Indonesia Blue Swimming Crab Fishery Improvement Project

Stock Assessment of the Blue Swimming Crab (*Portunus pelagicus*) for Sustainable Management in Java Sea in 2016

Conducted by

Center for Fisheries Research and Development, Ministry of Marine Affairs and Fisheries

Jalan Pasir Putih II, Ancol Timur, Jakarta,Indonesia

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Indonesian Blue Swimming Crab Association

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PERSONELS

The research was implemented by experts, research staff, as well as some of support enumerators in each sampling sites.

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Executive Summary

The Java Sea is the most southern part of the Sunda Shelf, where the latter connects the western part of Indonesia with the Asian mainland. The Java Sea itself is bordered by the Southern part of Sumatera, Kalimantan and by the northern coast of Java. Blue Swimming Crab (BSC) fishery has been playing as one of the commercial commodities until now. Intensive crab fishing activities conducted since the 1990s in line with the increasing demand of international markets in the USA.

Data describing the status of the blue swimming crab (*Portunus pelagicus*) fishery was collected from three important sites including Jakarta, Rembang, and Pamekasan-Madura in Java Sea (WPP 712) in 2016 by the Center for Fisheries Research and Development Ministry of Marine Affairs and Fisheries, and Indonesian Blue Swimming Crab Association over a period of 7 months between May and November 2016. Field data was collected at each sampling station by scientiest and enumerators.

Length-Based Spawning Potential Ratio (LB SPR) is a new and delightfully unconventional approach to stock assessment, developed over the past six years by a team of scientists in Western Australia led by Jeremy Prince and Adrian Hordyck. The LB SPR approach enables fishing communities and fishery managers in less developed countries (and elsewhere) to assess the status of fish stocks and then make local decisions about future management measures. Spawning potential ratio (SPR) – also referred to spawning potential per recruit – is not a new concept in the annals of fishery science. The LB SPR approach differs from conventional SPR approaches in terms of the initial data input requirements and the mathematical model used to calculate the spawning potential of the 'Fished' and the 'Unfished' fishery. The initial software application for LB SPR application entitled ***What's the Catch – assessing fisheries with limited data*** is available for anyone to use on the University Murdoch's web site[1].

Three thousand and ninety-fives (3,095) females and two thousand,two hundred and sixteen (2,216) males Blue Swimming Crab (BSC) were measured by enumerators at three sampling locations in Java Sea in 2016. The smallest and the largest female crabs caught were measured 64.94 mm and 163.70 mm carapace width (CW), respectively. The average size of female crabs caught in the Jakarta measured 126.58 mm (Standard Deviation 12.17 mm), 125.61 mm (Standard Deviation 12.75 mm) in Rembang, and 115.49 mm (Standard Deviation 15.47 mm) in Pamekasan-Madura. Carapace width measurement for female crab were uploaded to the LB SPR aplication ***'What's the Catch'*** in the form of a single coloumn Excel file (.csv format). The estimated spawning potential ratio (SPR) for the BSC fishery in Java Sea was 0.21 (StdDev 0.005) in Rembang and 0.28 (StdDev 0.007) in Pamekasan-Madura. The residual spawning potential (SP) of the BSC stock in Java Sea after fishing in 2016 was therefore 21% in Rembang and 28% in Madura. However, the SPR for the BSC in Jakarta could not estimate properly due to few fishers and lack of catch and sample during first half of observation periods and almost no BSC fisher caught the crabs at second half, because they change fishing tools and target. The results of the LB SPR assessment indicate that the BSC fishery in Java Sea was operating at above limit reference point (*i.e,* the Limit References Point SP = 20%) in 2016.

The lenght on selectivity (SL) for 50% and 95% of the catch were 123.3 mm (1.51 mm) in Rembang and 118.6 mm (2.19 mm) in Madura, respectively. The selectivity curve for the BSC fishery in all sampling sites was positioned well to the right of generic maturity curve of the population of *Portunus pelagicus* from the BSC fishery in Indonesia. The results of the LB SPR assessment suggest that the operation of the fishery enables almost all BSC to mature before entering the fishery.

