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STOCK STATUS OF BLUE SWIMMING CRAB (*Portunus pelagicus*) IN TANAH LAUT, SOUTH KALIMANTAN, AND ITS ADJACENT WATERS

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ABSTRACT

A study on the stock status of blue swimming crab (*Portunus pelagicus* Linnaeus, 1758) was conducted in Tanah Laut, South Kalimantan waters, based on data collected in March to November 2017. The results showed that the growth pattern of blue swimming crab in Tanah Laut waters was negatively allometric and the sex ratio of males to females was 1.0 : 1.7. The chi-square test indicated that the total males and total females of the blue swimming crab was significantly different. It means that there was an imbalance in numbers between males and females. The estimated length at first capture (L_c) was 127.26 mm (carapace width; CW), smaller than the length at first maturity (L_m) at 133.24 mmCW. The growth parameter of blue swimming crab was 1.1year with a maximum carapace width (CW_∞) of 204.3 mmCW. The estimated instantaneous total mortality (Z) and natural mortality (M) were 3.04/year and 1.24/year, respectively. While fishing mortality (F) and exploitation rate (E) were 1.80/year and 0.59/year, respectively, the estimated spawning potential ratio (SPR) was 11.1 %. Therefore, the stock status was categorized as overfishing. In order to ensure the sustainability of the blue swimming crab, a precautionary approach,, such as reducing fishing effort by 18 % of the current situation, is strongly recommended to apply.

Keywords: **Blue swimming crab; population dynamic; spawning potential ratio; Tanah Laut; FMA 712**

INTRODUCTION

Blue swimming crab (BSC, Portunus pelagicus Linnaeus, 1758), which has a local name "rejong", is one significant economic resource in Tanah Laut and adjacent waters (RIMF, 2017). The BSC resources have been exploited for a long time. Yet commercial fishing activity toward the resources was started in 1960 due to the presence of trawl fishery in the area. Since that year, the fishing activity of BSC has been intensively developed and increased from year to year due to the increasing numbers of fishing efforts and fishers (Naamin *et al.*, 1992; RIMF, 2017). This species is mainly caught by gillnet.

BSC resources are categorized as renewable resources, but intensive and unmanaged fishing activity could significantly be a significant component of the depletion of this resource. As it has occurred toward the BSC resources in Tanah Laut and adjacent waters, this condition would threaten the sustainability of the stock; as a result, the depletion of the stock will come soon. Naamin (1984) stated that increasing fishing effort to a certain level could increase the catch. After a certain level of the catch, called maximum sustainable yield,(MSY), is reached the catch will decrease even though the effort increases. Cunningham *et al.* (1985) added that the more effort increased, the more the resources were being exploited. Meanwhile, the resources themselves had a maximum capability to the long run of yield. Hence the catch ability coefficient would rise until MSY was reached, but as fishing was further intensified (increased effort), the productivity would decline. Therefore, the exploitation of BSC resources should be managed and the fishing effort should be appropriately regulated to enhance the stock sustainability.

The BSC stock and fishing activity in Tanah Laut waters should be appropriately managed to give a chance to the stocks to recover themselves so that the sustainability of the stock can be kept in the future. Some research toward the BSC stock status are needed to obtain scientific data for management purposes. This study discussed the stock status of

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BSC in Tanah Laut waters. It is expected that the information can be used for management purposes and the basis for further research.

MATERIALS AND METHODS

The samples of BSC were taken from the field sites in Tanah Laut and adjacent waters (Figure 1) from March to November 2017. Biometric studies (carapace width, sex, and gonad maturity identifications) were done on 681 samples mainly caught by gillnet. The relationship between the BSC carapace width and weight follows the cubic law (Ball & Rao,1984; King, 1995): $W = aL^b$, with *W* is weight (gram); *L* is length. in this research measured as the carapace width (mm); and *a and b* are constants. The sex ratio was calculated by comparing the number of males and females and analyzed to know whether the sex ratio is balanced or not by using the chi-square test (Walpole, 1993).

