

Indonesia Blue Swimming Crab Fishery Improvement Project

**Stock Assessment of the Blue Swimming Crab
(*Portunus pelagicus*) for Sustainable
Management in Indonesia in 2019-2020**

Conducted by



**Asosiasi Pengelolaan Rajungan Indonesia
Indonesian Blue Swimming Crab Association**

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ABSTRACT

The blue swimming crab (BSC) (*Portunus pelagicus*) as a highly valuable commercial fisheries species in Indonesia has received high fishing pressure that caused depletion of its stocks, threatening seafood industries at the local and regional level. The availability of life history parameters is the most important challenge for BSC stock assessment in small-scale and data-poor fisheries. This study aimed to evaluate the life history parameters of growth and maturity and to estimate the stock status of the blue swimming crabs in Indonesia. Biological data of BSC samples were collected from 8 important landing sites in Indonesia from 2019 to 2020. The results showed that growth parameters varied among locations and most BSC reach maturity approximately at 100 mm. The MLS policy had a significant effect on the harvest behavior and spawning potential of blue swimming crabs. Percentage of undersized crabs were mostly low (<10%) at landing sites, while the egg berried female were still relatively high. The estimate LB-SPR showed the value above the limit reference point of SPR20%, indicating the improvement of fishing activity towards sustainability. These results will help provide more insights related to the effectiveness of MLS strategy on improving stock status, and the methodology applied in this study could also be applied to the stock assessment in small-scale and poor-data fisheries.

INTRODUCTION

The blue swimming crab *Portunus pelagicus* (Linnaeus 1758) that locally called rajungan is an economically important commodity and is the the third rank of export of Indonesian fisheries after shrimps and tuna. Processing industries of blue swimming crab plays an important role on the crab production and marketing them abroad. It support fisherman and pickers across Indonesia. Their volume and value of blue swimming crab and mangrove crab exports from Indonesia in 2017 were 29.038 tonnes valued at US\$ 411 million. USA as main country country exporter 90% of total export (Ministry of Marine Affairs and Fishery 2018).

Blue swimming crab are found along Indonesian waters. They were landed from Medan, Lampung, West, Central and East Java, South Sulawesi, Southeast Sulawesi and West Kalimantan. From studies on crab stock and exploitation, reported that some locations mostly overfished. In addition, some crab exploitation rates and population dynamic parameters have been recently studied Kembaren et al. (2012), Ernawati (2013) Hamid and Wardiatno (2015). The results of these studies have shown that the population dynamic parameters (such as growth parameters, recruitment, and mortality) and exploitation rates of crabs varied among locations.

Study of the length-weight relationship in aquatic animals has wide application in delineating the growth patterns during their developmental pathways. In population studies, morphometric analysis provides a powerful complement to genetic and environmental stock identification approaches and length-weight relationships allow the conversion of growth-in-length equations to growth-in-weight for use in a stock assessment model. Information about individual body weight length/width relationships in populations is important for estimating the population size of a stock, specifically for the purpose of its exploitation. The length-width/weight relationships are regarded as more suitable for evaluating crustacean populations.

Historically, the official stock assessments were conducted using a surplus production model. However, in 2015, Length Based Spawning Potential Ratio (LB-SPR), was adopted by *Komnas Kajiskan* (Ernawati et al. 2017). SPR is a measure of the proportion of the unfished reproductive potential left at any given level of fishing pressure. SPR is commonly used to set target and limit reference points for fisheries (Hordyk, et al., 2015a; Hordyk, et al., 2015b). However, assessment of many data poor

fisheries is often limited by incomplete knowledge of life history parameters required to perform quantitative assessment such as SPR.

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 (FMA 712), Pamandati (FMA 714), and Pangkajene (FMA 713). The scope of these activities includes biological sampling and on port observation at four provinces (Central Java: Pemalang, Pati, and Rembang; East Java: Pamekasan, Sumenep, and Gresik; Southeast Sulawesi: Pamandati; and South Sulawesi: Pangkajene Island). 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 evaluate the variations in the life history parameters of growth and maturity of the Indonesian blue swimming.
2. To estimate stock status of BSC using length-based spawning potential ratio (LB-SPR) methods.