The ratio of fishing mortality to natural mortally (F/M) was 4.0 (StdDev 0.38) in Rembang and 2.88 (StdDev 0.35) in Pamekasan-Madura. The value of F/M estimated for the Java Sea fishery in 2016 is almost three to four times the generally accepted target value for F/M for a sustainably fishery (< 1.0). Althought the estimated of F/M ratio is much higher than the generally accepted target F/M value for sustainable fisheries, other data suggests that fishing mortality (F) is target larger, older crabs in the fishery. The corollary of this being that immature and juvenile crabs unlikely to be subjected to the level of fishing mortality indicated by the assessment. If this is so, the higher value of F/M observed from the fishery is not as much of a concern to the sustainability of the stock, as the estimate of F/M suggest.

Recommendations

Recommendations are proposed of further improve the BSC fishery in Java Sea (WPP712):

(1) BSC fishing communities, with the assistance of the Center for Fisheries Research and Development and the support of the APRI should take appropriate measures to decrease the curent level of BSC fishing pressure in 2017/18 to increase SPR at 40%,

(2) Continuously implemented and monitoring the Ministerial regulation concerning minimum legal size as well as destructive fishing,

(3) Monitoring population dynamics parameter and SPR in each two years at study sites,

(4) An appropriate spatial temporal data collection and stock analysis in Jakarta Bay during 2017 to understand the BSC population at relatively different population and environmental condition in Java Sea.

(5) Completing data and information of BSC stock assessment or stock monitoring in Java Sea, such as at east coast of Lampung, southern Kalimantan and Bangka Belitung in 2018.

FIP Activities : Stock Assessment of the Blue Swimming Crab (*Portunus pelagicus*) for Sustainable Management in Java Sea

Period : May – December 2016

Head of
Center for Fisheries Research and Development
Ministry of Marine Affairs and Fisheries

Prof. Dr. Hari Eko Irianto

Acknowledged by

Indonesia Blue Swimming Crab Association (APRI)

Kuncoro Catur Nugroho
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INTRODUCTION

The Java Sea is the most southern part of the Sunda Shelf, where the latter connects the western part of Indonesia with the Asian mainland. The Java Sea itself is bordered by the Southern part of Sumatera, Kalimantan and by the northern coast of Java. Blue Swimming Crab (BSC) fishery has been playing as one of the commercial commodities until now. Intensive crab fishing activities conducted since the 1990s in line with the increasing demand of international markets in the USA. According to Kailola *et al*. (1993) and Ng (1998), the distribution area of BSC are contributed in the waters of the Indo-Pacific, the Indian Ocean and east Pacific Ocean. Sumiono (1997) and Sumiono *et al*. (2011) mentioned the main distribution of BSC in Indonesia occured in the east coast of Sumatra, the north coast of Java and south Sulawesi, south and east Kalimantan. The Jakarta, Cirebon, Demak Rembang and Madura have been the largest significant producers in north of Java. Meanwhile, in the south of Kalimantan occurred at the area of Sampit and Tanah laut.

The production of BSC of Java Sea make an important contribution to total production of BSC of Indonesian. According to Anonymous (2015), about 35.78% of total catch of Indonesia BSC was produced from Java Sea in 2014. More over, the number of fishers based of the coast of the Java Sea. In 2014, the production of BSC in Fisheries Management Area of Java Sea (WPP-NRI 712) was 18,780 tons. The BSC production of Java Sea in 2000-2014 was fluctuated. Significantly increased production occurred between the years 2004-2008, followed by a decline in 2004and 2009, and increased again in the next following years.

The operation of the fishing gear to catch BSC was largely limited to waters shallower than 50m, and concentrated in the depth between 5 to 30m. The fishers caught of BSC in coastal waters by using collapsible traps and botom gillnets as the main gear.The fishing gear used is depending of fishing ground characteristics. The BSC is also a retained species in other fisheries such as those using trawl nets, trammel nets, , and seine nets.

Research of stock assessment of BSC in the Java Sea has been carried out in 2014 onwards and were collected continuously to the end of 2016 as a cooperation network between Center for Fisheries Research and Development (Puslitbang Perikanan) and Indonesian Blue Swimming Crab Processing Association (APRI). The present research proposed the status of BSC resources of the Java Sea based on primary and secondary data collected by scientists of 'Puslitbang Perikanan' and enumerators. The preliminary results it was found that the estimated population parameters of *Portunus pelagicus* from some sampling sites in north coast of Java were different values of growth rates, mortality rates and exploitation rates, as well as refference points to determine the status of the stock of BSC and harvest control rules. The result then give an indicates that wide prospect for development with the assumption that each location provide a separate unit stock. So, for completing data and information of BSC stock assessment of in Java Sea needs research surveys from other sampling sites.