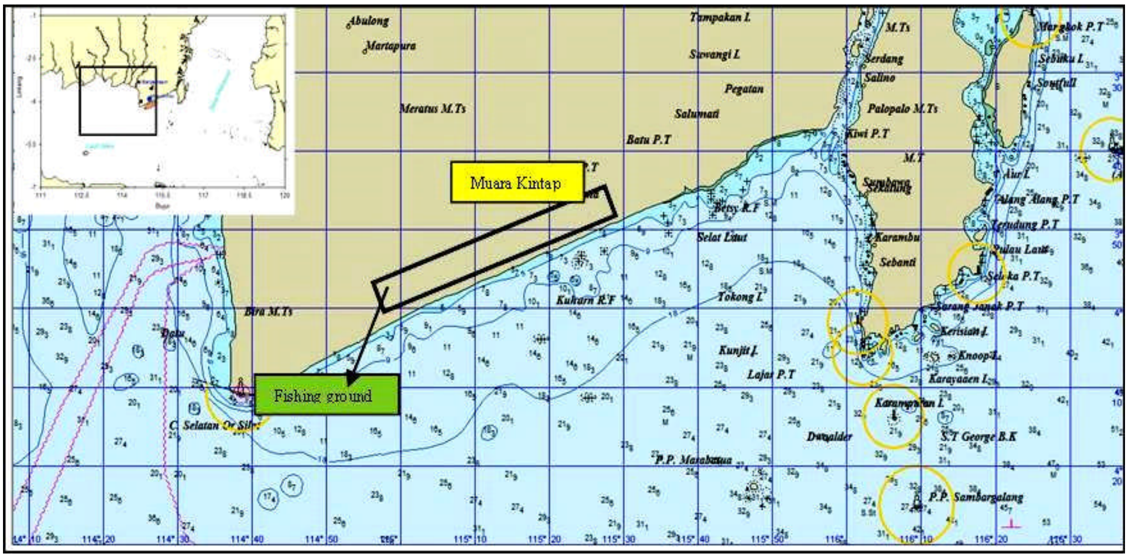

Figure 1. The fishing ground of blue swimming crab (*P. pelagicus*) in Tanah Laut and adjacent waters. (Source: Suman *et al.*, 2017).

The calculation of the size at first capture (*Lc*) was done using the Sparre & Venema (1992)'s equation as follows:

$$S_L = \frac{1}{1+\exp\left(S1 - S2xC\right)}; In\left[\left(\frac{1}{S_L}\right)-1\right] = S_1 - S_2 xL \quad .....(1)$$

where *SL* is the logistic curve and *S1* and *S2* are constants in the logistic curve equation.

The size at first maturity (*Lm*) was calculated by entering the carapace width value and P_{Lm} to the logistic function graph (King, 1995), using the following equation:

$$P_{Lm} = \frac{1}{1+\exp\left(aL+b\right)} \quad ....(2)$$

Growth rate (*K*) and maximum carapace length (L_∞) were analysed by tracing modus of monthly carapace width distribution using the ELEFAN program (Sparre & Venema, 1992, and Gayanilo *et al*., 2005). Total mortality (*Z*) was calculated from catch curve (Sparre & Venema, 1992 and Gayanilo *et al*., 2005) and natural mortality (*M*) was predicted using combination of Pauly empiric equation (Pauly, 1983) and fishing mortality rate (*F*) = *Z* – *M*, while exploitation rate (*E*) = *F/Z* (Sparre & Venema, 1992).

The spawning potential ratio (*SPR*) was estimated using fish length data based (Hordyk *et al*., 2014). Data input used in SPR analysis was the ratio of *M/K*, asymptotic length (L_∞), the proportion of 50% and 95% mature fish (L_{50}, and L_{95}), and fish length. Finally, estimation of *SPR* was based on a comparison of mature potential between fished ($SSBR_{fished}$) and unfished ($SSBR_{unfished}$) according to the equation introduced by Goodyear (1993).

$$SPR = \frac{SSBR_{fished}}{SSBR_{unfished}} \quad ....(3)$$

RESULTS AND DISCUSSION
Results

The Relationship Between Length-weight and Sex Ratio

The growth pattern of male and female BSC was allometric negative with values of *a* = 0.9512, *b* = 1.6673, and r^2 = 0.91. This phenomenon indicates that the carapace width increase in BSC was faster than the body weight gain.

