Blue Swimming Crab's Conservation Area Determination in The North of Java Sea Using Reproductive Indicator

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Abstract

Despite being operated on a small scale, Blue Swimming Crab (BSC), Portunus pelagicus fishery substantially contributes to Indonesia's fisheries as the country's third-largest export commodity after tuna and shrimp. The high of BSC's demand led to pressure on its stock. Hence a conservation area is needed to be set up, in this study, was proposed using reproduction indicators. with the case study of BSC Stock in Keboromo Waters, Pati Regency, North Central Java. The samples were collected from 38 sampling points at a distance of 2-12 miles from the coastline during November-December 2022 using collapsible crab traps. A reproduction observation on female crabs was carried out on their carapace width and gonad maturity stage. The data then were analyzed for the percentage of egg-berried females (EBF), size at first maturity (L_m) and first captured (L_c), and their spawning potential Ratio (SPR). This study found that the mature crabs (GMS2) in November and December were higher than in other stages while the proportion of ovigerous females (EBF) in December was higher than in November. At several sampling points, the size at first captures (L_c) was higher than that at first maturity (L_m) indicating a decrease in resource stocks due to a delay in the recruitment process. SPR of 19% showed that reproductive potential should be maintained before recruitment is limited, therefore based on the existence of EBF in particular sampling points it is recommended three conservation areas as a temporary no-take zone in BSC fishing ground in Keboromo Watres, Pati Regency.

Keywords: *Egg-Berried Female,* Gonad Maturity Stages*, No Take Zone, Portunus pelagicus*

Introduction

The Blue Swimming Crab (BSC), *Portunus pelagicus,* Linnaeus 1758 has the local name *Rajungan*. BSC is widely distributed in tropical waters. They can be found at depths of 5 to 25 m in the ecosystems of mangroves, sea grass, coral reefs, and estuaries. The highest BSC production in Indonesia is from northern Java and east Lampung (Afifah *et al.,* 2020), and their export gives the highest foreign exchange revenues too. In 2015, Indonesian crab exports were 29,038 tons, and in 2017, they reached 15867 tons (MMAF, 2018). According to Setyaningrum *et al*. (2022), Indonesia exported crabs valued around 613,25 million U.S. dollars in 2021. The primary market for these exports is the United States, which purchases over 80% of Indonesia's blue swimming crab stock. It is comparable to other nations whose demand for crab has grown in international trade (Wiyono and Ihsan, 2018).

The BSC fishery, which is run on a small scale, substantially contributes to Indonesia's fisheries as the country's third-largest export good after tuna and shrimp (Ghofar *et al*., 2018). In addition to attempts to increase crab fishery production, sustainable crab management is required to reduce fishing activity which could lead to a reduction in the crab population (Wiyono and Ihsan, 2018). Hence the sustainability of Indonesia's blue-swimming crab fisheries has attracted increasing attention.

It is impossible to apply a single management strategy to all fisheries resources. Redjeki *et al*. (2020a) assert that management must consider the stock of available resources to maintain a balance between resource use and conservation. According to Secor (2014), each population stock is often distinguished by particular biological characteristics. Phenotype, genetics (Aini *et al*., 2020), or both simultaneously (Hollander and Butlin, 2010) can reveal the disparities. The reproduction stage is a phenotype characteristic that was said could be used to perform a conservation area, such as a restricted zone (Nurdin *et al*., 2020). The benefits of imposing a restricted zone include overcoming the rate of damage and preventing the loss of biodiversity of overexploited populations or habitats (Dahlgren and Tewfik, 2015; Sala and Giakoumi, 2017). The conservation area proposed within this study is

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alternative management to regulate the continuous exploitation of the BSC resource along the North of Java.

Central Java has coastal areas of 971.52 km long, and most of it (645.08 km) lies on the north coast which has very good economic potential, including the BSC resources. Demak, Pati, and Rembang Regencies are blue swimming crab-producing areas in Central Java Province (PDSPKP, 2020). Fishermen generally use BSC resources continuously without regard to resource and environmental conditions (Ningrum *et al*., 2015). According to Wardiatno and Zairion (2011), BSC production in the Java Sea fluctuated and rose in response to fishing activity. It now poses a possible threat to the environment and the resources available to crabs. It was also demonstrated by a decline in crab catch-per-trip and crab size (Zairion *et al*., 2015; Ghofar *et al*., 2018).

A recent management order that sets the minimum legal size (MLS) of caught crabs at more than 100 mm carapace width has been implemented for the Indonesian BSC fishery (MMAF, 2021; 2022). However, the poorly understood reproductive biology of the crab was not fully taken into account when this directive was implemented. Additionally, only a few accurate stock estimates have been conducted in Indonesian waters, particularly in areas with the highest BSC production, like the north coast of Java.