Puslitbang Perikanan and APRI cooperation networks reported upon here was one of the outcomes of the Seminar on the Stock Assessment of BSC in the Java Sea, which took place

in Bogor at the beginning of 2015. From these Seminars agreed to cooperate in carrying out of a advanced research of the Stock Assessment of BSC in the Java Sea and adjacent areas, to provide the basis for sustainable management of BSC. In effective fishery management, the decisions made by policy makers should be based on accurate data and information obtained from research results.

Management measures based on stock assessment and referent points have been applied in BSC fisheries of Indonesia. Currently, BSC fisheries management in Indonesia was made based on size limitations of BSC and maturity stages of females by the Regulation of the Minister of Marine Affairs and Fisheries No. 1/2015 and Minister Circular Letter No.18/2015. These regulation contained that minimum legal size (MLS) for BSC caught was 10 cm in carapace width or individual weight of 55 grams. Meanwhile, ovigerous female should not be caught. The regulation applies until January 1, 2016. For the management purposes, the evaluation should always be performed to assess whether the need for adjustments or new measures are necessary. The evaluation should be done together with the stakeholders, as the basic fisheries manager part of their territory of interest.

ACTIVITIES

The activities includes stock assessment of Blue Swimming Crabs (*Portunus pelagicus*) in the Java Sea, especially in sub areas of fisheries management at north coast of Java. The scope of these activities includes Biological sampling and on-port observation at certain location (Pulau Lancang, Rembang, and Pamekasan).

The outputs are expected to be use as a basic for development planning and Fisheries Management Plan (RPP), such as : stock status and population. Dynamic.

OBJECTIVES

The objectives of the activities are as follows:

1. To collect and analyze biological data include : population parameters (growth, mortality), mean carapace width of first capture and first maturity, and analysys of Spawning Potential Ratio (SPR)
2. To estimate stock status of BSC through analytical model in three sampling points (Pulau Lancang, Rembang and Pamekasan).

MATERIALS AND METHODS

1. Research Area

The research area was cover FMA-712. Java Sea . These include 3 sampling sites for biological analyses, i.e. Jakarta Bay (site : Pulau Lancang), Rembang, and Madura Strait (site : Pamekasan). (Figure 1).