Chi-square test informed that the total individuals of males and females was an imbalance. It was also identified that the sex ratio of the BSC in Tanah Laut waters was found to be 1.0 : 1.7.

*The Length at First Capture (Lc) and the Length at First Maturity (*Lm*)*

From the analysis using a logistic curve of BSC, it shows that the *Lc* was found at a carapace width (*CW*) of 127.26 mm (Figure 2).

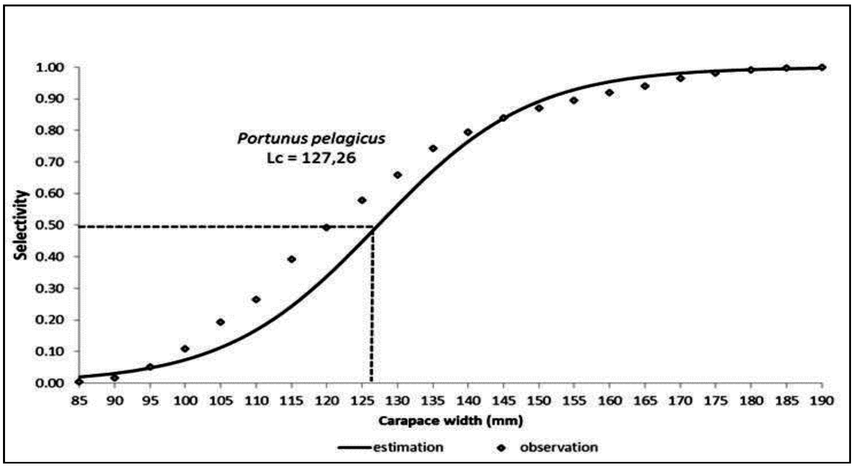

Figure 2. The length at first capture of blue swimming crab (*P. pelagicus*) in Tanah Laut and adjacent waters.

Meanwhile, the BSC analysis using a logistic function method found that the length (carapace width) at first maturity (*Lm*) was 133.24 mmCW (Figure 3).

Growth Parameter

Basically, the ELEFAN program is applied to interpret carapace length in time series data adjusted to the von Bertalanffy growth curve. The value of growth rate (*K*) and maximum carapace length (L_∞) of endeavor shrimp was recorded by identifying monthly carapace width frequency (Figure 4), namely 1.1/year and 204.3 mmCW, respectively.

Mortality Rate and Exploitation Rate

The estimated total mortality (*Z*) represented by the value of slope (*b*) between *Ln N/t* and relative age (Figure 5) was 3.04/year. Meanwhile, the value of natural mortality (*M*) and fishing mortality (*F*) was 1.24/ year and 1.80/year, respectively.

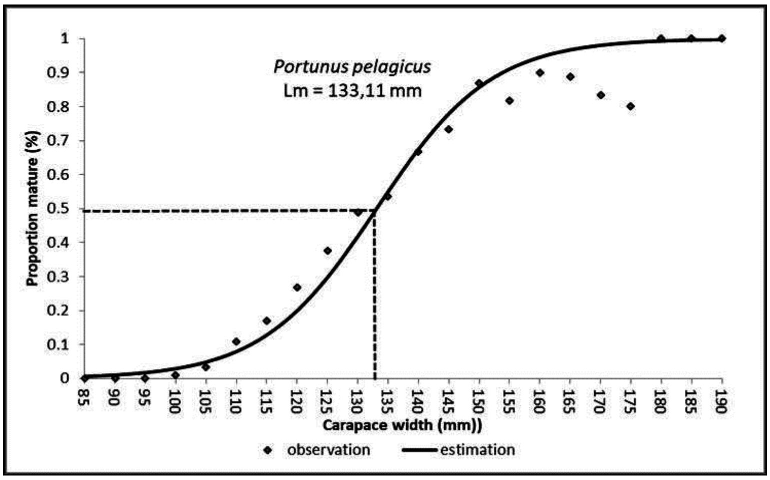

Figure 3. The length at first maturity of blue swimming crab (*P. pelagicus*) in Tanah Laut and adjacent waters.