According to several studies (Sunarto 2012; Zairion *et al.,* 2015; Hisam *et al*., 2018; Redjeki *et al.,* 2020b) reproductive biology knowledge could contribute to a better understanding of population dynamics and aid in stock conservation. Because the reproductive biology of BSC is highly variable across its distribution area, it gives more complexity to the design of management strategies. The measurement of stock reproductive potential may become incorporated into scientific recommendations for sustainable fisheries management (Cooper *et al.,* 2013). Extrapolating results from one location to populations in another, such as those in Indonesian coastal waters, would not be suitable because the reproductive potential of BSC resources varied spatially (Johnson *et al*., 2010). To determine an acceptable size-based reference point and create a precautionary approach (PA) to sustainable crab harvesting, such as creating a BSC conservation area, local data on the reproductive biology of *P. pelagicus* in particular waters are needed. The present study aimed to propose the conservation area for BSC based on their reproduction activities.

Materials and Methods

The research was carried out in November and December 2022 to represent the wet season, at Keboromo Waters, Pati Regency of Central Java, one of the BSC fishing grounds in north Central Java belonging to the Indonesian Fisheries Management Area of 712. The *P. pelagicus* samples were collected daily using a collapsible crab trap size of 33,5cm x 31.5 cm x 17.5cm with a mesh size of 1,25 inches) as the main fishing gear of local fishers for which each boat of 1-2 GT set 100-500 units of crab traps (Redjeki *et al*., 2020a, b). The 38 sampling points were laid on an area of 2-11 miles from the coastline (Figure 1.) and the geographical coordinates were presented in Table 1. The crab traps were deployed during flood tide and then were hauled when ebb time began in the following days. Ecological factors were measured simultaneously with setting up the traps, i.e., salinity dissolved oxygen, pH, and temperature using a refractometer, DO-meter, pH-meter, and thermometer, respectively (Redjeki *et al*., 2020b).

Carapace width and weight measurements, and gonad examination

As the examination was only done on the female crab, so after the crabs were removed from the trap, they were separated from the male crabs. Male crabs have a V-shaped abdomen, whereas the abdomen of female crabs is broad and rounded (Hosseini *et al*., 2014), and the abdomen of immature crabs is closely attached to the cephalothorax (Zairion *et al*., 2015). Then, measurements of the carapace width (CW) and weight of the female individual samples were made (Potter *et al*., 2001; de Lestang *et al*., 2003).

The BSC gonad's maturity stage (GMS) was assessed morphologically using modified techniques of Kunsook *et al*. (2014) and Josileen (2015). The three GMS categories of females were as follows. The character of female GMS 1/ Immatures, GMS 2/adult non-ovigerous, and GMS 3/ovigerous/egg-bearing (EBF) were triangular-shaped white/transparent abdomen (V-shape), globular-shaped abdomen (U-shape), and egg-beared in the abdomen, respectively (Figure 3.).

The proportion of egg-berried/ovigerous females (EBF) was calculated as a percentage of females with eggs at GMS 3 ($\sum B_T$) out of total females ($\sum B$) using the method of Pradana *et al*. (2019), as follows.

$$\mathrm{EBF} = \frac{\sum \mathrm{B_T}}{\sum \mathrm{B}} \times 100\%$$

Size at first maturity and at first captured

The minimum size class data of BSC females were used to calculate the length at first sexual maturity (length at maturity/L_{m50}). Crabs with gonad stage 1 were thought to be immature, while crabs with gonad stage 2 and ovigerous crabs were thought to be mature individuals. From the proportions of mature female crabs in each of the five mm CW size classes and the logistic regression curve presented by King (2007), the size at which 50% (L_{m50}) of females were sexually mature was calculated as follows

$$L_m = \frac{1}{1 + \exp(aL + b)}$$

L_m is the proportion of crabs with a carapace width of L that has matured eggs (Razek *et al.*, 2019). Calculation of the average size of the first captured (L_c or L_{c50}) using the escape gap selectivity approach with the logistic function (Spare and Venema, 1999) with the equation:

$$L_c = \frac{1}{1 + \exp(aL + b)}$$

L_c is a crab with a carapace width of L which is retained on the fishing gear; a and b are curve parameters (a< 0 and b> 0), so the length at 50% captured (L_{c50}) is the same as –a/b (Kembaren and Surahman, 2018).

Spawning Potential Ratio (SPR)

To understand the relative reproduction rate in an exploited stock of *P. pelagicus* in Keboromo Waters, Pati, an index of Spawning Potential Ratio (SPR) was applied. The SPR was calculated using the methods of Prince *et al*. (2015) and Hordyk *et al*. (2015), with the web-based interface. The data used is the carapace width of mature female crabs at GMS 2 and GMS 3, which then were input into the website www.barefootecologist.com. The results of the SPR analysis were then classified according to Walters and Martell (2004), in which the status of the fishery consists of 3 groups, namely Under-exploited (> 40%); Moderate (20% < SPR < 40%); and Over-exploited (< 20%). SPR of 20% is the limit of optimal utilization in fisheries management or called Biological Sustainability Limit (Ernawati *et al*., 2015).