MATERIALS AND METHODS

Research Area

The study area cover FMA-712, FMA-713, and FMA-714 of Indonesian water, which include 8 landing sites (Pemalang, Pati, Rembang, Pamekasan, Sumenep, Gresik, Pamandati, and Pangkajene) (Fig. 1).

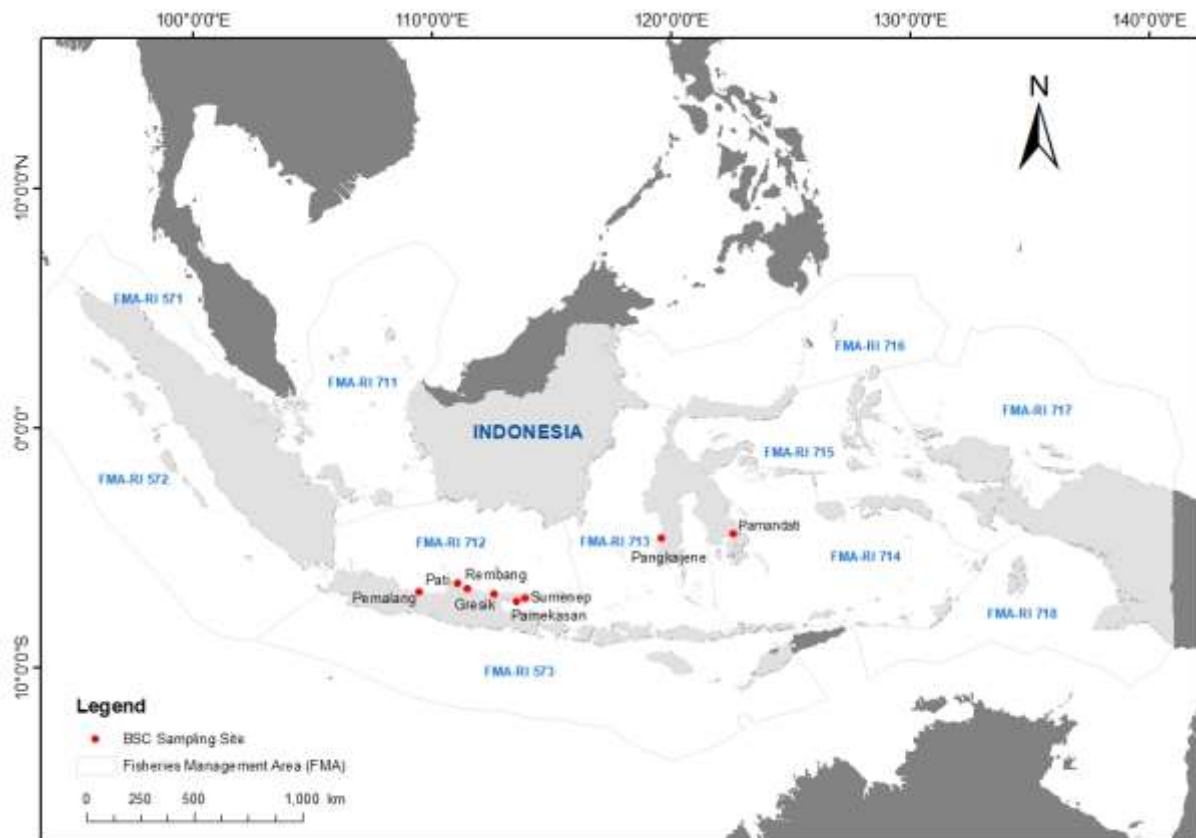


Fig. 1. Sampling site for BSC research activities in Indonesia over period 2019-2020

Data Collection

Biological sampling activities of the BSC were conducted weekly in each month. Trained local enumerators were placed at each site to collect the biological data of landed BSC from local fishers, which include carapace width (mm), weight (g), sex (male and female), and the maturity stages of female crabs. Carapace width was measured to the nearest 0.1 mm using digital caliper. Gonad maturity stages was determined using the scale of three level, which are immature, mature, and berried females. A total of 105745 crabs were recorded over period 2019-2020. Detailed information about BSC samples at each landing site was listed in Table 1.

