Sustainability of blue swimming crab Portunus pelagicus commodity in Banten Bay, Indonesia

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Bongbongan K. Hutapea, Erick Nugraha, Hari Prayitno, Herry Choerudin, Suharyanto, Dedy H. Sutisna, Arief Effendy, Abdul Bashit

Fishing Technology Department, Faculty of Fishing Technology, Jakarta Fisheries University, Jakarta, Indonesia. Corresponding author: E. Nugraha, nugraha_eriq1@yahoo.co.id

Abstract. Blue swimming crab (*Portunus pelagicus*) is the third highest commodity fisheries in Indonesia after shrimp and tuna. One of the blue swimming crab (*Portunus pelagicus*) deployments in Indonesia is in the area of Banten Gulf waters. Fishery statistical production data from years 2007-2017 from Archipelago Fishing Port (AFP) Karangantu experienced a peak in 2004 with 326,730 kg with fishing effort for 5.644 trip. While the amount of the lowest production occurred in 2007 with a total production of 19,225 kg and the efforts of 1.998 catching trip. For the calculation of CPUE that has been done can be seen that the highest CPUE values occurred in 2002 which reached 26,929.667 kg/boat, while the lowest CPUE values occurred in 2010 which only reached 288 kg/boat. Sex ratio was dominated by male *P. pelagicus* with a ratio of 2:1 (male:female), carapace width (CW) ranged from 6.2 to 18.4 cm with CW dominance from 11.2 to 12.5 cm. *P. pelagicus* CW-sized under 9 cm was represented by 1.39%, between 9-11 cm CW by 30.65% and with CW size above 11 cm by 67.96%. Pairwise comparison analysis with an index value of 46.19% indicated a less sustainable status. After the efforts made through improvements to the attributes that have a value of high sensitivity and negative effect on leverage analysis, the obtained value into a sustainability index is 59.97% with fairly sustainable categories in which an increase in the index leads to a very sustainable status.

Key Words: CPUE, CW, pairwise comparison, fishery statistics.

Introduction. Indonesia has a vast sea area and Indonesia has been dubbed a maritime country because its sea area is wider than land area (Erick & Mugi 2017). Blue swimming crab (*Portunus pelagicus*) is a sea crab that is widely found in Indonesian waters. The crab has long been sought by the public both domestically and abroad. Besides being enjoyed domestically, the crab meat is also exported to foreign countries such as Japan, Singapore and America (Hardjito 2006). Crab in Indonesia is still a fishery commodity that has high economic value (Ningrum et al 2015).

P. pelagicus has distinct morphological characteristics. They come in a variety of colors and most have white patterns on their carapace (Hidayani et al 2018).

The more intensive catch of crabs can cause the natural population of the crab to decline. As a result of catching in uncontrolled nature, there is a scarcity of crab populations in Indonesian waters (Juwana & Romimohtarto 2000). The condition of crab fishing in all Indonesian waters is 63% with overfishing status (Suman et al 2016), so a sustainable expoitation management should be developed and implemented.

In compiling the crab management strategy in an area, among others, it must be based on crab ecobiology data which includes data on habitat conditions, reproductive biology and crab population dynamics (Arshad et al 2006).

Utilization of crab resources is a big challenge that requires appropriate solutions, so that proper management is needed (Ihsan et al 2014).

The ecosystem approach in fisheries management is one of the implementation of responsible fisheries (CCRF) where this approach combines two different principle namely conventional fisheries management and ecosystem-based management (Fajri et al 2018).

Material and Method. The equipment in this study consisted of a ruler with accuracy of 1 cm, digital scales with accuracy of 0.01 g, digital cameras, gillnet fishing gear and trap, fishing boats while the biological material used was *P. pelagicus*.