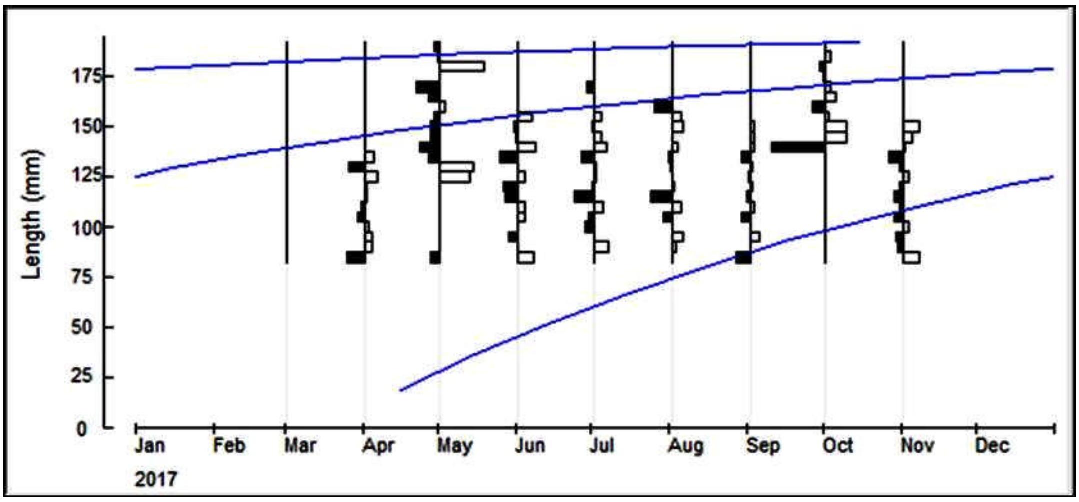

Figure 4. The carapace width distribution of blue swimming crab (*P. pelagicus*) in Tanah Laut and adjacent waters.

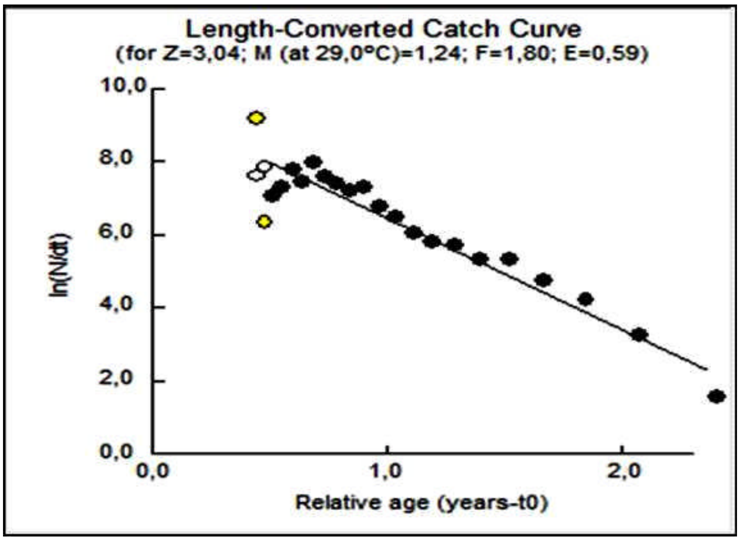

Figure 5. The value of total mortality (*Z*) of blue swimming crab (*P. pelagicus*) in Tanah Laut and adjacent waters.

Using the exploitation rate equation *E* = *F*/*Z*, it was obtained that *E* of BSC in Tanah Laut and adjacent waters was 0.59/year.

Spawning Potential Ratio (SPR)

Spawning potential ratio (SPR) method analysis was based on biological and growth parameters data. They estimate the length at first maturity (*Lm*), von Bertalanffy growth equation, length-weight relationship, and early cohort. It was found that the *SPR* of BSC was 11.1 % (<20%) (Figure 6). This value was obtained from extrapolation between fish length and *SPR* below and above the *Lm* value. This result indicated that the status of BSC stock was overfishing.