Table 1 Overview of sampling sites and number of the blue swimming crabs (*Portunus pelagicus*) samples in Indonesia from 2019 to 2020

No	Study Site	Location	Sampling Period	BSC Sample (n)	
				Male	Female
1	Pemalang	Central Java	Jan 2019 – Sept 2020	4566	8625
2	Pati	Central Java	Jan 2019 – Sept 2020	10051	9089
3	Rembang	Central Java	Aug 2019– Sept 2020	6908	7408
4	Pamekasan	East Java	Jan 2019 – Sept 2020	8076	12547
5	Sumenep	East Java	Aug 2019 – Jun 2020	2414	5514
6	Gresik	East Java	Jan 2019 – Aug 2020	9480	4374
7	Pamandati	Southeast Sulawesi	Aug 2019 – Sept 2020	5835	8230
8	Pangkajene	South Sulawesi	Aug – Sept 2020	1188	1440

Data Analysis

Growth parameters

The growth parameters of BSC were determined by fitting the von Bertalanffy growth model (Sparre and Venema 1998), as follows:

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

L_{∞} and K were estimated using the program ELEFAN 1 incorporated in FISAT II. The input data requirement in this analysis was the monthly carapace width frequency.

As for t_0 can be calculated as:

$$\log(-t_0) = -0.3922 - 0.2752 \log(L_{\infty}) - 1.038 \log(K) \quad (2)$$

where L_t is the carapace width at age t (mm), L_{∞} is asymptotic carapace width (mm), K is a growth coefficient (year^{-1}), and t_0 is the theoretical BSC age at zero carapace width. Maximum age of BSC ($t_{\max}$) was equal to $\frac{3}{K} + t_0$ (Pauly 1984).

The natural mortality of BSC was estimated using a empirical formula developed by Hoenig (1983):

$$M = 4.31 t_{\max}^{-1.01} \quad (3)$$

where M is the natural mortality (year^{-1}) and $t_{\max}$ is the maximum age of BSC (year).

Size at first maturity

Size at first maturity was analyzed for female crabs. Female crabs were categorized as immature (gonad level I), mature (gonad level II), and egg berried (gonad level III). The number of mature female crabs (gonad level II&III) was counted for each carapace width class. A logistic curve was fitted to the proportion (P) of sexually mature females by carapace width (King 1995) as:

$$P = \frac{1}{(1 + \exp[-r(L - L_m)])} \quad (4)$$

where L_m is the size of maturity at which 50% (L_{50}) and 95% (L_{95}) of a population is mature, r is the slope of the curve. The Solver function in Microsoft Excel was used to find optimal values of L_m and r .

% undersized and berried female crabs

Ministry of Fisheries and Marine Affair (MMAF) of Indonesia regulated the minimum legal size policy for BSC fisheries (Minister Decree No. 1, year 2015). The policy set a minimum carapace width of 100 mm and the restriction of harvesting berried females. BSC was considered undersized when carapace width less than 100 mm. Berried female was obviously seen by egg mass covering the abdominal flap (Zairion et al. 2015). Percentages of undersized crabs (MLS) and egg berried female (EBF) can be calculated as follows:

$$MLS = \frac{\text{number of BSC} < 100 \text{ mm}}{\text{total number of samples}} \times 100\% \quad (5)$$

$$EBF = \frac{\text{number of egg berried female}}{\text{number of female crab samples}} \times 100\% \quad (6)$$

Spawning potential ratio (SPR)

The length-based assessment of spawning potential ratio (LBSPR) have been widely used for evaluating the stock status of BSC fisheries due to its well-developed theoretical foundation and relatively simple data requirements (Hordyk et al. 2015; Prince et al. 2020). Spawning potential ratio (SPR) is defined as the proportion of natural, or unfished, reproductive production left in a population under fishing pressure (Walters and Martell 2004). Given the fact, unfished stocks have an SPR of 100%, therefore SPR of 20% is accepted as a limit reference point below which

stocks risk recruitment impairment, and SPR of 30-40% is a target level for ensuring sustainable stocks. LBSPR was performed using the web-based interface software (<http://barefootecologist.com.au/>) (Hordyk et al. 2015). The inputs to the LBSPR models are: (i) the M/K ratio, (ii) the mean asymptotic length (L_{∞}), and (iii) the estimated size of maturity (L_{50} and L_{95}).