Results and Discussion

The traditional blue swimming crab (*P. pelagicus*) fishery in the Pati Regency of north Central Java has been developed since 1993. Although there are four landing sites, *i.e.*, Alastuwo, Keboromo, Margomulyo, and Pecangaan; the catch has not been recorded in the Regency Annual Fisheries Statistics data (Ernawati *et al*., 2014). At present, the study site of Keboromo is the biggest BSC landed. The study was carried out during November-December 2022, based on the data from the Maritime Climatologic Station in Semarang, which is northwest monsoon. The temperature, salinity, dissolved oxygen, and pH in 38 study sites at Keboromo waters range from 27.00–30.00ºC (an average of 28.71±0.76ºC), 27.08–32.99 ppt (an average of 30.07±1.94), 5.08–7.82 mg.L^{-1} (an average of 6.22±0.61mg.L^{-1}), 6.04–8.74 (an average of 7.18±0.79), respectively, which

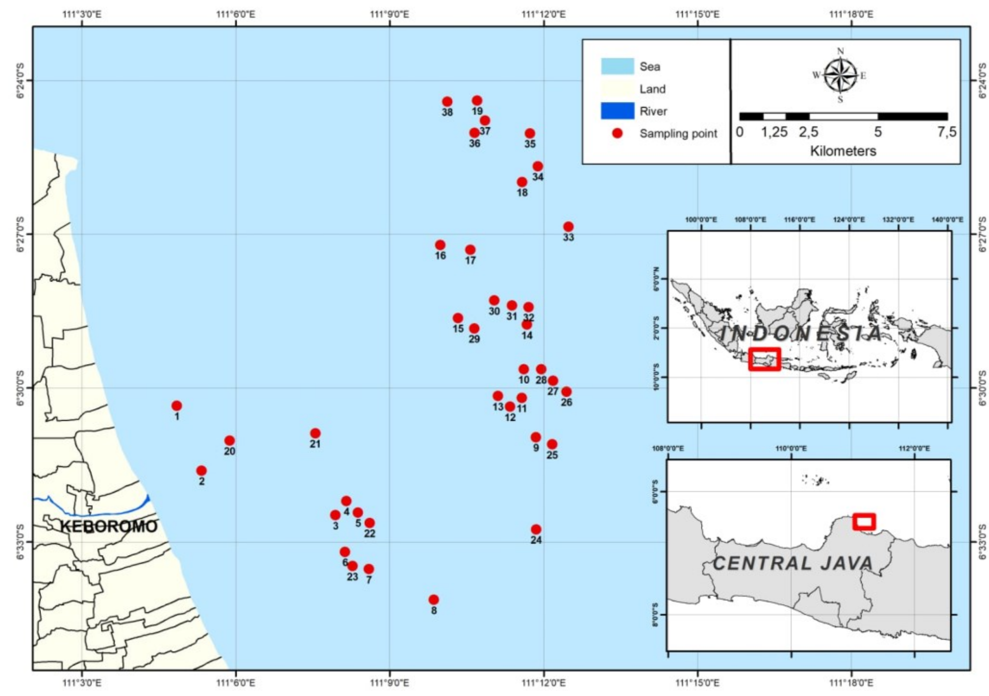


Figure 1. The study area in Keboromo Waters of Pati Regency, Central Java, Indonesia

is in the range of water quality suitable and appropriate for marine life, including *P. pelagicus* (Wagiyo *et al*., 2019; Nabila *et al*., 2022). The water quality in the area near the coast will be influenced by runoff from the land and the river (Sidabutar *et al*., 2019). During spawning, the BSC migrates to an area of higher salinity (Jumaisa *et al*., 2016).

The BSC life cycle is known to be very complex and has patterns of migration or displacement during several phases of its life (Kumar *et al*., 2003). Adult blue swimming crabs move or migrate to the open sea with higher salinity and a muddy sand substrate for spawning and release their eggs (Prihatiningsih and Wagiyo, 2009; Jumaisa *et al*., 2016). The crab eggs hatch and develop into several phases, namely the zoea, megalopa, young (crablet), and adult crabs. The zoea and megalopa phases are planktonic and follow the currents in the open sea with low salinity, while the young crabs live in areas around the coast (Nitiratsuwan *et al*., 2010; Pane *et al*., 2017; Redjeki, 2022). The Keboromo Waters of Pati Regency are suitable for blue swimming crabs. Keboromo waters are known to have a salinity value of 27–32ppt, which is an essential environmental factor that influences the survival rate of the crab larval stage. The adult swimming crab life release their eggs at high salinity (30-32ppt) then the larvae will head to low salinity in the river estuary (Nitiratsuwan *et al*., 2010; Edi *et al*., 2018).

Carapace width and weight measurements, and gonad examination

The samples were separated between male and female crabs and only the females were further observed. A total of 1,105 females (8-49 indv.day^{-1}) of this species were collected and their carapace widths were in the range of 70-168mm and had weight of 20-300g. The size distribution of the carapace width during both months was almost the same, and the highest class was in the 106-114mm class (112 and 162 individuals in November and December). Actually, the allowable CW size captured has been regulated in the Decree of the Minister of Maritime Affairs and Fisheries Number 16 of 2022, *i.e.*, more than 100mm, but in the fishing ground, as seen in Figure 2, the undersize crabs were still captured by the fishers (9 and 12,93% in November and December, respectively).