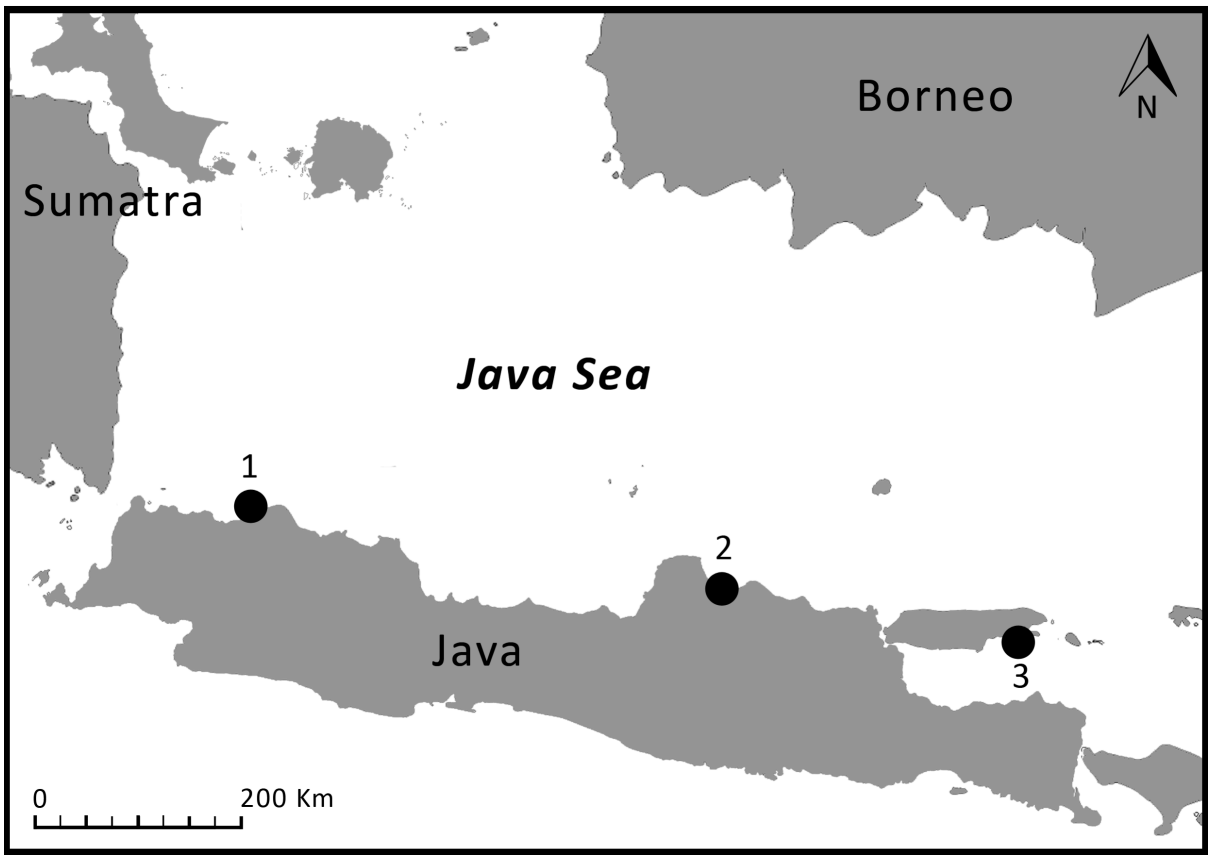


Figure 1. Sampling site for BSC research activities in Java sea (1: Jakarta, 2: Rembang, 3: Pamekasan) over period May to November 2016

2. Data Sampling

2.1. Landing survey

Information on catch and effort of BSC fisheries will be collected by enumerators using sampling sheets. During monthly periods, enumerators go to BSC's collectors ("pedagang pengumpul rajungan") to interview about fishing activities (fishing ground, BSC's landing, fishing numbers). By end of the month, the forms will be sent to Puslitbang Perikanan encoding into the BSC database.

2.2. Biological survey

Biological sampling activity of the BSC will be collected weekly in each month. Each sampling period 100 BSC were randomly sized from the catches of fish trap and gillnet fishing boats. BSC samples was analyzed individually for sex, carapace width (CW, mm), body weight (W) and maturity stage (barried females). CL and CW were measured to nearest 0.1 mm using digital caliper. Gonad maturity stages was determined using the scale of 5 level as discribed by Sumpton *et al*. (1994). Four months data have been collected from Pulau Lancang i.e. June-November 2016, Rembang and Pemekasan from May-November 2016 and June-November, respectively.

Table 1. Number of *Portunus pelagicus* samples based on sex (male and female) at each landing site.

Site	Period	Male	Female
Jakarta	May-August 16	177	476
Rembang	May-Nov 16	1095	1204
Pamekasan	June-Nov 16	944	1415
Total		2216	3095

3. Data analysis

3.1. Biological data analysis

Carapace width – weight relationship

Length – weight relationship of BSC is fitted using power regression for male and female BSC separately: $W = a*CW^b$ for the carapace width with weight. Where CW is carapace width, a is anabolism and b is catabolism factor. The size – weight relationship of male and female is tested using t-test

Growth.

The growth parameters of BSC are determined by fitting the von Bertalaffy growth function $CW_t = CW_\infty * (1-e^{-k(t-to)})$ to the length frequency to the length frequency data using ELEFAN 1 incorporated in FiSAT II (Gayanilo *et al*., 2005) where CW_t is the carapace width at the time t; CW_∞ is the asymptotic carapace width; k is growth coefficient; t_o is the theory assumed carapace width at age 0.