RESULTS

Carapace Width Composition

The study showed that the size of BSC varied according to landing sites (Table 2). The smallest size of females caught were 65 mm in Pamandati, while the largest was 174 mm in Pamandati too. Similarly to female, the smallest males were 63 mm in Pamandati, while the largest male crabs were recorded in Pamekasan. Table 2 showed the average carapace width of males and females crab found to be largest in Rembang, while the average size of crabs were found to be smallest in Pamandati.

Table 2. Width composition of male and female of blue swimming crabs at each landing sites during 2019-2020.

No	Site	Male (mm)				Female (mm)			
		n	min size	max size	mean $\pm$ sd	n	min size	max size	mean $\pm$ sd
1	Pemalang	4566	66	170	116.3 $\pm$ 13.2	8625	67	167	116.9 $\pm$ 13.5
2	Pati	10051	74	160	110.9 $\pm$ 10.4	9089	75	172	112.9 $\pm$ 12.6
3	Rembang	6908	68	167	120.3 $\pm$ 12.2	7408	71	170	119.3 $\pm$ 14.3
4	Pamekasan	8076	72	172	115.9 $\pm$ 12.6	12547	72	170	117.5 $\pm$ 11.7
5	Sumenep	2414	74	169	113.8 $\pm$ 10.8	5514	72	164	113.0 $\pm$ 10.8
6	Gresik	9480	83	167	117.7 $\pm$ 12.1	4374	81	163	116.0 $\pm$ 11.8
7	Pamandati	5835	63	162	107.0 $\pm$ 17.0	8230	65	174	109.4 $\pm$ 17.5
8	Pangkajene	1188	87	142	113.8 $\pm$ 8.9	1440	85	143	112.8 $\pm$ 9.3

Estimates of Growth Parameters

The growth of blue swimming crab by monthly carapace width distribution at eight landing sites in Indonesia is shown in Fig. 2. The estimated asymptotic carapace width (L_{∞}) of combine male and female BSC ranged from 160.65 to 179.55 mm. The estimated growth parameters (K) were 0.74-1.13 per year. The von Bertalanffy growth equation was used to determine the maximum age of BSC in each location. The

maximum age was less than three year. The rate of natural mortality estimated by empirical formula of Hoenig (1983) was about 1.62-1.77 year⁻¹. These results indicated that Indonesian BSC is a fast growing crustacean with a short lifespan.