Data collecting method. Data collection was done in the form of primary data and secondary data. Primary data was obtained by direct observation by participating in carrying out fishing activities and interviews with fishermen around the Archipelago Fishing Port (AFP) Karangantu by using a questionnaire to find out:

1. *P. pelagicus* management activities in several aspects in Banten Bay;
2. Production of the average activity of the results of capturing per trip;
3. Fishing season and *P. pelagicus* fishing area;
4. Gill net and trap units;
5. Fleet (Boat).

Secondary data consisted of geographical and demographic conditions, literature studies (theoretical references related to research), statistical and annual reports (2007-2017) AFP Karangantu, Serang, Banten Province.

Research methods

a. Capture per unit effort (CPUE)

The linear Schaefer model (1954) assumes that the population logistic growth is that catches increase rapidly at the beginning, but then the rate of change slows with increasing effort.

$$CPUEt = Catch\ it / Effort\ it$$

Where:

CPUE it = the second capture device to t
Catch it = the catch (catch) result of the catch to time t
Effort it = effort to catch the second time to t

b. Maximum Sustainable Yield (MSY)

The optimum capture effort (fopt) and MSY can be calculated using the *schaefer* equation. The optimum effort is calculated using the equation:

$$fopt = a/2b$$

MSY is calculated by the equation:

$$MSY = a^2/4b$$

Where:

A = intersept
B = slope in the linear regression equation

The use of the formula to look for MSY is valid only if parameter b is negative, meaning that the addition of catching efforts will cause a decrease in CPUE. If in the calculation a positive value of b is obtained, then the calculation of potential and optimum fishing effort cannot be continued but it can only be concluded that the addition of fishing efforts is still possible to increase the catch. This equation is often used to calculate MSY and optimum capture effort because calculations using Schaefer model (1954) is simple, easy and the results can be understood by anyone including policy makers (Ningrum et al 2015).

Weight length:

$$W = al^b \quad \text{With:} \quad \text{Log W log} = \log b + \text{alg C}$$

Where:

W = crab weight (gram)
L = carapace width (mm)
a = intercep (condition factor)
b = slope (growth coefficient)

The hypothesis used is:

1. If the value of b = 3 is called an isometric growth pattern (length growth pattern equals weight growth).
2. If the value of b ≠ 3 is called allometric, namely:
   a. If b>3 is called a positive allometric growth pattern (weight growth is more dominant);
   b. If b<3 is called the negative allometric growth pattern (dominant width growth).

Data analysis. The EAFM technique is carried out by looking at several aspects related to the sustainability of fisheries resources. These aspects include ecology, technology, economy, social, cultural and legal/institutional dimensions. Then, in each of these dimensions several attributes were developed that were used to capture the conditions of each of these aspects. The condition of each of these attributes was analysed, then quantified through scoring, so that quantitative analysis can be carried out. In its implementation in Karangantu, the above approach was carried out through the following stages:

Field verification

This phase was done to improve accuracy and complete EAFM attribute information/data that cannot be filled based on available literature/secondary data. This field verification was carried out in a participatory manner, namely by combining the results of interviews/discussions/consultations with various resource persons (fishermen, fisheries service officials, and related key figures). In his stage were included:

a. Determination of the type of fisheries analyzed: in this case, based on data available at the Serang Fisheries and Marine Service, as well as district and provincial reports, and discussions with fisheries officials, and dominant fisheries issues related to crab management in Banten Bay were chosen, which was reviewed in order to describe the general condition of fisheries in the region. The distribution of fisheries was based on fishing gear, which was also intended to represent the type of fish group (demersal, small pelagic, large pelagic, etc.) and represented the type of waters (beach and offshore).
b. Location determination: Locations were determined based on the concentration of the types of equipment, which were also attempted to represent the distribution of areas in the Fish Auction and Archipelsgo Fishing Port (AFP) included in the analysis unit.
c. Field interviews: with a list of questions prepared in advance, interviews were conducted with respondents chosen randomly to represent the type of tool and location.
d. The results of the interviews were reviewed through discussions with fisheries officials, and matched with additional data collected during activities in the field.