The range of *P. pelagicus* carapace width found in these studies (70-168 mm) was wider than other studies such as in Alastuwo, Pati (105-134 mm) (Ernawati *et al*., 2015), Lombok (95-155mm (Santoso *et al*., 2016), Kotabaru (90-180mm) (Tirtadanu and Suman, 2017), Jepara (96-165mm) (Setiyowati and Sulistyawati, 2019), Salemo Island (96-134mm) (Nurdin *et al*., 2019), Jakarta Bay (51-134mm) (Wagiyo *et al*., 2019), Bintan, Riau Islands (102-187mm) (Muzammil *et al*., 2021), but narrower than in Betahwalang, Demak (51- 172mm) (Redjeki, 2022). The differences in the width of the crab carapace in various areas may be caused by environmental and genetic factors (Warner, 1977), as well as the process of distribution or migration of crabs. According to Hosseini *et al.* (2012), many young to adult crabs have been identified near the beach and in more profound, highly salinized waters. This carapace width size distribution can be used to indicate the age group of a BSC population (Kembaren *et al*., 2012). During this study, the blue swimming crabs in Keboromo waters are known to have 2 age groups indicating that the condition of the population is stable and sustainable so that where the previous age group begins to decline, it will be continued by the new existing age group and recruitment happen.

The female maturity stages in portunid crabs could be recognized by morphological variation. After assessing based on a modification of Kunsook *et al.,* (2014) and Josileen (2015), the result can be seen in Figure 3.

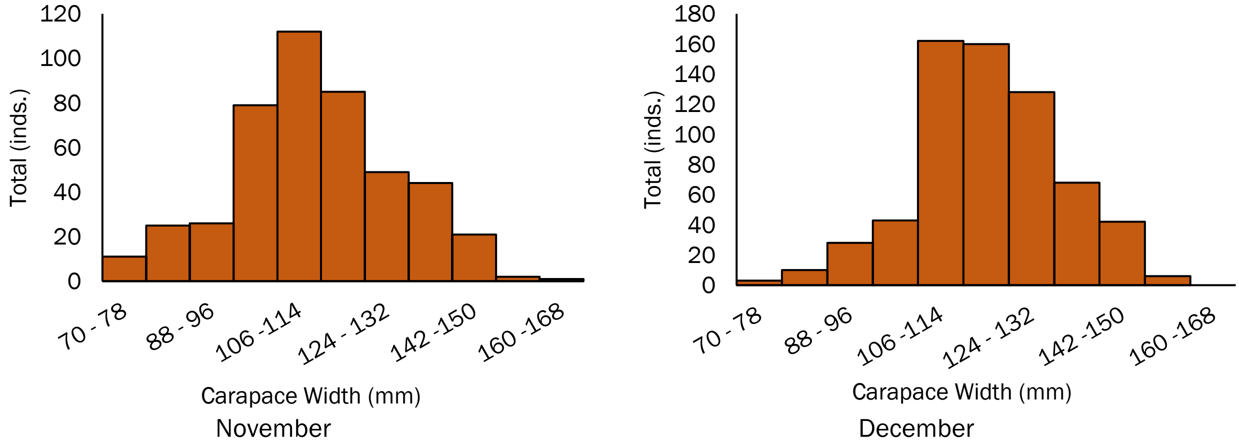


Figure 2. Class distribution of female *P. pelagicus* during the present study in Keboromo Waters, Pati Regency of Central Java.

Figure 3. Gonad Maturity Stages of the *P. pelagicus* Samples based on modified morphological classification by Kunsook *et al.* (2014) and Josileen (2015).

Table 2. Total number, carapace width, and weight of non-ovigerous and ovigerous *P. pelagicus* females at Keboromo Waters, Pati Regency

Female	Total (individual)	Carapace width (mm)	Weight (g)
Non-ovigerous	596	70–159 (108,28±13,79)	20–250 (82,58±33,91)
Ovigerous	509	97–168 (126,83±10,96)	27–300 (142,66±38,72)

The development of the level of gonad maturity in female crabs could be observed macroscopically by looking at the changes in gonad morphology and color (Ikhwanuddin *et al*., 2012). From the gonad examination, in Keboromo waters the female crabs generally have gonad maturity stage 2 (GMS 2) in November and ovigerous female (GMS 3) in December (Figure 4.). The highest number of females with GMS 2 was in sampling point 16 in November (74%; 23 individuals). While in December, the highest was GMS 3 in sampling point 38 (84%; 41 individuals). While the immature female crabs (GMS 1), were found with the highest percentage at sampling point 4 in November (61%; 14 individuals) water and sampling point 20 in December (65%; 11 individuals) and it is assumed to be the new recruit crab population. Based on the analysis of gonadal maturity levels, November and December were the spawning season for female *P. pelagicus* in Keboromo waters.

As could be seen in Figure 4, in Keboromo waters, mature crabs (GMS2) at every sampling point in November and December were 57% and 33% of the total observed female crab samples. Based on the above data, it is known that Keboromo waters have a spawning season in November which is indicated by the highest percentage of mature female crabs (57%) compared to December. According to Lakudo *et al*. (2017), female blue swimming crab spawning occurs throughout the year from October to November.