Mortality

Natural mortality can be estimated using the empirical formula Pauly (Sparre & Venema, 1999) are as follows:

$$L_nM = -0.152 – 0.279* \ln L_\infty + 0.6543 \ln K + 0.4634 \ln T$$

Length and Converted Catch Curve (LCCC)

LCCC method is analysed by using monthly carapace width frequency data. It's method can estimate the total instantaneous mortality coefficient (Z), natural mortality coefficient (M) and fishing instantaneous mortality coefficient (F). To obtained the exploitation rate (E) of BSC was calculated by the following the equation : E = F/(F+M). A stock has over exploited if *E>0.5* or under exploited if *E<0.5*. It's assumed that optimal exploitation (*E opt*) is 0.5. Using of *E ~ 0.5* as the optimum value exploitation of the stock is assumed if natural mortality could be equal with fishing mortality (F=M) (Gulland, 1971).

Size at first maturity

Size at first maturity (CW_{m50}) of BSC is estimated by fitting a logistic curveto the relationship between proportion mature and size class:

$$P = \frac{1}{1 + e^{[-r(CW - CW_{m50})]}}$$

(King, 1995) where P is the proportion mature and r is constant.

Size at first captured

Calculating the average size of crabs at first time captured (L_{50}) or Lc in the same gear as the trap or trawl selectivity approach is to use the escape gap logistic function. The formula used is as follows :

$$r(l) = \frac{\exp(a + bl)}{1 + \exp(a + bl)}$$

Where :

r(*l*) = opportunities crabs on certain size that retained

l = carapace width of crabs that captured

a & b = selectivity curve parameters (a<0 and b>0), so the carapace width at 50% retained, L_{50} or Lc will be: L_{50} = -a/b

Spawning Potential Ratio (SPR)

The spawning potential ratio is an index of the relative rate of reproduction in an exploited stock. The basic concept of SPR is a proportion of the unfished reproductive potential left by fishing pressure. By explanation, unfished stock and individuals in an unfished stock have an SPR of 100% ($SPR_{100\%}$) and fishing mortality decreases $SPR_{100\%}$ from the unfished level to $SPR_{X\%}$ (Prince *et al.*, 2014). SPR method is recommended for applying to stocks in poor data fisheries (Brooks *et al.*, 2010). SPR will be calculated for each site.

RESULTS

Carapace width composition and Carapace width – weight relationship

The study observed that smallest and largest size of males caught were 80.81 mm CW in Rembang and 167.79 mm CW in Pamekasan, whiles the smallest and largest females were 64.94 mm CW in Pamekasan and 163.7 mm CW in Rembang. However, the smallest average males and females size was 111.86 ±16.87 mm 115.49 ±15.47 CW in Pamekasan (Table 2). The average size of both male and female crabs in Jakarta (125.65±12.95 mm CW) seem to be larger than the other two sites since most the smallest crabs have been not caught by the smallest net mesh size and minitrawl in Jakarta Bay. In addition, most of BSC fisher change the fishing gear and target.

Table 2. Width composition male and female of BSC at each landing sites during study period

Site	Male (mm)			Female (mm)			Pooled data (mm)		
	min	max	mean±SD	min	max	mean±SD	min	max	mean±SD
Jakarta	85.45	156.77	123.14±14.58	91.95	156.34	126.58±12.17	85.45	156.77	125.65±12.95
Rembang	80.81	164.31	121.66±13.8	80.67	163.7	125.61±12.75	80.67	164.31	123.73±13.40
Pamekasan	67.34	167.79	111.86±16.87	64.94	157.09	115.49±15.47	64.94	167.79	114.03±16.14

The males were heavier than females as shown by bigger *b* exponent for males (Table 3). The values for exponent (b) in the present study was differed significantly than 3 (b<3 or b>3) indicated allometric growth.

Table 3. Carapace width-weight relationship of *Portunus pelagicus* by landing sites

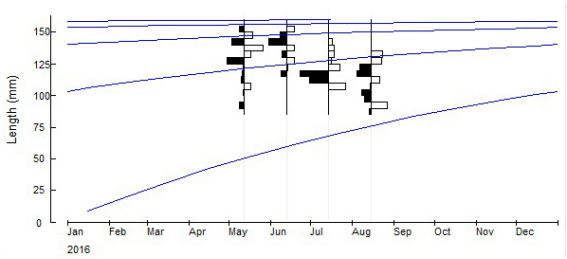
Sex	Variable	Length-weight relationship ($W = aL^b$)		
		Jakarta	Rembang	Pamekasan
Male	a	0.000009	0.00001	0.00001
	b	3.4358	3.4093	3.3846
	R^2	0.9309	0.9347	0.9624
Female	a	0.00002	0.00003	0.00003
	b	3.3013	3.1972	3.1364
	R^2	0.8946	0.9145	0.9524
Pooled data	a	0.00002	0.00005	0.00003
	b	3.2862	3.2416	3.1364
	R^2	0.8932	0.9075	0.9524