Results and Discussion

Sex ratio. The number of samples obtained in October was 106 carbs consisting of 76 male and 30 female individuals. While the number of samples obtained in November were 149 individuals, consisting of 90 male and 59 female *P. pelagicus* (Table 1).

Table 1

The evolution of *Portunus pelagicus* sex ratio in absolut and relative values

Month	*Sex*		*Total (ind)*	*Comparison*
	Male (ind)	*Female (ind)*		*Male : Female*
October	76	30	106	2:1 (2.53:1)
November	90	59	149	1:1 (1.5:1)

ind – individuals.

Based on the results of the present study, it can be seen that *P. pelagicus* sex ratio is dominated by male individuals with a ratio of 2:1. Suadela (2004) in his study performed in Banten Bay found a proportion of 66% of male and 34% of female *P. pelagicus*.

The carapace width (CW) of *P. pelagicus* ranged from 6.2 to 18.4 cm with dominance of the 11.2-12.5 cm category. CW size below 9 cm as much as 1.39%, CW between 9-11 cm as much as 30.65% and CW size above 11 cm as much as 67.96%.

Gonad maturity level (GML). In October GML from *P. pelagicus* were found starting from level I to level IV. At level I as many as 11.33%, at level II as much as 20.75%, at level III as many as 51.88%, an at level IV as much as 16.03% (October) was found. Whereas in the second observation (November), GML from *P. pelagicus* are also found starting from level I to level IV. At level I as much as 18.12%, at level II as many as 31.54%, at level III as much as 37.58%, and at level IV as much as 12.75% was found (Table 2).

Table 2

Gonad maturity level (GML) of *Portunus pelagicus*

Month	*Gonad maturity level (GML)*	*GML of P. pelagicus*	
		Individuals	*Frequency (%)*
October	I	12	11.33
	II	22	20.75
	III	55	51.88
	IV	17	16.03
November	I	27	18.12
	II	47	31.54
	III	56	37.58
	IV	19	12.75

Based on the data presented in Table 2, *P. pelagicus* caught at GML III ripe was more consistent compared to other categories. Observations during October revealed the highest percentage of crabs in GML III reached 51.88% and in November 37.58%, while the lowest score concerning GML I in October reached 11.33% and in November GML IV reached 12.75%.

Another measure that can be used as a reference criterion for catching crabs is 11 cm CW where the blue swimming crabs of that size have been sexually mature and have produced at least 2 eggs for one season. In the waters of South Australian crab may be caught if the carapace width is more than 11 cm and has no eggs (Kangas 2000 in Gardenia 2006). Based on observations of caught blue swimming crabs of less than 8 cm CW as many as 13 pcs (5.10%), between CW 8-11 cm as many as 60 pcs (23.53%) and measuring more than 11 cm CW as many as 182 pcs (71.37%). Based on the description above, it can be concluded that the catch of the blue swimming crab in the bay of Banten has passed the size of the first gonad mature.

Relationship between carapace length and body weight. Sparre & Venema (1992) stated that growth is basically the determination of body size of age. The relationship between the *P. pelagicus* length and weight follows the cubic law (Bal & Rao 1984): $W = aL^b$, with W as the weight (g); L as the BSC carapace width (mm) and a, b as constants.

Based on observations the size of the caught *P. pelagicus* is less than 8 cm CW, represented by 13 individuals (5.10%), between 8-11 cm CW 60 individuals (23.53%) and above 11 cm CW size by 182 individuals (71.37%). Data analysis of the relationship between body weight and width of crab's carapace obtained during the study was different for each sex. Based on the results of the analysis, a regression equation was found for the relationship between body weight and carapace width, as shown in Table 3.