Comparing the spawning season of Keboromo Waters to other areas such as in Asahan waters where the female crab spawning season occurs in January and August (Pane *et al*., 2017), in the Aru Islands waters was in February-March and August-September (Kembaren and Surahman, 2018) and in Betahwalang waters, Demak, the female crab spawning peaks in February and September (Redjeki, 2022). Environmental factors including water temperature, the availability of food, and fishing activity impact the variations in gonadal maturity levels in each region. Variations in water temperature can accelerate gonad maturity and spawning (Ikhwanuddin *et al*., 2012).

Information on the proportion of egg-berried (ovigerous) females is one of the aspects needed in implementing sustainable management as it can describe the condition of the population, reproductive potential, and survival of blue swimming crabs in Keboromo waters. In total, the number individual of non-ovigerous was higher (596 individuals) than the ovigerous females (509 individuals) (Table 2.), while the proportion of ovigerous females in December was higher than in November samples (Figure 5.). The highest number of ovigerous females was found at sampling point 17 in November (68%; 17 individuals) and sampling point 38 in December (84%; 41 individuals). Female *P. pelagicus* generally lay eggs in December.

Each sampling point in this study revealed nearly equal distributions of female spawning crabs. According to Figure 4, sample points 17 (November; 17 individuals) and 38 (December; 41 individuals) have the most considerable proportions of egg-berried female crabs. This ovigerous female crab is found in the open sea at a distance of 8-12 miles from the coastline. The existence of ovigerous female BCS crabs was influenced by the high salinity value of the waters, where the female crab spawns eggs (Jumaisa *et al*., 2016). The size of the carapace width of ovigerous female spawning crabs ranges from 97-164mm. The sizes of crabs varied with water depth and indicated that there was pressure due to crab fishing in Keboromo waters and its surroundings. The presence of relatively small egg-berried female crabs suggests that the female crab gonads are under pressure to mature more quickly to maintain the population, which will harm the survival of the incubated embryos and prevent them from developing into larvae (Ernawati *et al*., 2015; Lakudo *et al*., 2017).

Size at first maturity and at first captured

The average size at first maturity (L_{m50}) female BSC from Keboromo waters in November and December was 112.53 mm and 114.47 mm, while the average size at first captured (L_{c50}) was 107.21mm and 113.89 mm (Table 3). The difference in the size of the first gonadal maturity and the first time captured in each water is mostly due to fishing activity. The pressure of fishing activity will change the reproductive pattern of the blue swimming crab so that the gonads will mature more quickly (the L_m value is relatively small), this can be proven by the size at first captured which is smaller than the size at first maturity ($L_c < L_m$).

In Keboromo waters there were several sampling points where the values of size at first captures were more significant than the size at first maturity ($L_c > L_m$), i.e., 15.8% (in November at sampling points 13, 17, 19) and 63.2% (in December at sampling points 26, 27, 28, 30, 31, 32, 33, 34, 35, 36, 37, 38). According to Damora and Erfind (2016), optimal fishing conditions are, when the size of the individual caught (L_c) is greater than the size of the mature gonads (L_m), which are crucial for supporting the recruitment process. A catch size that is lower than the maturity size of the gonads will cause a decrease in resource stocks due to a delay in the recruitment process (Pinheiro and Lins-Oliveira, 2006). The comparison of BSC L_c and L_m in another area in Indonesia is presented in Table 4. The L_m and L_c of BSC in Pati were longer in this study than in Ernawati's study in 2014.

Spawning Potential Ratio (SPR)

Spawning Potential Ratio (SPR) is an index to determine the status of the population of blue swimming crab resources in water by using data, one of which is the width of the female carapace (Prince *et al*., 2015; Prince *et al*., 2020). It was found that the SPR of BSC at Keboromo Waters Pati regency was 19% (Figure 5.) or less than 20%. According to Bunnell and Miller (2005), it includes a Biological Limit Reference Point (20%) where reproductive potential should be maintained before recruitment is limited. This SPR result is almost the same in another study in Indonesia, such as in Belitung of 5% (Ernawati *et al*., 2015), Southeast Sulawesi of 14% (La Sara *et al*., 2016), Cirebon of 11%, Demak of 15%, Rembang 15%, and Sumenep 24% (Ernawati *et al*., 2017), and Betahwalang, Demak of 19% (Nabila *et al*., 2022). This value means that the reproductive potential and recruitment of crabs in nature is being disturbed, hence the effort must be made to maintain the reproductive potential of crabs in these waters (Ernawati *et al*., 2017).