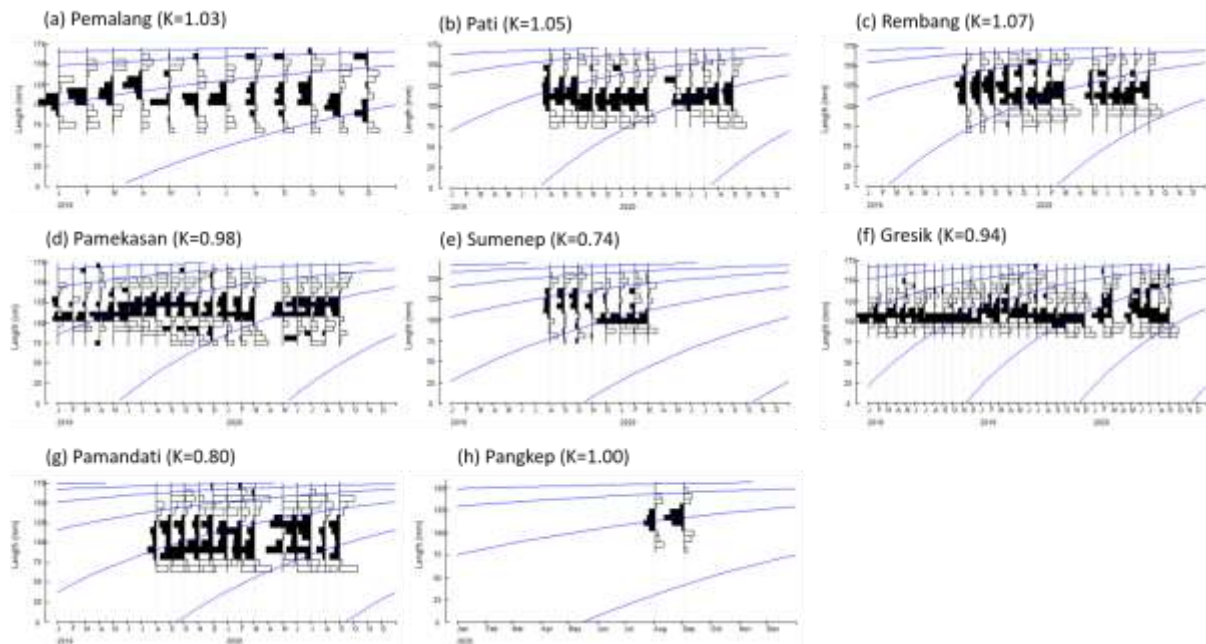


Fig. 2. Length frequency distribution data and the growth curves estimated using ELEFAN for the blue swimming crabs (*Portunus pelagicus*) in Indonesia

Estimates of Size at First Maturity

The logistic curves about a size at sexual maturity showed variations among study sites (Fig. 3). We estimated the mean carapace width at which 50% of female crabs reached maturity (L_{50}) ranged from 86.5 mm to 103.9 mm. Meanwhile, the mean carapace width at which 95% of females crabs became mature (L_{95}) was varied from 106.3 mm to 121 mm. The BSC size at first maturity in Central Java (Pemalang, Pati, and Rembang) was relatively small compared with those in East Java and Sulawesi.

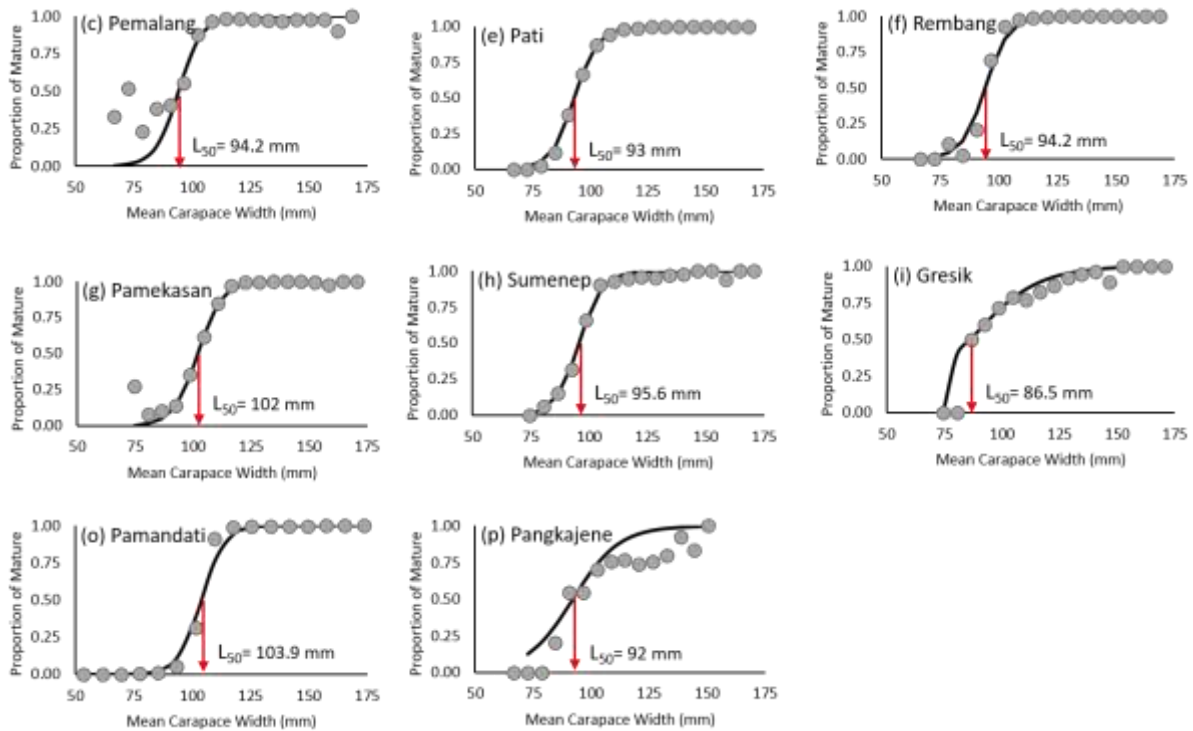


Fig. 3. Logistic curve showing the proportion of mature females blue swimming crabs (*Portunus pelagicus*) for each carapace width ranges in Indonesia