Table 3

Portunus pelagicus regression equation

Sex	*Regression equations*	*R*	*N*
Male	Log BT = 3.3532 + 3.1838 CW	0.9288	166
Female	Log BT = 3.2554 + 3.2058 CW	0.9158	89

The results of observations on *P. pelagicus* obtained the value of slope (b) for males of 3.1838 (r = 0.92) and for females 3.2058 (r = 0.91). So that the regression coefficient (b) obtained from each regression equation >3, shows that almost all samples obtained have faster body weight gain than the increase of the carapace width. The relationship between body weight and carapace width has a very strong correlation indicated by the correlation coefficient (r) approaching 1, thus it can be concluded that the growth pattern of male and female *P. pelagicus* in Banten Bay is positive allometric, which means that body weight gain is more dominant than the increase in carapace width. Fahresa et al (2019) reported that big size and high number of *P. pelagicus* were caught in deeper waters, while small size and low number of crabs was caught in lower depth.

The highest production of *P. pelagicus* in Banten Bay in AFP Karangantu which was catched for 10 years from 2008 to 2017 was 326,730 kg with efforts (amount trip/ fishing boats) of 5.644, while the lowest production was 19,225 kg with an effort (amount trip/fishing boats) of 1.998, with the CPUE value (production (kg) : fleet/trip) yields 57.8898 kg/boats, and the lowest CPUE in 2011 was 2.5902 kg/boats (Table 4).

Table 4

CPUE of *Portunus pelagicus* in Banten Bay, Indonesia

Year	*Amount product (Kg)*	*Amount trip/fishing boat*	*CPUE*
2008	307,875	6.465	47.6218
2009	326,730	5.644	57.8898
2010	113,353	3.474	32.6290
2011	19,225	1.998	9.6221
2012	50,358	3.189	15.7912
2013	87,501	5.262	16.6288
2014	79,203	9.646	8.2110
2015	70,998	24.616	2.8842
2016	72,545	28.008	2.5902
2017	83,297	26.676	3.1225

Based on the linear regression from Figure 1, is obtained a constant value of 2,223 and the constant value b is 0.084 so that the MSY analysis and optimal capture can be calculated as follows:

MSY $= a^2/4b$

MSY $= (2223)^2 / 4*(0.084)$

$= (494{,}172) / 0.336$

$= 147{,}075.26$ kg/year

Fmsy $= a/2b$

$= (2223) / 2\ (0.084)$

$= 2223 / 0.168$

$= 132$ unit

CPUEopt = MSY/ *f*msy
= 147,075.26/ 132 = 1,114.20 kg/unit

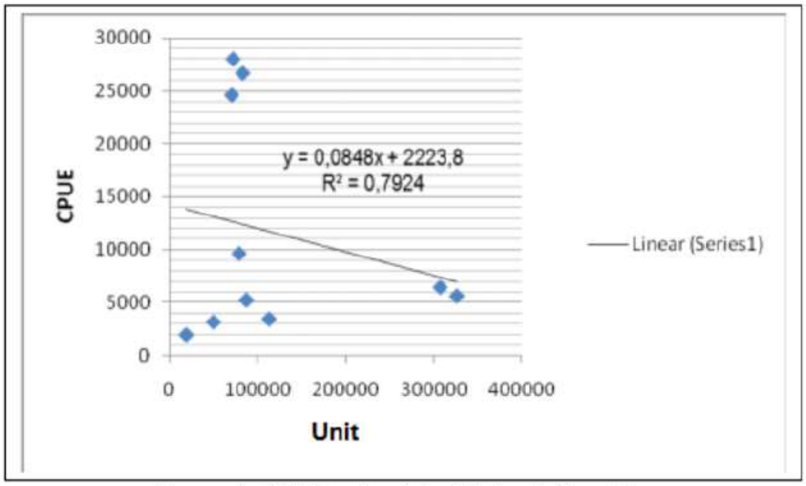

Figure 1. CPUE and catched fish relationship.

MSY is one of the biological standards used in management and as a basis for determining sustainable fisheries resource policies. The results of the analysis of sustainable potential (MSY) city of Serang's *P. pelagicus* resources amounted to 147,075.26 kg/year with optimum fishing efforts of 132 units and optimum CPUE of 1,114.20 kg/unit, thus based on the data described above it can be concluded that fishing efforts and potential sustainable management by *P. pelagicus* fishermen in Banten Bay Serang has exceeded the maximum utilization limit (Figure 2).

