

Stock Status of Blue Swimming Crab (*Portunus pelagicus* Linnaeus, 1758) in Tiworo Strait Waters, Southeast Sulawesi, Indonesia

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Abstract

The blue swimming crab (BSC) fishery in Tiworo Strait has been heavily exploited since two decades ago when its worldwide demand and price was very high. Study on population aspects of this organism in this waters is limited. The aim of present study was to investigate growth patterns, population stock status, and size at first gonad maturity of *Portunus pelagicus*. One of the main fishing ground of BSC around Tiworo Strait waters is at Bangko and Gala Islands. Samples of BSC were taken monthly using gillnet and collapsible trap. Each sample taken was identified its sex, measured its carapace width, and weighed. Data collected from fishing ground of BSC were analyzed to find out growth patterns, population stock status using spawning potential ratio (SPR) method, and the first gonad maturity (CW_{50}). The results of study showed that growth patterns of BSC male and female following isometric growth patterns ($b=0$) ($P<0.05$). It was found out that SPR of BSC from both fishing ground was 22.46% and 23.71%, respectively which indicates that population stock status of BSC in Tiworo strait waters is "moderate level" ($SPR > 20\%$). The size at first gonad maturity (CW_{50}) was attained at carapace width of 9.16 cm for male and 10.16 cm for female. Those imply that BSCs allowed to be caught should be >10 cm.

Keywords: spawning potential ratio, size, first maturity; crabs

Introduction

Habitats of blue swimming crab (BSC) distributed around Southeast Sulawesi waters, such as in Tiworo strait, Lasongko bay, Kabaena island waters, and Wakatobi waters (La Sara et al., 2014), Toronipa waters (Mughtar et al., 2017; Basri et al., 2017), Bungin Permai waters of South Konawe (Permatahati et al., 2019), Purirano waters (Mardhan et al., 2019). Fishing ground of BSC in Tiworo strait constitutes one of the biggest fishing ground in Indonesia after northern Java waters and Lampung waters (La Sara et al., 2014; Kunjana, 2018). The BSC exploitation activities in Tiworo strait spread out in several big and small islands, such as at Gala, Bangko, Mandike, Tasipi, Maginti, Tiga islands, etc. (La Sara et al., 2014), Tinanggea waters (Mawaluddin et al., 2016) and Bungin Permai waters (Permatahati et al., 2019). Generally, BSCs caught are exported to many countries around the world, particularly to USA ($\pm 50\%$ of total export) by many big companies such as PT. Philips and PT. Blue Star Food. It is about 21% of BSC production in Indonesia is supplied from Southeast Sulawesi (La Sara, 2015). In 2016, Indonesia exported BSC reaching 19,837 tons, however, it decreased to be 16,845 tons (Direktorat Pengelolaan Sumber Daya Ikan, 2020).

The BSC exploitation in Tiworo strait waters particularly in Bangko and Gala islands, Tinanggea and Bungin Permai waters are all year round using gillnet and collapsible traps (La Sara et al., 2016; Mawaluddin et al., 2016; Permatahati et al., 2019), and sold to the mini plants of crab meats processing. Those mini plants buy all BSCs caught (La Sara et al., 2014; 2016b) to be taken its meats and further is packaged to be collected and exported to abroad by companies. Demand of BSC meat is continuously increase which is very dependent on catch result of fishermen (Ernawati et al., 2014). In the previous years showed an indication that BSC population in several fishing ground of Tiworo strait have experienced over exploitation and have risen apprehensive because of its carapace width (CW) size is already dominated by small size of < 6 cm, the individual number caught and biomass per trip is few, its fishing ground is continuously narrow, limited and moving afield from shore line (La Sara et al., 2016b; 2016c), and SPR of $\pm 14\%$ (La Sara and Astuti, 2015; La Sara et al., 2016c).