Percentages of Undersized Crabs and Berried Female Crabs

The percentages of undersized crabs and berried female showed great spatial and temporal variations (Fig. 4). The undersized crabs being caught were found to be lowest in Rembang, Pamekasan, Sumenep, and Pangkajene, the percentages were less than 10%. Meanwhile, the highest percentage of undersized crabs was found in Pamandati. Pemalang and Gresik showed an improvement where the percentage of undersized crabs tend to decrease in 2020. Comparatively, egg berried female was still relatively high (>10%) in most landing sites, except Pamekasan and Pamandati.

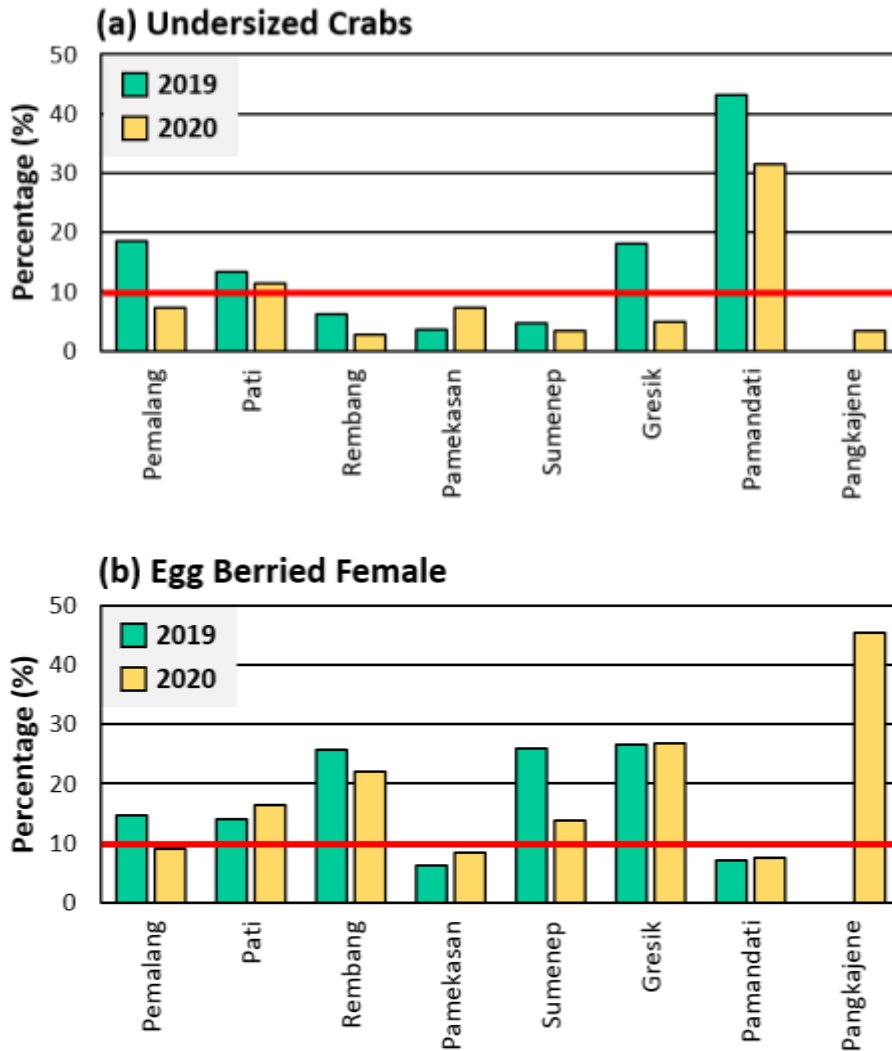


Fig. 4. The percentages of undersized crabs and egg berried female of the blue swimming crabs in Indonesia during 2019-2020

Estimates of Length-Based Spawning Potential Ratio

Table 3 showed the life history parameters used to estimate the stock status of the BSC population across Indonesia using the Length Based Spawning Potential Ratio (LB SPR) approach.