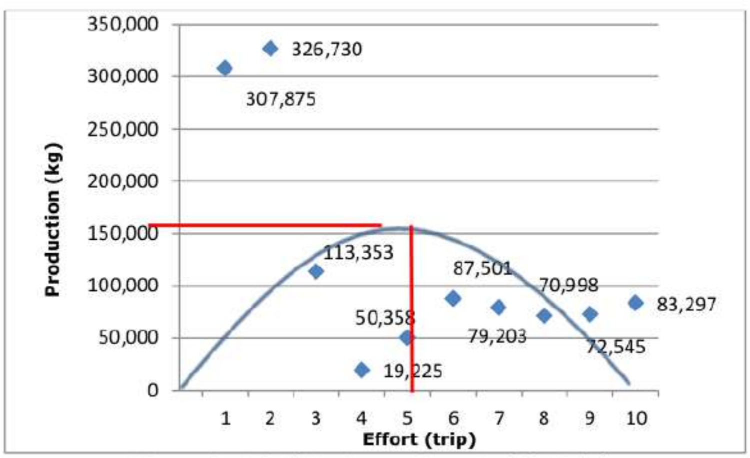

Figure 2. MSY (Maximum Sustainable Yield).

Management scenario. The strategy carried out in making *P. pelagicus* management policies in Banten Serang Bay is to conduct interference and improvement in an effort to maximize the scale of the attributes that have high sensitivity values of each.

Changes in the scoring value of some of the sensitive attributes above show that it is still far from the normal scale in the management of maintenance *P. pelagicus* farming. Then an analysis of the ecosystem for fisheries management (Ecosystem Approach For Fisheries Management - EAFM) was carried out to see if this indicator might be used to improve fisheries management performance in several scenarios, as well as providing improvements related to the budget, to improve data efficiency. The magnitude of the change in index value is based on the results of the EAFM analysis, as shown in Table 6.

Table 5

Sustainability index value with scenario

Dimensions	*Combined weight*	*Measured weight*	*Mds*		*Measured Mds*	
			Existing	*Mds scenario*	*Existing*	*Mds scenario*
Social	0.1951	0.2025	36.99	62.61	17.30	12.68
Technology	0.4506	0.4676	48.82	56.21	9.88	26.28
Ecology	0.0452	0.0469	50.40	50.40	2.36	2.36
Economy	0.2728	0.2831	58.81	58.81	16.65	16.65
Total	0.9637	1.000	195.02	228.03	46.19	59.97

Mds - Multi Dimension Scaling.

In the Table 6, it can be seen that after interference with several attributes, especially from the social and technology dimensions, there has been an increase in the sustainability index in each dimension where there are significant changes in the social and technological dimensions resulting in an increase in status from the previous status while the economy and the ecology are permanent.

Table 6

Changes in attribute increase per dimension

Dimensions	*Attributes*	*Assessment*		*Scale*
		Now	*1-5 y.o.*	*B-G*
Social	Education level	0	2	0-2
	Environmental knowledge	0	2	0-2
Technology	Landing locations	3	1	3-0
	Size of *P. pelagicus* fishing boat	3	1	3-0

y.o. – year old.

The sustainability index value of multi dimensions without scenarios, after verification by experts on the Pairwise Comparison analysis obtained an index value of 46.19% with a less sustainable status. After efforts made through improvements to attributes that have high sensitivity values and negatively affect leverage analysis, the sustainability index value is obtained to be 59.97% with a category that is sufficiently sustainable where an index increase which approaches towards very sustainable status.

Thus it can be explained that if repairs are carried out in accordance with the direction of the operational policy, fishing activities in the Banten Bay by fishermen can be favored as capture fisheries that are closer to a very sustainable direction. Changes in the status category can work in accordance with the scenario, so that the results of the improvement are obtained as shown in Figure 3.