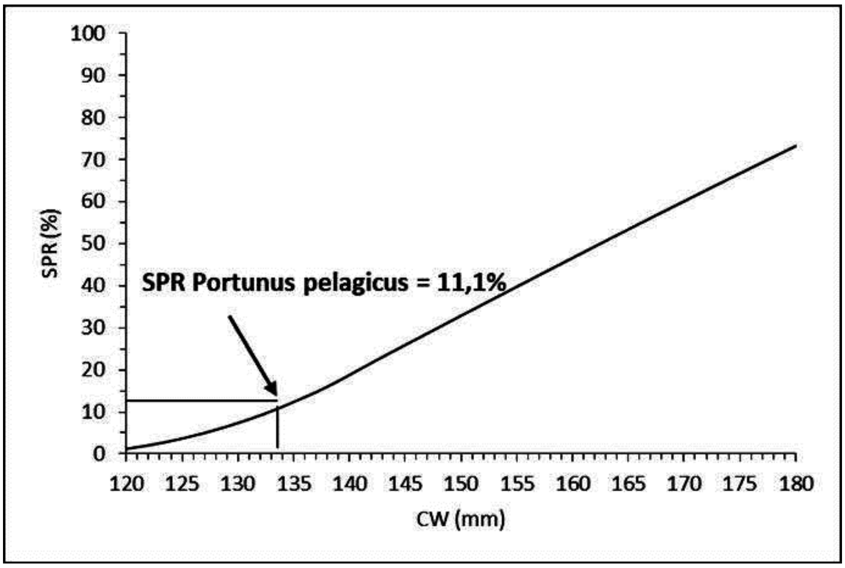

Figure 6. The Spawning Potential Ratio (*SPR*) curve of blue swimming crab (*P. pelagicus*) in Tanah Laut waters.

Discussion

The analysis of the relationship between carapace width and weight was used to predict the growth pattern of BSC in Tanah Laut and adjacent waters. The result of the t-test showed that the BSC growth pattern was negative allometric. This growth pattern suggested that the increase in carapace width was faster than the weight gain. Table 1 presents the results of the study of carapace width and weight relationship of BSC in various waters.

Table 1. The relationship between carapace width and weight of blue swimming crab (*Portunus pelagicus*) in some waters

Waters	Growth pattern	Source
Tangerang – West Java	negative allometric	Prihatiningsih & Wagiyo, 2009
Mandapam-India	positive allometric	Josileen, 2011
Pati, Central Java	positive allometric	Ernawati *et al*., 2014
Betahwalang , Demak Central Java	positive allometric	Pristya *et al*., 2015
Jakarta Bay	negative allometric	Panggabean *et al*., 2018

This growth pattern depends on the availability of food and the water temperature (Monterio, 2002 in Fauzi *et al.*, 2013). Differences in length increments could also be caused by differences in external and internal factors. According to Effendie (2002), internal factors are factors that are difficult to control, such as genetic, sex, age, and diseases. On the other hand, the main external factors that influence fish growth are temperature and food.

Data on the sex ratio of BSC are essential and as necessary information for the reproduction biology of the stock (Suhendrata & Merta, 1986). The sex ratio of male and female endeavour shrimp was imbalance (1.0 : 1.7). The dominance of females indicates that the recovery of the population in these waters will not disturb (Naamin, 1984). This finding is different to ones reported from various waters (Table 2). This phenomenon possibly occurred due to the different analyses of male and female sex ratios done prior to and during spawning season (Nikolsky, 1963).

The prediction of age and the length at first maturity is important for management purposes because exploitation has to let some stocks, which are at the same or bigger size when they reach maturity, still live (Sudjastani, 1974). The length at first maturity (*Lm*) of the BSC in Tanah Laut waters was 133.24 mmCW. The *Lm* value found in this study is different than those reported from the various waters (Table 3.).