Growth

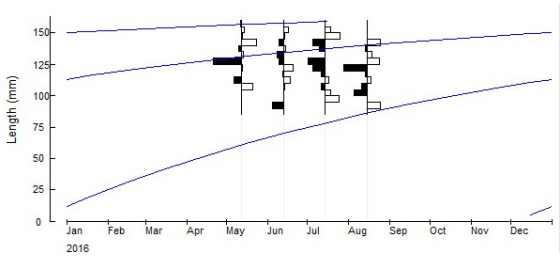
The growth parameters have indicated variation in different locations. The growth of BSC by monthly carapace width distribution in three landing sites is shown in Figure 2. The von Bertalanffy growth equation can determine the maximum age of BSC in each locations. The infinite length of males and females at three landing sites was ranged from 161.50 to175.00 mm and 171.30 to 178.30 mm; with maximum age was less than 3 years and growth rate (K) has indicated a fast growth as shown by K value more than 1. (Table 4).

A

Male

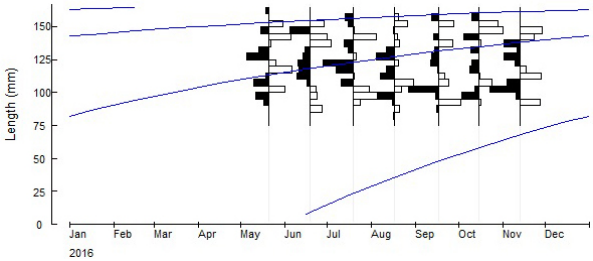


Female

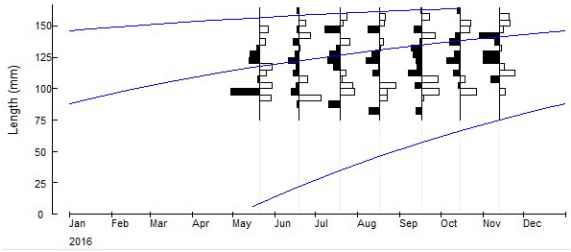


B

Male

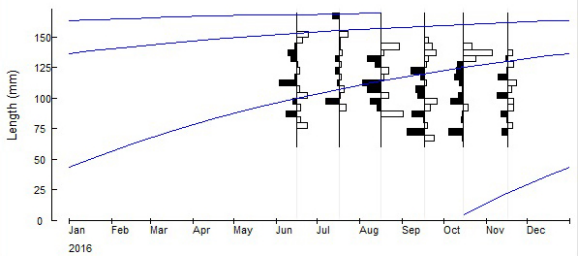


Female

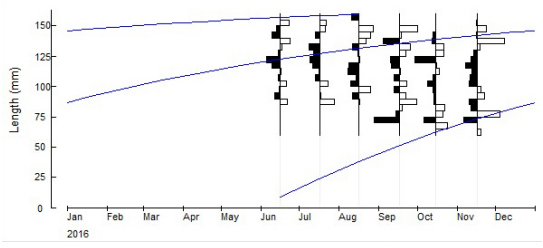


C

Male



Female



Figures 2. Growth of BSC by monthly carapace width distribution based on sex in three landing sites (A: Jakarta, B: Rembang, C: Pamekasan) in 2016

Table 4. The growth parameters: L∞ (mm) = length at infinity, K (per year) = growth rate, to = age, tmax (year) = maximum age of BSC at each landing site.