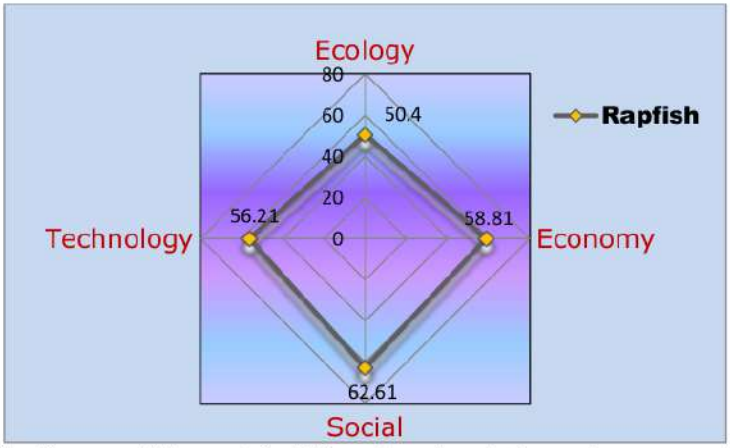

Figure 3. Kite diagram of the sustainability value of each dimension on operational policy with the scenario.

Conclusions. During 2007-2017, the peak of blue swimming crab production was 326,730 kg (2004) with fishing efforts of 5.644 trips. While the lowest production occurred in 2007 with a total of 19,225 kg, with 1,998 trips being taken. The highest CPUE occurred in 2002 and the lowest in 2010. Analysis of pairwise comparison obtained an index value of 46.19% with a less sustainable status. After efforts are made through attribute improvements having high sensitivity values and negatively influencing leverage analysis, the sustainability index value becomes 59.97% with a category that is sufficiently sustainable where an index increase which approaches towards very sustainable status through improvement in the direction of policy.

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Authors:
Bongbongan Kusmedi Hutapea, Jakarta Fisheries University, Faculty of Fishing Technology, Fishing Technology Department, Indonesia, Jakarta, South Jakarta, Pasar Minggu, Jl. AUP no. 1, e-mail: bkhutapea@gmail.com
Erick Nugraha, Jakarta Fisheries University, Faculty of Fishing Technology, Fishing Technology Department, Indonesia, Jakarta, South Jakarta, Pasar Minggu, Jl. AUP no. 1, e-mail: nugraha_eriq1@yahoo.co.id
Hari Prayitno, Jakarta Fisheries University, Faculty of Fishing Technology, Fishing Technology Department, Indonesia, Jakarta, South Jakarta, Pasar Minggu, Jl. AUP no. 1, e-mail: hariprayitno46@gmail.com
Hery Choerudin, Jakarta Fisheries University, Faculty of Fishing Technology, Fishing Technology Department, Indonesia, Jakarta, South Jakarta, Pasar Minggu, Jl. AUP no. 1, e-mail: herychoerudin@yahoo.com
Suharyanto, Jakarta Fisheries University, Faculty of Fishing Technology, Fishing Technology Department, Indonesia, Jakarta, South Jakarta, Pasar Minggu, Jl. AUP no. 1, e-mail: suharyanto.jfu@gmail.com
Dedy Heriadi Sutisna, Jakarta Fisheries University, Faculty of Fishing Technology, Fishing Technology Department, Indonesia, Jakarta, South Jakarta, Pasar Minggu, Jl. AUP no. 1, e-mail: naoneta@yahoo.com
Arief Effendy, Jakarta Fisheries University, Faculty of Fishing Technology, Fishing Technology Department, Indonesia, Jakarta, South Jakarta, Pasar Minggu, Jl. AUP no. 1, e-mail: arief_dkp@yahoo.com
Abdul Bashit, Jakarta Fisheries University, Faculty of Fishing Technology, Fishing Technology Department, Indonesia, Jakarta, South Jakarta, Pasar Minggu, Jl. AUP no. 1, e-mail: bashit@gmail.com

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