At the present, BSCs caught by fishermen are dominated by CW small size. The CW small size and berried female of BSC caught constitute the main factors causing population stock decreasing (Nitiratsuwan et al., 2013). In order to sustain

population of this BSC, it needs to know the population stock status as a base of its good management formulation. One of the estimation method for BSC stock population is Spawning Potential Ratio (SPR). This method shows rate of BSC stock reproduction which experiencing exploitation (Brooks *et al.*, 2010). This biological reference point method explains that fishing mortality causing SPR decrease from SPR stock prior is exploited (Bunnell and Miller, 2005). This method is generally recommended for BSC which its data is very few (poor stock data) (Brook *et al.*, 2010). Estimation of BSC in Tiworo strait uses this method due to catch data availability is very limited so it is unreliable using comprehensive and analytical analysis to estimate BSC population stock status. The aim of study was to know growth patterns, population stock status, and size at first maturity of BSC taken from Tiworo strait waters of Southeast Sulawesi.

Materials and Method

The study was conducted in Tiworo strait of Southeast Sulawesi. Sampling locations were chosen in fishing ground of Bangko and Gala islands (Figure 1.). Samples were taken monthly from January to May 2018 using gillnets and collapsible traps. Each sample of BSC collected was identified its sex, measured its CW using a caliper (0.1 mm), and weighed its body weigh using electronic balance (1 g) (Josileen, 2011; La Sara *et al.*, 2016b; 2016c).

One among input parameters of SPR is CW and body weight (W) relationship which was analyzed using an equation of $W = aCW^b$ (where, W= body

weight (g); CW= carapace width (cm); a and b= constant). SPR was estimated based on CW size of BSC. Estimation of SPR used an equation of Prince *et al.* (2014) namely recruit number of BSC at age of 0 (N_{t0}) assumed at equilibrium condition with initial cohort size assumed as many 1,000 individuals. The SPR analysis procedure is as the following:

$$SPR_t = \frac{\sum_{t=0}^t EP_t}{\sum_{t=0}^{t_{max}} EP_t}$$

$$EP_t = (N_{t-1}e - M)f_t$$

where: SPR_t = proportion of reproduction potential at age t; EP_t = output reproduction at age t; N_t = individual number at age t with N_0 is 1,000; M = natural mortality; f_t = average of fecundity.

The SPR obtained was further compared to reference point which is classified into 3 fisheries status namely under exploited ($SPR > 40\%$), moderate ($20\% < SPR < 40\%$), and over exploited ($SPR < 20\%$) (Walters and Martel, 2004; Prince *et al.*, 2015). Analysis on BSC CW size at first gonad maturity (CW_{50}) used cumulative percentage of 50% (stated from cumulative total of CW size). This point of 50% from cumulative total percentage is a size of BSC attaining gonad maturity (Poovichiranon, 1992; La Sara, 2001).

Results and Discussion

The BSCs obtained from fishing ground of Bangko island amounted 1,179 individuals which consisted of 531 individual males and 648 individual females and from fishing ground of Gala island

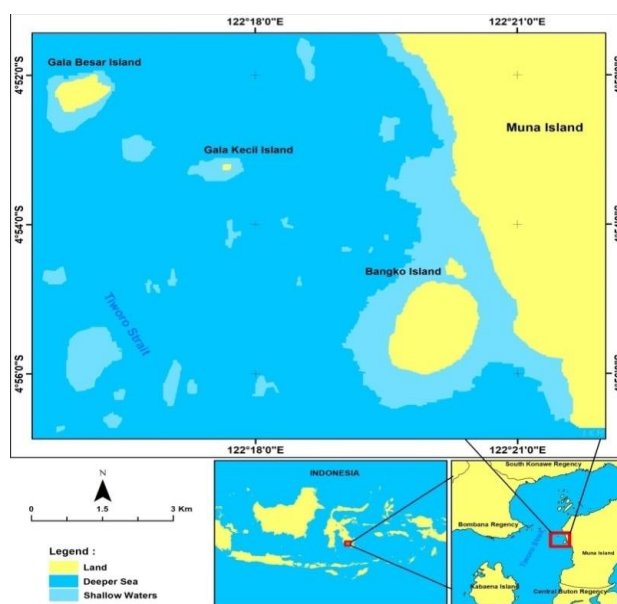


Figure 1. Sampling Location of BSC in Bangko and Gala Islands of Tiworo Strait, Southeast Sulawesi