Table 2. The sex ratio of blue swimming crab (*Portunus pelagicus*) in some waters

Waters	Male	Female	Source
Australia Estuaria	dominant	not dominant	Sumpton *et al.,* 1994
	1	1	Potter *et al*., 1986
	dominant	Not dominant	Bellchambers & Harris, 2005
Kung Krabaen Bay, Thailand	1.08	1	Kunsook, 2011
Brebes	0.82	1	Sunarto, 2012
Bone Bay	1.08	1	Kembaren *et al.* 2012
Pangkep	1.20	1	Ihsan *et al*. 2014
Pati	1	1.18	Ernawati., *et al*. 2014
Lampung	not dominant	dominant	Kurnia *et al*., 2014
Betahwalang, Demak	1	1.1	Pristya *et al*., 2015
Lasongko Bay	1.06	1	Hamid, 2015
Jakarta Bay	1.0	0.8	Panggabean *et al*., 2018

Table 3. The value of length at first maturity (*Lm*) of blue swimming crabs (*Portunus pelagicus*) in some waters

Waters	Lm (mm)	Source
South Australia	58.5	Xiao & Kumar, 2004
Jakarta Bay	-	Nuraini., *et al*. 2009
Brebes	108	Sunarto, 2012
Bone Bay	71.63 - 107	Kembaren *et al*., 2012
Pati	107	Ernawati, 2013
Kung Krabaen Bay, Thailand	58.2 - 85.0	Kunsook *et al*., 2014
Pangkep	106	Ihsan *et al*. 2014
Betahwalang, Demak	136	Pristya *et al*., 2015
Lasongko Bay	115,7	Hamid, 2015
Jakarta Bay	106.81	Panggabean *et al*., 2018

Nikolsky (1963) stated that *Lm* value is influenced by some factors, such as the depth and type of habitat in association with food availability, temperature, and light. According to Sivakami *et al*. (2001), the difference in *Lm* value for each fish is caused by the different size of samples collected, the maximum and minimum length, and frequency of fish that are gonad-mature. Apparently the availability of food and environment conditions in Tanah Laut waters are better than ones in some other waters.

Further analysis showed that the size at first capture (*Lc*) of BSC in Tanah Laut waters was smaller than the size at first maturity (*Lm*). This condition is unexpectable in terms of fisheries management. It was recommended that *Lm* value was larger than *Lc* value. If this condition is left for a long period, the stock of BSC in Tanah Laut waters would continue to decrease until a level in which the BSC stock will be disrupted and finally no more BSC stock available in the waters enough as a fishery resource. In contrast, if *Lc* is higher than *Lm*, it means that the individuals of BSC have chances to spawn to maintain the population. In order to ensure the sustainability of the resources, the fishing pattern should allow a number of BSC broodstock to escape (Sudjastani, 1974). To prevent stock degradation in Tanah Laut waters, a regulation of net mesh size is needed in catching BSC.

According to Sparre & Venema (1992), the lower growth coefficient (*K*) needed a longer time for the species to reach the asymptotic length. On the other hand, the higher growth coefficient needed a shorter time for the species to approach the asymptotic length. The growth rate (*K*) of BSC in Tanah Laut waters was 1.1 per year and this showed that the growth rate was considered fast (Sparre & Venema, 1992). Therefore, the precautionary approach should be taken when planning the amount of effort allowed to be applied each year for exploiting the BSC stock in order to obtain a rational management of the stock. If the value of recommended effort was lower, uncapture BSC stock would be useless or the number of natural mortality would be high because the growth type of the stock was fast growth. It means that the stock had a short life span. In contrast, if the value of recommended effort was higher, the stock would be disturbed, even jeopardized because there was not enough time for the population members to renew the stock which led to the decrease of recruitment number and amount of next year stock. This phenomenon differed from the results of other studies in various waters (Table 4).

Table 4. The growth rate (*K*) and maximum carapace width (CW) of blue swimming crab (*P. pelagicus*) in some waters

Waters	K(Year $^{-1}$)	CW∞ (mm)	Source
Brebes	Male (1.2) and female (0.78)	Male (81.10) and female (81.38)	Sunarto, 2012
Lasongko Bay	Male (0.93) and female (0.68)	Male (152.04) and female (173.04)	Hamid, 2015
Bone Bay	Male (1.27) and female (1.08)	Male (159.0) and female (154.9)	Kembaren *et al*., 2012
Pati	Male (1.26) and female (1.13)	Male (185) and female (187)	Ernawati 2013
Pangkep	Male(1.2) and female (1.5)	Male (173.78) and female (186.38)	Ihsan *et al*., 2014
Jakarta Bay	1.12	157	Panggabean *et al*., 2018

The differences in growth parameters could be caused by the differences in the maximum length of collected samples and the differences in the location of the waters (Widodo & Suadi, 2006). Knaepkens *et al*. (2002) and Effendie (2002) stated that the differences in the values of *K* and L∞ are caused by internal/intrinsic and external factors. Internal factors that are influential are genetics, parasite infestations, and diseases, while the external factors are temperature and the availability of food.