Table 3. The life history parameters used to estimate the stock status of the blue swimming crabs fishery in the study sites, using the length based spawning potential ratio

No	Study Site	Mortality/ Growth Ratio (M/K)	Size on Maturity (L50)	Size on Maturity (L95)	Length infinity (L_{∞})
1	Pemalang	1.470	94.2	107.5	175.35
2	Pati	1.470	93	109.1	178.60
3	Rembang	1.470	94.2	106.3	177.45
4	Pamekasan	1.469	102	115.6	179.55
5	Sumenep	1.466	95.6	115.6	173.25
6	Gresik	1.468	86.5	115.6	176.40
7	Pamandati	1.466	103.9	113.3	179.55
8	Pangkajene	1.471	92	121	160.65

Results showed the mean estimates of spawning potential ratio for Indonesian BSC was varied, ranging from 20% in Pamandati to 38% in Rembang (Fig. 5). The SPR values of BSC in Indonesia are mostly above the limit reference point of recruitment level at SPR 20%. Pemalang and Rembang reach the target reference point of SPR30%. The highest estimated SPR in Rembang and Pamekasan indicated the effectiveness of co-management on harvest behavior by fishers.

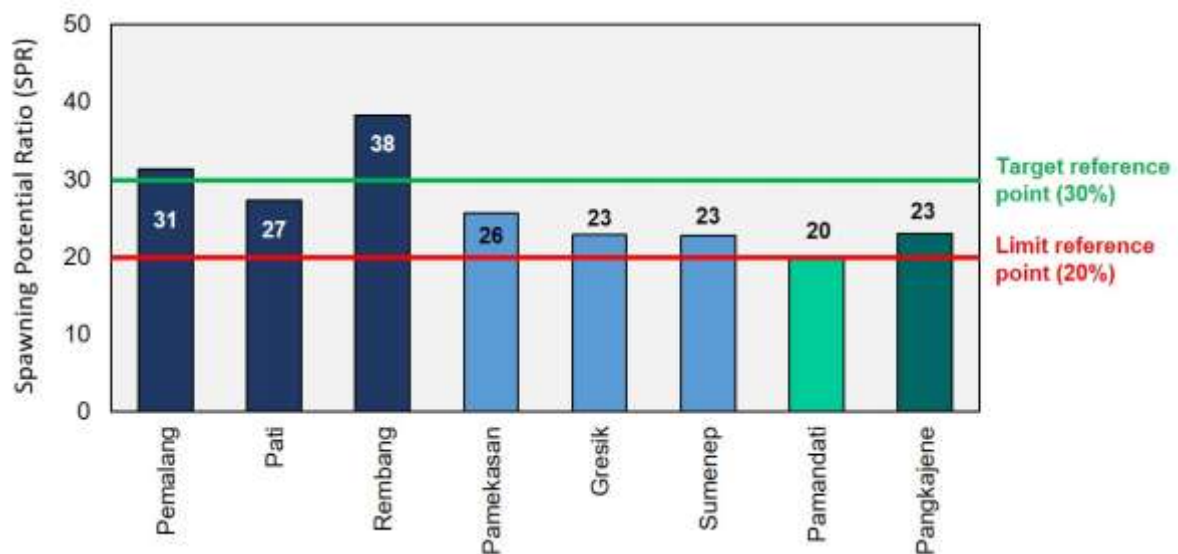


Fig. 5 The estimated spawning potential ratio (SPR) of blue swimming crab in Indonesia over period 2019-2020.

CONCLUSION

The size of blue swimming crabs (*Portunus pelagicus*) varied among landing sites in Indonesia. Growth parameters showed spatial variations, but the results indicated that blue swimming crab in Indonesia is categorized as a fast growing crustacean with a short lifespan. The percentages of undersized crab (<10cm) were relatively low in all locations (<10%), except for Pamandati, while the percentages of egg berried female were still found to be high (>10%). The mean carapace width at first capture was higher than the mean carapace width at first maturity, which mean the BSC was generally captured after mature and spawn. Spawning potential ratio (SPR) of BSC in Indonesia ranged from 20% to 38%, which are above the limit reference point of SPR20%. Management measures are still needed to improve the BSC fishery in Indonesia, especially through GTK5! Program by releasing small crab and egg berried female to the sea or by building crab apartment as a shelter for berried female.

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