Table 1. Regression Coefficient of *Portunus* from Various Locations

Location	Species	Regression coefficient (b)		Reference
		Male	Female	
Western Australia waters	<i>P. pelagicus</i>	3.260	3.056	Kangas (2000)
South Karnataka waters, India	<i>P. sanguinolentus</i>	3.122	3.054	Dineshababu et al. (2007)
Trang coastal waters, Thailand	<i>P. pelagicus</i>	3.219	3.186	Sawusdee and Songrak (2011)
Bandar Abbas, Persian Gulf, Iran	<i>P. pelagicus</i>	2.757	2.748	Kamrani et al. (2010)
Tiworo Strait of Southeast Sulawesi waters	<i>P. pelagicus</i>	0.0224	0.0238	La Sara et al. (2016a)

amounted 1,375 individuals which consisted of 705 individual males and 670 individual females. There was strong CW and W relationship of male and female from those fishing ground ($r= 0.807-0.917$) and both sexes following isometric growth pattern ($b=3.0$) ($P<0.05$) (Figure 2.). It is one of the important indicators to estimate population biomass, number of BSC meat used from various sizes, and for conversion of CW to W (Sukumaran and Neelakantan, 1997). Correlation of CW and W of BSC of male and female obtained from Tiworo island was strong ($r= 0.807-0.913$) which both sexes followed isometric growth pattern ($b=3.0$) ($P<0.05$) (Figure 2). In other analysis on monthly data also showed isometric growth patterns ($b=3.0$) ($P<0.05$). La Sara et al. (2016a) found out that correlation coefficient (r) of W and CW of both sexes was significance and positive, while regression coefficient (b) which indicating growth patterns of both sexes was different ($b<3$). The regression coefficient (b) indicates ratio of growth rate between CW and W (Sunarto et al., 2010).

Increasing CW of BSC will continue up to reach CW asymptotic (CW_{∞}). When individual of BSC reach CW_{∞} that only W sizes change – may increase or decrease – depending on intrinsic and extrinsic factors of BSC. This relationship constitutes also direct response on environmental conditions (Turra et al., 2002), particularly food availability, water salinity and temperature (La Sara et al., 2010; 2016a). There are several studies had been done from several locations which show various regression coefficients (b) (Table 1).

Generally, regression coefficients (b) of BSC CW and W relationship from those locations show relative similar with the present study. However, regression coefficients (b) of males generally have higher than that of females. The very contrast of regression coefficients (b) of BSC CW and W found in Tiworo strait were 0.0224 for male and 0.0238 for female (La Sara et al., 2016a). It was due to BSCs sampled during the study were almost juvenile sizes of $CW<6.00$ cm. The differences of those regression coefficients (b) may affect sizes at first maturity, as shown in Table 3.

The difference of growth coefficient on crustacean could be caused by several factors such as age, genetic derivation, and seasons leading to affect water temperature. Sex, level of mature, and disappearance organs could contribute to those both coefficients (La Sara et al., 2016a). Other factors such as food availability, water salinity and temperature (La Sara et al., 2002), and exploitation rate (Branco and Fracasso, 2004) mainly affect growth rate of crustacean. Time of sampling taken (temporal), sampling method, fishing gears used, and number of samples taken may also affect coefficient of growth patterns in the analysis. La Sara et al. (2002) also explained that growth patterns of crustacean generally vary between genus and species, each of them has unique growth pattern.

The results of SPR analysis using data of CW sizes taken from those fishing ground of Tiworo strait were 22.41% and 23.71%, respectively (Figure 3.). Those SPRs show exploitation activities of BSCs done by fishermen are still in “the moderate category” (Walters and Martel, 2004; Bunnell and Miller, 2005; Prince et al., 2015). However, the SPR of the stock or proportion of the stock reproduction retained at several levels of fishing pressure (Walters and Martell, 2004; Badrudin, 2015) and generally is used for limit references point of fisheries management in term of few or lack of fisheries data condition (Badrudin, 2015; Hordyk et al., 2015).

