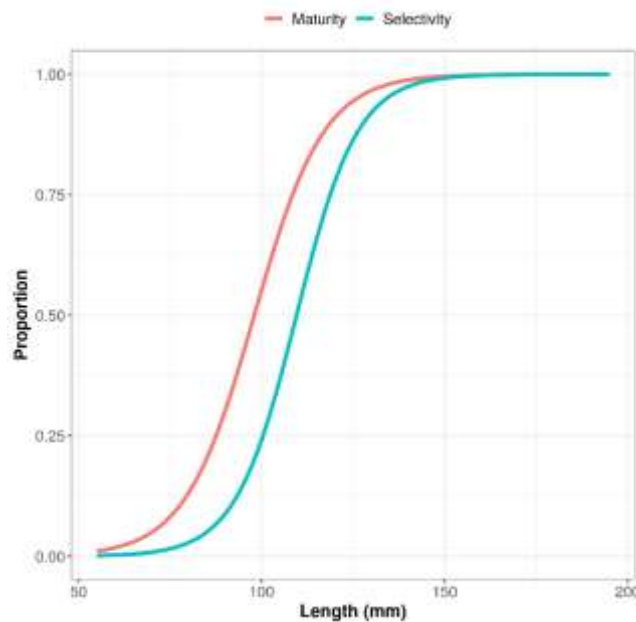


Figure 4. Comparison of Lc and Lm Based on SPR Analysis

### Recruitment Patterns

The peak recruitment season for blue swimming crabs in the coastal waters of East Lampung is estimated to occur throughout the year. Peak recruitment seasons occurred in May 2020 (without sex differentiation), July 2020 (male blue swimming crabs), and May 2020 (female blue swimming crabs). A single peak spawning season indicates that there is only one age group or cohort in the blue swimming crab stock (Figure 5).

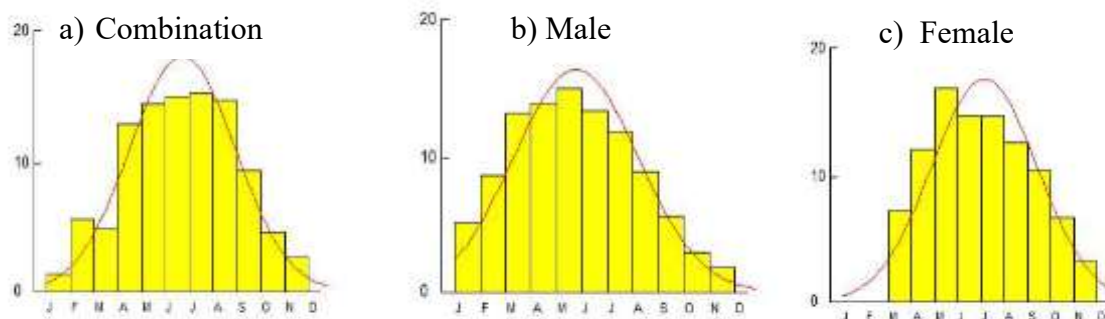


Figure 5. Blue Swimming Crab Recruitment Patterns in East Lampung Waters During Overfishing Conditions

Several factors influence recruitment, including the proportion of male and female broodstock, growth rate, predation, disease, fishing pressure, and water quality (Hamid & Wardiatno, 2015). Under these conditions of overfishing pressure, blue swimming crab recruitment patterns in East Lampung waters are expected to remain stable, as indicated by the normally distributed recruitment curve with a single peak. This condition indicates that recruitment occurs once a year, and this aligns with the opinion of Romimohtarto & Juwana (2005), who stated that in general, recruitment of species living in tropical waters occurs throughout the year, with peak recruitment periods varying depending on water conditions.

### Carapace Width-Based Spawning Potential Ratio

The results of the length-based spawning potential ratio (LBSPR) analysis of blue

swimming crabs in East Lampung waters indicate a spawning potential ratio of 19% (Figure 6), indicating that spawning potential has significantly decreased, likely due to overfishing.