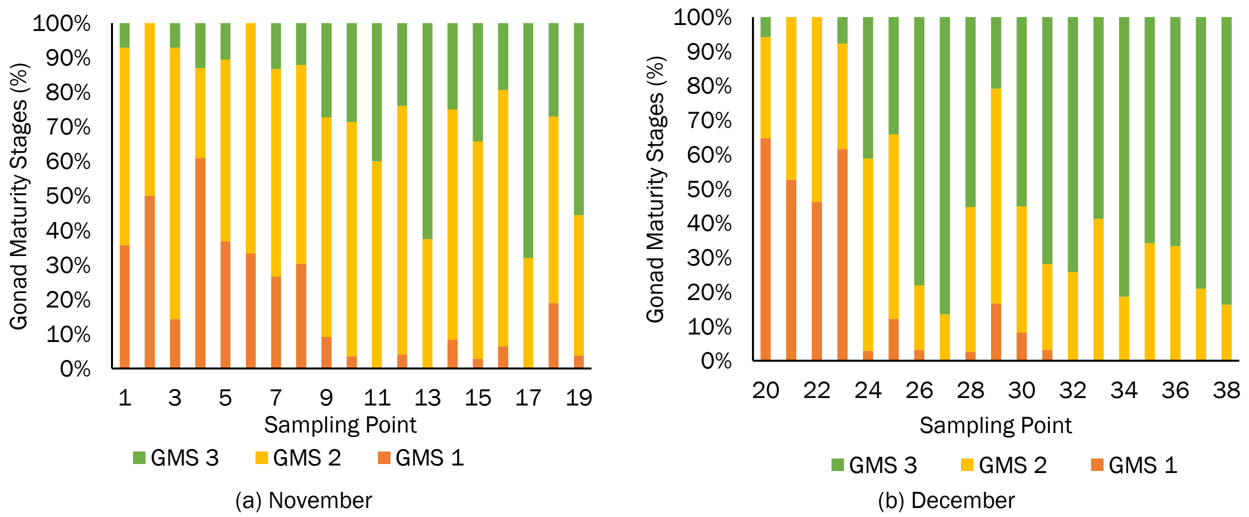


Figure 4. Comparison of Gonad Maturity Stages of Female *Portunus pelagicus* (a) November and (b) December in Keboromo Waters

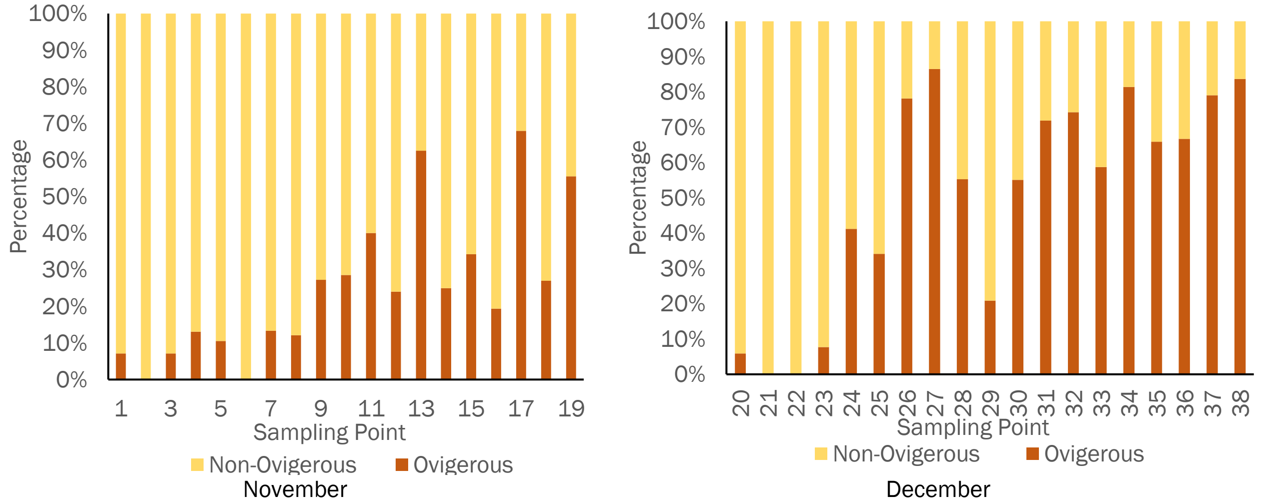


Figure 5. The proportion of non-ovigerous (non-egg-berried) and ovigerous (egg-berried) *Portunus pelagicus* at Keboromo Waters, Pati Regency during November and December 2022.