The SPR is used also as a tool to measure stock reproduction capacity, aside analyzing the impact of over fishing recruitment (Badrudin, 2015). In the original condition prior fishing activity, the SPR can reach 100% natural reproduction potential. The SPRs of BSC obtained in Tiworo strait (Figure 3.) seem high enough. It may be due to those samples of BSCs were taken mainly in the deep sea water of about 20 m (offshore) which mainly is occupied by big CW sizes (mature sizes). Those such SPRs should be maintained as “biological target reference point” which constitutes a target to have crustacean biological sustainability (Badrudin, 2015).

Those BSC SPRs of moderate category have strong correlation with CW sizes of big BSCs caught

by fishermen, namely 11.60 cm (fishing ground of Bangko island) and 13.06 cm (fishing ground of Gala island). Also those high SPRs have strong correlation with size at first gonad maturity in the fishing grounds in the respective of 9.16 cm and 10.16 cm (Figure 4). Other study shows that SPR of BSC in the fishing ground of Belitung waters, Sumatera had reached critical SPR of 5% (Ernawati *et al.*, 2015). The BSC caught in this waters has small average CW size of 9.3 cm, bigger than that of size at first gonad maturity of 11.89 cm. This data implies that BSCs in Belitung waters have been heavy exploited prior to those BSCs spawning or releasing eggs. This such condition includes in the “biological limit reference point” category. It means that BSC reproduction potential is

already in the danger population condition (SPR<10%). There are several studies on Portunidae conducted in various locations found different SPR (Table 2.). Those data of SPRs less than 20% mean BSC population found in Belitung, Cirebon and Demak waters had been over exploited (SPR<20%) (Walters and Martel, 2004; Prince *et al.*, 2015), while the other SPRs in the respective 28% and 40% were moderate exploitation which is relatively similar with SPRs in the present study of 22.41% and 23.71%. Those SPRs in the present study figure that the BSC sizes caught in Tiworo strait were in the biological limit reference point. The lower SPRs of BSC (Table 2.) implies more disturb recruitment of BSC in the population.