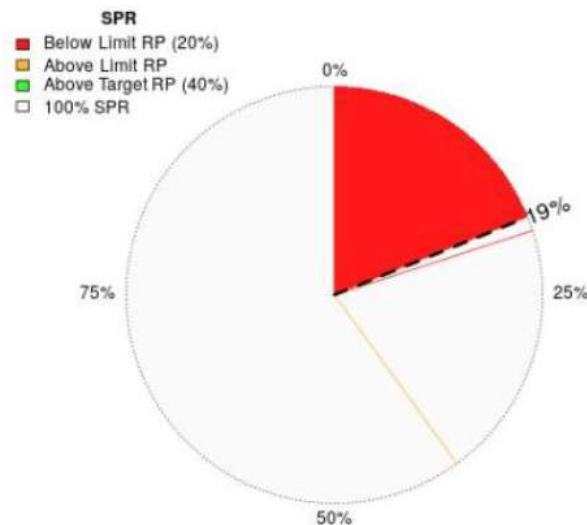


Figure 6. LBSPR Value of Blue Swimming Crabs on the Coast of East Lampung

## DISCUSSION

High fishing pressure can result in higher population mortality (Wagiyo *et al.*, 2019). High levels of exploitation can lead to growth overfishing and recruitment overfishing. Growth overfishing is a condition where blue swimming crabs are caught before they reach maturity, while recruitment overfishing is a condition where the addition of new individuals to the stock is reduced. Mortality estimates indicate that fishing is the dominant cause of blue swimming crab mortality, as the  $F$  value is greater than the  $M$  value (Ningrum *et al.*, 2015).

The analysis shows that the fishing mortality rate ( $F$ ) for blue swimming crabs reaches 3.20 per year, while the natural mortality rate ( $M$ ) is only 1.31 per year. This comparison indicates that fishing pressure is almost 2.5 times greater than natural mortality. In other words, most mortality in the blue swimming crab population is caused by fishing activities, not by ecological factors such as predation or disease. The  $E$  value of 0.71 is well above the threshold of 0.5 recommended by Sparre & Venema (1999) as an acceptable exploitation limit for maintaining stock sustainability. Values exceeding 0.5 are consistently interpreted as overfishing, a condition where fishing exceeds the population's ability to recover through growth and reproduction. An  $E$  value of 0.71 indicates that 71% of total mortality in the blue swimming crab population is caused by fishing, placing this level of exploitation in the excessive category. This condition has the potential to cause a decrease in broodstock biomass, reduced recruitment, and, in the long term, could lead to significant stock declines if stricter management is not implemented.

Fluctuations in the abundance of blue swimming crabs caught by fishermen show a seasonal pattern, with a gradual increase starting in August, peaking in March–April, and then declining again until July. While this pattern reflects natural population dynamics, the sharp variation between months indicates that the stock is under high fishing pressure. The rapid decline in abundance after the peak suggests that cohorts entering the fishing grounds are quickly depleted before they have a chance to contribute significantly to stock regeneration. Differences in abundance between males and females, particularly decreases in female abundance during certain periods, point to potential disruptions to the reproductive structure of the population. This fluctuation pattern is consistent with the results of mortality analysis, which indicate overfishing ( $E = 0.71$ ), where fishing mortality is significantly higher than

natural mortality ( $F = 3.20$ ;  $M = 1.31$ ). Despite high abundance in certain seasons, fluctuations in abundance and population dynamics of the blue swimming crab (Figure 2) reflect overexploitation that could hinder long-term stock recovery.

The distribution of carapace widths shows a unimodal distribution, with a predominance of medium-sized individuals (110–130 mm) and a sharp decline in the large size class (>150 mm). This pattern strongly indicates size truncation, which is common in overfished stocks. High fishing mortality results in individuals being captured before reaching their maximum size, resulting in a near-absence of large size classes in the sample. The dominance of the medium size class suggests that population structure is driven by newly recruited juvenile cohorts, while the presence of large broodstock, which plays a crucial role in egg production, is limited. This narrowing of the size range is consistent with the higher  $F$  value (3.20) compared to  $M$  (1.31), and contributes directly to the low spawning potential. The observed carapace width size distribution confirms that fishing pressure has shifted the population age structure and reduced the recovery capacity of the crab stock in this region.

The Von Bertalanffy growth parameter estimation results show that the blue swimming crab in East Lampung waters has a theoretical maximum carapace width ( $CW_{\infty}$ ) of 191.6 mm with a growth coefficient  $K = 1.30 \text{ years}^{-1}$ . The high  $K$  value indicates that the blue swimming crab in this region is a fast-growing species, capable of reaching large sizes in a relatively short time. Based on these parameters, the time required for the blue swimming crab to approach its maximum size ( $t_{\max}$ ) is approximately 0.74 years, or equivalent to 8–9 months. This indicates that the blue swimming crab growth cycle is rapid, with an intensive growth phase occurring in the early months after recruitment. The negative  $t_0$  value ( $-0.0727$ ) illustrates that initial growth begins before the organism reaches its theoretical zero size, as is commonly found in crustacean growth analyses. Blue swimming crab growth is more influenced by the conditions of East Lampung waters, which have a high level of fertility (productivity), resulting in sufficient food availability for the blue swimming crab. High aquatic productivity is due to the extensive mangrove ecosystem, particularly around the crab fishing grounds near Way Kambas National Park. This is consistent with Kembaran *et al.*, (2012) finding that the availability of sufficient natural food allows crabs to metabolize effectively, resulting in relatively rapid growth. Furthermore, rapid crab growth rates are common among most crustacean species in tropical waters. However, if crabs reach their maximum carapace width more quickly, their lifespan is also shortened. These growth characteristics have important implications for fisheries management, as species with high  $K$  tend to be responsive to fishing pressure; although they can recover quickly, stocks can also experience drastic declines if fishing mortality exceeds their reproductive and growth capacity.