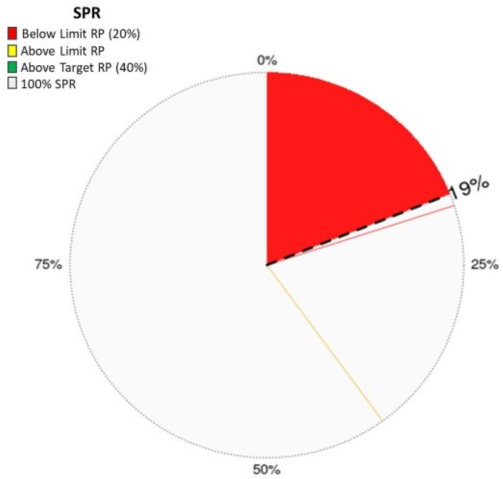


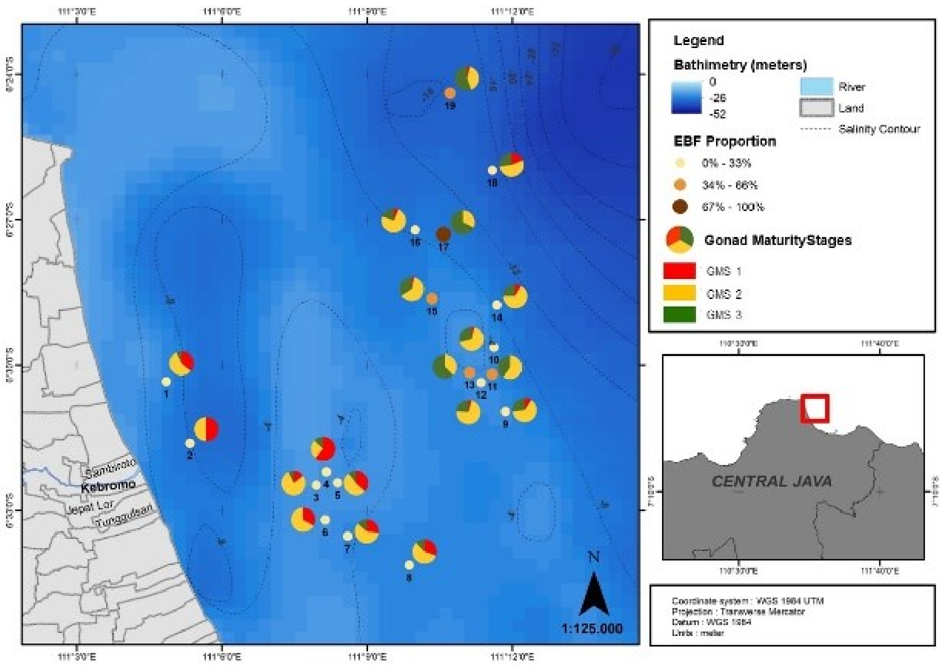
Figure 5. Spawning potential ratio (SPR) of *P. pelagicus* in Keboromo Waters, Pati Regency

Table 3. Percentage Ratio of L_{m50} and L_{c50} of Female *P. pelagicus*

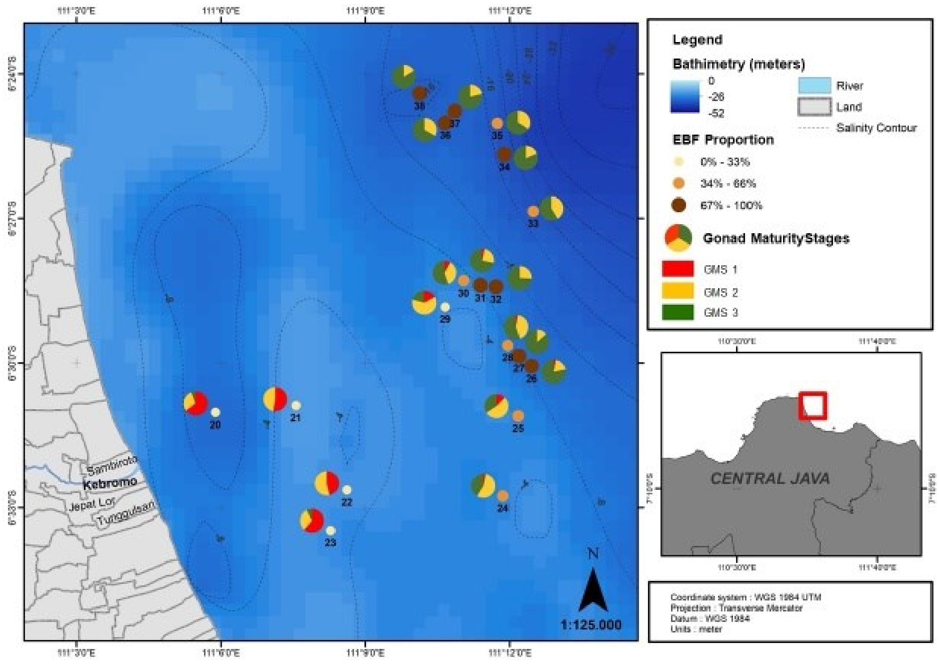
Month	Average L_{m50} (mm)	Average L_{c50} (mm)	$L_{m50} < L_{c50}$ (%)	$L_{m50} > L_{c50}$ (%)
November	112.53	107.21	15.8	84.2
December	114.47	113.89	63.2	36.8
Total	113.50	110.55	39.5	60.5

Table 4. The value of BSC L_m and L_c in several Indonesia Waters

Location	L_m (mm)	L_c (mm)	Reference
Alastuwo, Pati	107	108	Ernawati *et al.* (2014)
Labuhan Maringgai, East Lampung	113.50	109.72	Damora and Erfind (2016)
Lasongko Bay, Central Buton	115	105	Lakudo *et al.* (2017)
Aru Islands	119.9	133.4	Kembaren and Surahman (2018)
Jakarta Bay	68.8	93.87	Wagiyo *et al.* (2019)
Betahwalang, Demak	108.25	107	Redjeki (2022)
Keboromo, Pati	107.21	113.89	This Study



November



December

Figure 6. Distribution of *P. pelagicus* in Keboromo Waters, Pati Regency, based on their Gonad maturity Stage

The abundance of egg-berried (ovigerous) females could indicate the reproductive potential of blue swimming crabs in certain areas. During this study egg-berried female swimming crabs could be found almost in every sampling observation point. There is increasing evidence of 50% egg-berried females from November (3 sampling points) to December (12 sampling points) (Figure 6.). The high captured level of female swimming crabs in Keboromo Waters negatively impacts crab stocks in nature. The swimming crabs that lay eggs should be able to release their eggs in nature, but because they are caught by fishermen, there are no new recruits in the waters.