Site	Sex	Growth parameters			
		L_∞ (mm)	K (per year)	t_o	t_{max} (year)
Jakarta	Male	161.50	1.01	-0.0990	2.97
	Female	171.30	1.01	-0.0974	2.97
Rembang	Male	173.25	1.10	-0.0889	2.72
	Female	178.30	1.03	-0.0944	2.91
Pamekasan	Male	175.00	1.23	-0.0789	1.24
	Female	171.60	1.20	-0.0814	2.50

Length and Converted Catch Curve (LCCC)

The result of mortality estimate in three locations was varied (Table 5). The analysis result showed that exploitation rate (E) of BSC in Jakarta, Rembang dan Pamekasan is higher than 0.5. So, it can said the exploitation rate of BSC in all landing sites had been over exploited.

Table 5. Mortality parameters and exploitation rate (Z = Total Mortatility, M = Natural Mortality, F = Fishing Mortality), E = Exploitation rate)

Location	Sex	Z	M	F	E
Jakarta	Male	-	-	-	-
	Female	-	-	-	-
Rembang	Male	4.16	1.19	2.98	0.72
	Female	4.65	1.13	3.52	0.76
Pamekasan	Male	4.87	1.27	3.60	0.74
	Female	4.89	1.26	3.63	0.74

Size at first maturity and at first captured

The mean carapace width at first maturity (L_m) in Java sea that landed in some landing sites is 100 mm and 103.8 mm carapace width (Table 5), with the lowest Lm of female crabs was landed in Pamekasan-Madura and it could not estimate female crabs Lm properly in Jakarta since the few smale size sample obtained and related fishing .

Table 6. The mean length (mm) at first maturity (Lm/L50) and mean carapace width at first capture (Lc) of female BSC from collapsible trap used at each landing site.

Site	Lm/L50 (mm)	Lc/L50 (mm)
Jakarta	-	-
Rembang	103.80	123.30
Pamekasan	100.00	118.60

The carapace width at first capture (L_c) of BSC was varied at three landing sites. The lowest L_c was obtained from bottom gillnet in Jakarta and followed by dredge net in Cirebon (Table 7). The highest L_c was observed from Collapsible trap and gill net from Demak and Sampit, respectively.

Table 7. The life history parameters used to estimate the status of the female Blue Swimming Crabs population in the study sites, using the Length Based Spawning Potential Ratio approach.

The life history paramenters	Jakarta	Rembang	Pamekasan
Mortality/Growth Ratio (M/k)	-	1.09	1.05
Size on Maturity (50%) (L_{50})	-	103.80 mm	100.00 mm
Size on Maturity (95%) (L_{95})	-	150.00 mm	145.00 mm
SoM/Linf Ratio (L_{50}/L_∞)	-	0.58	0.58
Length Infinity (L_∞)	171.30 mm	178.30 mm	171.6 mm
B (egg production α lengths)	-	-	-

Spawning Potential Ratio (SPR)

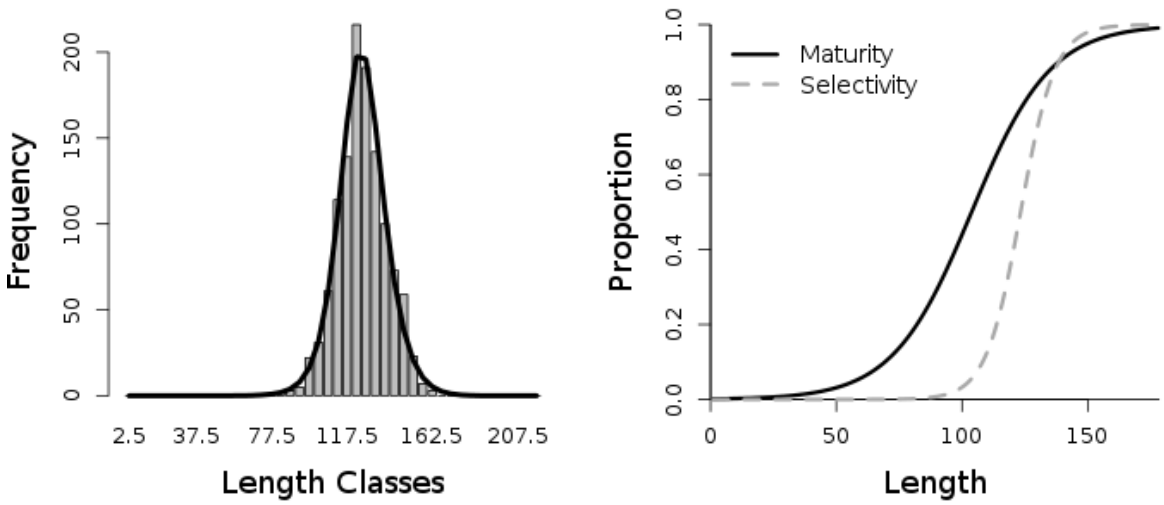
The estimated spawning potential ratio (SPR) for BSC was in 21% and 28% at each landing site in Rembang and Pamekasan, respectively (Table 8). The SPR below 20% means that Biological Limit Reference Point below which reproductive potential should not be allowed to fall in case recruitment is impaired. While the SPR in Rembang and Pamekasan-Madura was observed below 30%; meaning that Biological Target Reference Point the bottom-line target for purely sustainability concerns (Table 7). The highest length on selectivity of the catch was 123.9 mm (SD 1.51mm) and 143.5 mm (SD 2.50 mm) in Rembang for 50% and 95%, respectively. An image of the data uploaded to the online application and the maturity and selectivity curves calculated by the LB SPR application is shown in Figure 5. The ratio of fishing mortality to natural mortality (F/M) was observed with the highest value in Rembang (4.17) and the lowest in Pamekasan (2.88).