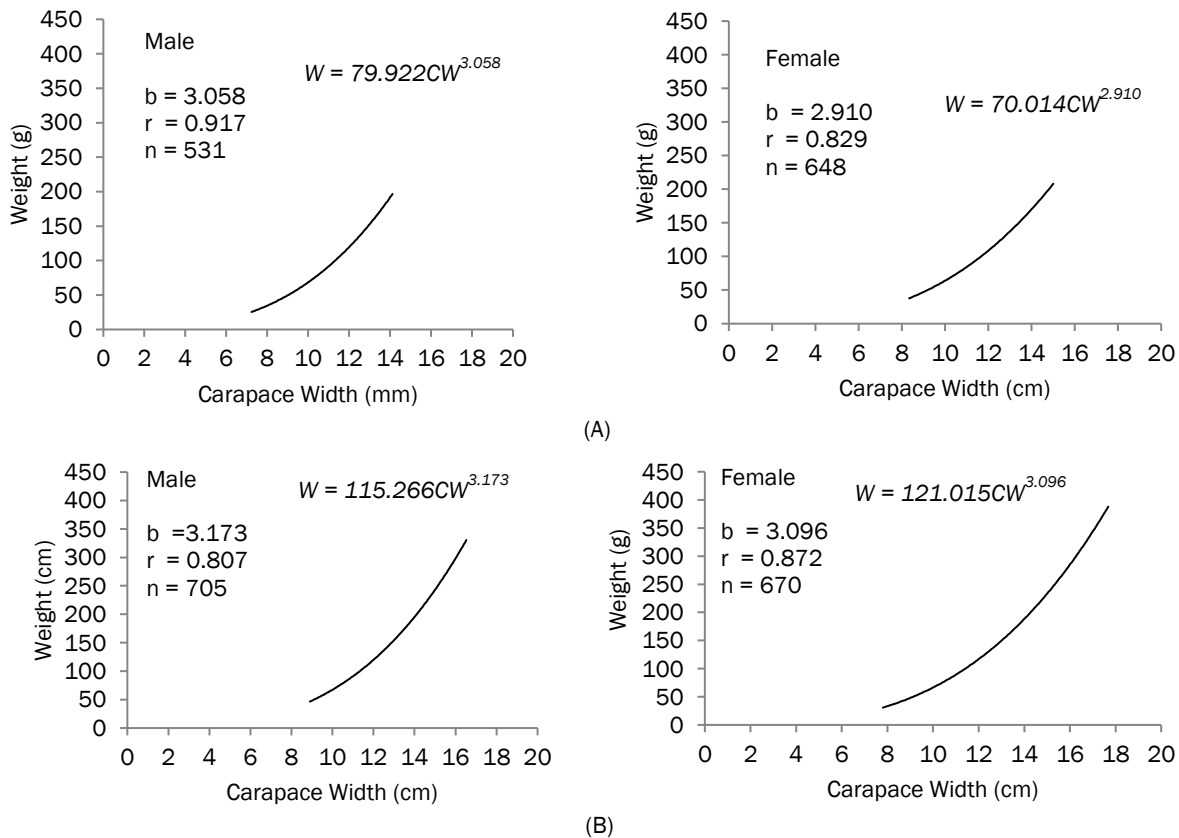


Figure 2. Blue Swimming Crab Carapace width (CW) and Body weight (W) Relationship in Tiworo Strait, Southeast Sulawesi (A = Bangko island; B = Gala island)

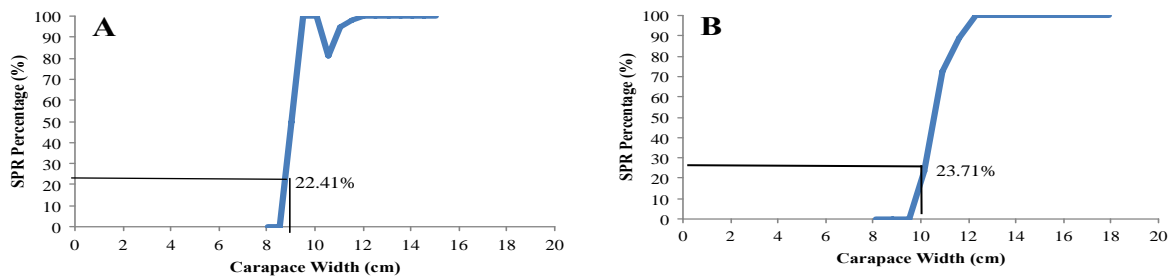


Figure 3. Estimated of BSC SPR in Tiworo Strait, Southeast Sulawesi (A = Bangko island; B = Gala island)

The BSC CW size at first gonad maturity (CW_{50}) analyzed using cumulative percentage of 50% (stated from cumulative total of CW size) was 9.16 cm and 10.16 cm, respectively (Figure 4.). The size at first gonad maturity of BSC in fishing ground of Bangko island (<10 cm) indicates that it needs to be wary in the exploitation of BSC due to BSCs caught by fishermen had small CW which had not spawned yet. The exploitation BSC size of <10 cm without restrained will lead to over exploited and even to fully exploited.

The age of mature BSCs is generally around one year (Smith, 1982) with varies CW sizes in the various locations. There are several studies had been conducted in the several locations showing different size at first gonad maturity (Table 3). Our data in the

present study are relatively similar with those data in different location. Those data show that size at first maturity may rely on fishing ground of BSCs.

In general, the size at first gonad maturity of BSCs vary depending on latitudes and locations (La Sara *et al.*, 2002; Dineshbabu *et al.*, 2008), habitat (La Sara *et al.*, 2002; Dixon and Hooper, 2009), and species. The study of La Sara (2015) in Tinanggea waters of Tiworo strait explained that fishermen catch BSCs have bigger CW sizes (11.60–13.06 cm) than that of size at first gonad maturity. It is very useful to be maintained in order to sustain BSC population due to almost BSCs caught had spawned. The size of BSC allowed to be caught is ≥ 10 cm (La Sara, 2015; La Sara *et al.*, 2016a; La Sara *et al.*, 2016b).