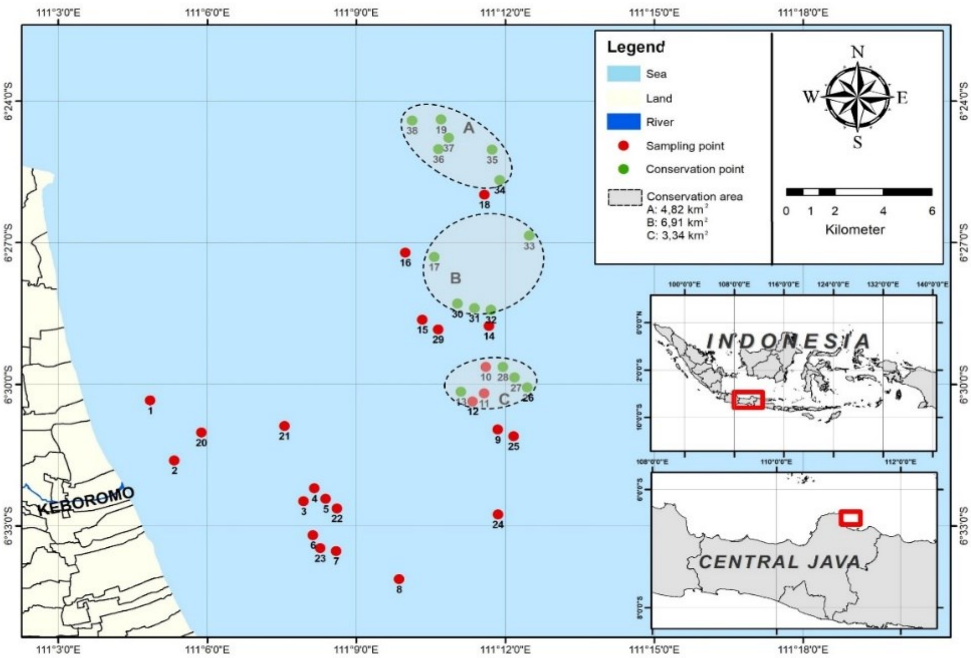


Figure 7. Recommendation of Conservation Area for BSC stock in Keboromo Waters, Pati regency

The BSC fishing by the fisher is done continuously and it will have an impact on the decline of crab population resources. To maintain the reproductive areas, it is required to manage BSCs by creating crab conservation areas. Adams *et al*. (2019) stated that, the importance of determining reproductive protection areas as a strategy in stock recovery in nature. The management that can be carried out is applying an open–closed season system or opening and closing fishing areas, especially in or around conservation areas in December because female crabs are releasing their eggs and producing new individuals to increase recruitment and stability of crab stock (sustainability) in Keboromo Waters and increasing the selectivity of crab population catching activities referring to PERMEN-KP No. 16 of 2022 concerning catching blue swimming crab (*P. pelagicus*), so that crabs that may be captured in Keboromo waters have carapace widths above 100 mm in size and not in spawning conditions visible on the outside of the abdomen.

The results of the study in Keboromo Waters provide recommendations for establishing a conservation area (Figure 7.), in BSC fishing ground, as three temporary no-take zones area, i.e., Area A (4.82 km^2), Area B (6.91 km^2), and Area C (3.34 km^2). The distance from the coastline is about 8-12 miles with a fishing boat of 1-2 GT. The design of a conservation area is expected to provide opportunities especially for egg-berried female crabs to lay or release their eggs and hatch become larvae (new recruits) so that the process of crab recruitment crabs in nature continues to increase. This also inline with the MMAF regulation of No. 17/2021 and 16/22 that prohibit the captured of BSC's EBF. Implementing this regulation requires cooperation between the fishing community and local government because the management of the crab conservation area will be successful in its implementation with the support of all stakeholders.

According to Roberts and Hawkins (2000), mechanisms for improving biomass in a conservation area such as a proposed no-take zone like in this study can benefit the fishery nearby the zone through spillover (distribution of young and adult blue swimming crabs from the conservation zone to the nearby waters), eggs and planktonic larvae that drift from the zone into its surrounding areas; and prevents overall damage of the population when areas outside the zone are collapsing. Therefore, the determination of the reserved area must address the source of the population (spawning ground and the place where BSCs spend their larval life stages). Therefore, the recommendation for establishing the conservation area based on this result study is urgently implemented.

Conclusions

There are two size class groups of BSC population the in Keboromo waters, Pati Regency, in which the mature crabs (GMS2) at every sampling point in November and December were 57% and 33%

of the total observed female crab samples while the proportion of ovigerous females (EBF) in December was higher than in November samples. There were several sampling points where the size at first captures L_c was higher than the size at first maturity (L_m) and will cause a decrease in resource stocks due to a delay in the recruitment process. SPR of 19% indicated that reproductive potential should be maintained before recruitment is limited, therefore based on the existence of EBF, it is recommended three conservation areas as a temporary no-take zone in BSC fishing ground in Keboromo Waters, Pati regency.

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