Table 8. Parameter Estimates (SD) from the Length Based Spawning Potential Ratio assessment of the Blue Swimming Crabs fishery in the Java Sea for F/M (Fishing Mortality to Natural Mortality Ratio), SPR (Spawning Potential Ratio), SL50 (Length on 50% Selectivity) and SL95 (Length on 95% Selectivity).

Site	F/M	SPR	S_{L50}	S_{L95}
Jakarta	-	-	-	-
Rembang	4.17 (0.391)	0.21 (0.005)	123.9 (1.466)	143.9 (2.405)
Pamekasan	2.88 (0.35)	0.28 (0.007)	118.6 (2.192)	146.2 (3.3)

The selectivity curve (see figure 3) for BSC fishery at each landing sites is positioned well to the right of the generic maturity curve. The result of the LB SPR assessment suggest that the operation of the fishery enables almost all BSC to mature and spawn before entering fishery.

A



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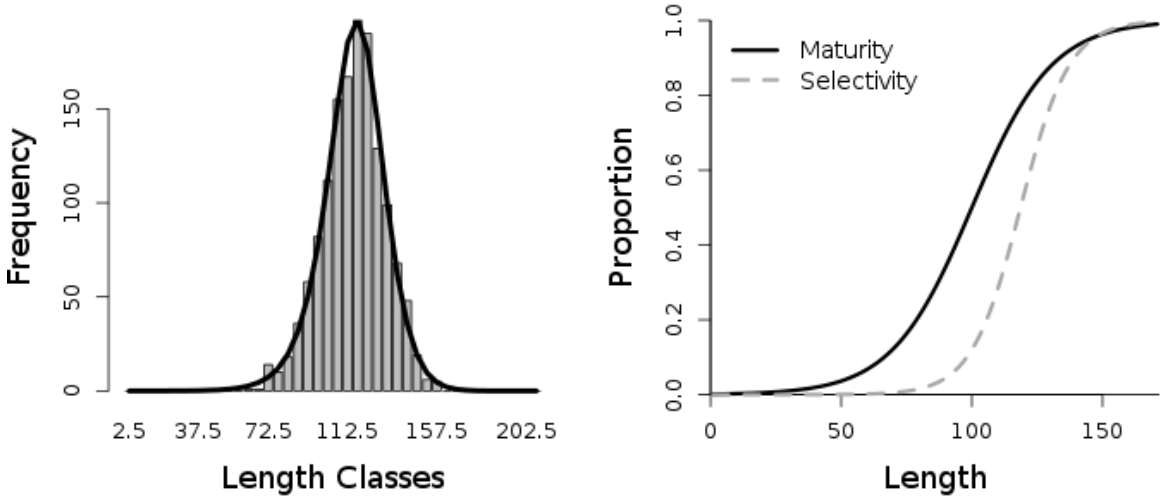

Figure 3. Observed frequency of carapace length classes and proportion of length at each sites showing selectivity and maturity of captured crab at each sites (A: Rembang and B: Pamekasan)

ACKNOWLEDGEMENT

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