A comparison of gonadal maturity curves and gear selectivity indicates that the size at first capture ( $L_c$ ) is larger than the size at first gonadal maturity ( $L_m$ ). This indicates that most crabs have reached sexual maturity and are potentially capable of spawning before capture. Biologically, this reduces the risk of recruitment overfishing because the stock still has the opportunity to produce new recruits before adults are removed from the population. However, the high fishing mortality rate ( $F = 3.20 \text{ years}^{-1}$ ) and the exploitation value reaching  $E = 0.71$  indicate that utilization pressure on the stock remains excessive. Thus, although the current selectivity structure relatively supports reproductive continuity, high total mortality and declining broodstock biomass still have the potential to reduce the population's long-term regeneration capacity.

With the SPR value slightly below the 20% threshold, there is concern that the blue swimming crab (blue swimming crab) in the coastal waters of East Lampung will be difficult to sustain if not properly managed, as it is already below the lower limit of the "replacement level" for the risk of declining recruitment of blue swimming crab stocks in the wild. This is consistent with a study by Prince *et al.*, (2020) stated that the SPR of swimming crabs in

Indonesia (Java Sea: Gresik, Pati, Pemalang, and Pamekasan; Tiworo Strait, Southeast Sulawesi: Kasiputeh, Kendari, and Pamandati) is generally very low, ranging from 4% to 17%, and the lowest estimate of the average SL50% corresponds to the lowest estimate of the average SPR. Most estimates of the average SL50% are around 100 mm (range 93–108 mm) with the lowest outlier being 74 mm. Meanwhile, the SL50% value in East Lampung waters is still around 108.8 mm, which means it is still in accordance with government regulations.

According to Walters & Martell (2004), the spawning potential ratio (SPR) is defined as the proportion of natural, or unfished, reproductive production remaining in a population under fishing pressure. By definition, an unfished group has an SPR of 100% (100% SPR). When its natural lifespan is shortened by fishing, the natural spawning potential of that group is reduced to some proportion, or ratio, of the unfished natural level (SPRX% or  $<1.0$ ). Furthermore, Mace & Sissenwise (1993) stated that for management purposes, an SPR of 30–40% is internationally recognized as a target level to be achieved, while a 20% SPR is accepted as a 'surrogate level' below which stock recruitment risks decline and is used as a reference limit, above which the stock should be managed.

The SPR of swimming crabs in coastal waters of East Lampung during overfishing conditions was below the 20% biological reference limit and the 40% biological reference target. Stock status below the biological reference limit will affect reproductive potential and thus disrupt recruitment (Prince *et al.*, 2014). An SPR lower than the biological reference limit and biological target reference points can threaten the existence of blue swimming crab stocks. Increasing the biological reference limit could be a solution to increase the SPR value. The Indonesian Minister of Maritime Affairs and Fisheries' regulation regarding the minimum catch size of 10 cm or 100 mm for all management areas does not align with the habits of blue swimming crabs, which migrate locally. Based on the results of the SPR analysis, the average size of blue swimming crabs caught (Lc50) in the coastal waters of East Lampung was 109.54 mm. Blue swimming crabs, whose survival depends on their habitat, have unique characteristics that may differ from those in other habitats. Therefore, the initial size of blue swimming crabs caught should be varied in each fishing area.

To some extent, the higher SPR in the coastal waters of East Lampung compared to blue swimming crabs in Indonesia, according to a study by Prince *et al.*, (2020) which is partly due to relatively lower fishing pressure (F/M) with an F/M value of 3.75 ( $<4$ ), while in the waters of the Java Sea and the Tiworo Strait of Southeast Sulawesi it is already very high ( $>4$ ), especially in the waters of Gresik, Pati, and Pemalang (Prince *et al.*, 2020). However, in reality, the fishing pressure of blue swimming crabs on the coast of East Lampung is also very high, with an E value reaching 0.71. Thus, the higher SPR in the waters of East Lampung is mainly due to the larger size where the blue swimming crabs were first caught (SL50%) ranging from 108.8 mm, while in the waters of the Java Sea and Tiworo Strait it ranges from 74–108 mm.

## CONCLUSION

The crab resource stock in East Lampung waters is being overexploited (overfished), with the utilization rate reaching 0.71 per year. Under these overfishing conditions, several biological parameters of the crab population, such as growth, recruitment patterns, sex ratio, size at first capture, and carapace width distribution, still show good conditions. However, this overfishing condition has resulted in the crab spawning potential ratio (SPR) being unsustainable, with an SPR of 19%. An SPR value above 20% can be achieved if fishing effort is reduced and the minimum catch size is 108.8 mm.

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