Table 2. SPR of Portunidae from Various Locations

Location	Species	SPR (%)	Reference
Belitung waters, Indonesia	<i>P. pelagicus</i>	5	Ernawati <i>et al.</i> (2015)
Pamekasan waters, Indonesia	<i>P. pelagicus</i>	28	Balitbangkan KKP and APRI (2016)
Cirebon waters, Indonesia	<i>P. pelagicus</i>	11	Ernawati <i>et al.</i> (2017)
Demak waters, Indonesia	<i>P. pelagicus</i>	15	Seafood Watch Consulting Researcher (2018)
Shark Bay, Western Australia	<i>P. armatus</i>	40	Chandrapavan (2018)

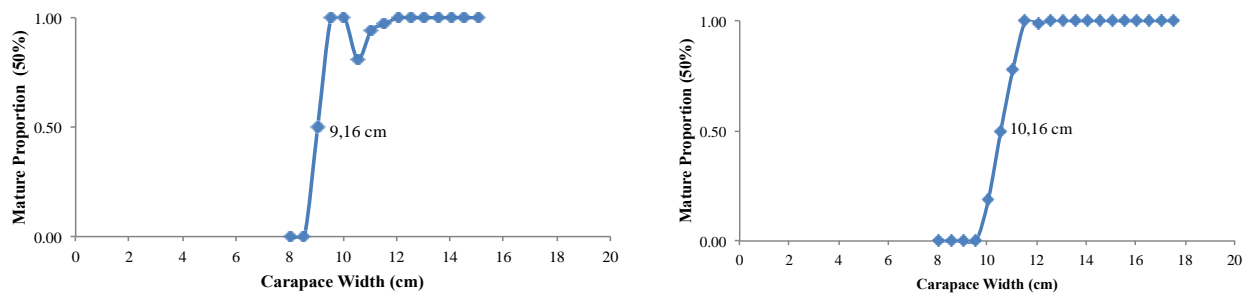


Figure 4. Size at First Gonad Maturity (CW_m) of BSC in Tiworo Strait, Southeast Sulawesi (A = Bangko island; B = Gala island)

Table 3. Size at First Gonad Maturity (CW_{50}) of *Portunus* from Various Locations

Location	Species	Size at First Maturity (cm)	Sources
Tiworo Strait, Southeast Sulawesi	<i>P. pelagicus</i>	11.957 (male) 10.802 (female)	La Sara <i>et al.</i> (2016a)
Pulau Salemo, Indonesia	<i>P. pelagicus</i>	9.20	Nurdin <i>et al.</i> (2016)
Kung Krabaen Bay, Thailand	<i>P. pelagicus</i>	10.62	Kunsook <i>et al.</i> (2014)
Perairan Kien Giang, Vietnam	<i>P. pelagicus</i>	9.92	Ha <i>et al.</i> (2014)
Perairan India	<i>P. sanguinolentus</i>	9.02	Soundarapandian <i>et al.</i> (2013)
Sarawak, Malaysia	<i>P. pelagicus</i>	9.52	Ikhwanuddin <i>et al.</i> (2009)
Ragay Bay, Luzon, Filipina	<i>P. pelagicus</i>	10.50	Dineshbabu <i>et al.</i> (2008)
Leschenault Estuary, Australia	<i>P. pelagicus</i>	87.2 (male) 98.0 (female)	de Lestang <i>et al.</i> (2003)
Estuary Leschenault, Australia	<i>P. pelagicus</i>	9.75	Potter and de Lestang (2000)
Queensland, Australia	<i>P. sanguinolentus</i>	7.42	Sumpton <i>et al.</i> (1989)
Estuary Peel-Harvey, Australia	<i>P. pelagicus</i>	9.83	Potter <i>et al.</i> (1983)
Tiworo Strait, Southeast Sulawesi	<i>P. pelagicus</i>	9.16 (Bangko) 10.16 (Gala)	Present Study

Conclusion

The SPR of BSC stock population of 22.46% AND 23.71% In Tiworo strait indicates that the population status level is in the moderate category exploitation (SPR>20%) and should be maintained as “biological target reference point”. Those SPRs have strong correlation with growth and size at first gonad maturity of BSC which was attained at quite big CW of 9.16 cm and 10.16 cm. It implies that those BSCs have spawned at least once to maintain its population sustainability. This result of study is in line with the Ministry Regulation of Marine Affairs and Fishery of the Republic of Indonesia No.1/2015 which only allows fishermen catch BSC when CW size of ≥ 10 cm as minimum legal size.

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