The total mortality rate (*Z*) is a combination of the natural mortality rate (*M*) and the fishing mortality rate (*F*) (Sparre & Venema, 1992). The instantaneous total mortality rate (*Z*), natural mortality rate (*M*), and fishing mortality rate (*F*) were 3.04/year, 1.24/year and 1.80/year, respectively. This phenomenon differed from the results of other studies in various waters (Table 5).

Table 5. The total mortality (*Z*), natural mortality rate (*M*) and fishing mortality rate (*F*) of blue swimming crab (*P. pelagicus*) in some waters

Waters	Sex	Mortality (year $^{-1}$) Z	M	F	E (year $^{-1}$)	Source
Brebes	Male and Female	2.52	0.98	1.53	0.391	Sunarto, 2012
Bone Bay	Male	9.21	1.33	7.88	0.86	Kembaren *et al*. 2012
	Female	6.90	1.21	5.69	0.82	
Pati	Male	6.24	1.27	4.97	0,80	Ernawati, 2013
	Female	6.19	1.18	5.01	0.81	
Pangkep	Female	2.53	1.44	1.09	0.43	Ihsan *et al*. 2014
	Betina	3.22	1.27	1.95	0.60	
Lasongko Bay	Male	2.80	1.09	1.71	0.61	Hamid, 2015
	Female	2.95	0.86	2.09	0.71	

It was presented that the differences in the value of BSC mortality rates in several waters (Table 5) were caused by the different levels of effort number, predator, and environment condition (Pauly *et al*., 1984). The *M* value of BSC in several waters appeared to be smaller than the *F* value, and this suggests that most of the BSC in Tanah Laut waters died due to capture.

Using the exploitation rate equation (E) = F/Z, it was obtained that the E of BSC in Tanah Laut waters was 0.59/year. It was concluded that the overfishing of the BSC occurred in Tanah Laut waters because the rational fishing stock in that waters if values E = 0,5 (Pauly et al., 1984). If the value of E is more than 0.5, the stock will be endangered, thus the effort will decrease to sustain the stock. The phenomenon of the BSC stock in Tanah Laut waters suggested that the fishing effort of the BSC stock should be lowered until 18% of the present status.

The spawning potential ratio (*SPR*) is the relative reproductive index used to determine the stausage of fish stocks that have been cultivated (Prince *et al*., 2015; Walters & Martell, 2004). The *SPR* is also known as a measure of the level of reproductive capacity of a resource that has declined from its original condition or the condition has not been exploited (Smallwood *et al*., 2013). The analysis of the *SPR* of BSC in Tanah Laut waters is 11.1% and this indicates that the status of the BSC stock is at the stage of overfishing. This is in accordance with fisheries stock status criteria based on *SPR*, which are classified into 3 groups, namely under exploited (*SPR*>40%), moderate (20%<*SPR*<40%), and over-exploited/overfishing (*SPR*<20%) (Walters & Martell, 2004; Prince *et al*., 2015).

CONCLUSIONS

The growth pattern of BSC (*P. pelagicus*) in Tanah Laut and adjacent waters was negative allometric, which suggested that the body width growth was faster than the weight gain. The sex ratio of male and female was imbalance with the dominant one was female. The length at first capture (*Lc*) that is smaller than the length at first maturity (*Lm*) may disturb endeavour shrimp resource sustainability. The growth rate and mortality rate of BSC are high, so a care must be taken in the management options. The rate of exploitation (*E*) of BSC is 0.59 per year and SPR is 11.1 %, thus the status of BSC stocks in Tanah Laut waters is already at the stage of overfishing. To ensure sustainability, a regulation on the gillnet mesh size and a reduction of approximately 18% of the current fishing effort are. For determining the gillnet mesh size, further research is still needed in these waters. In addition, an assessment of the socio-economic aspect may result in a more accurate stock status of BSC in Tanah Laut and adjacent waters.

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