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The frequency distribution of the length, gonad maturity stages, sex ratio, length at first mature and catch, width-weight relationship, and fisheries factors of blue swimmer crab (*Portunus pelagicus*) caught by crab nets landed at Tegalsari coastal fisheries port in Central Java

Dadan Zulkifli, Mugi Mulyono, Firman Agus Heriansyah and Hendra Irawan

Abstract
The research of biology and fisheries aspects of blue swimmer crab (*Portunus pelagicus*) caught by *arad* trawl was done at Tegalsari Coastal Fishing Port in Central Java. Data were collected from 755 individuals. The research method was survey, descriptive analysis and interviews. The most frequently catch fish was between 115.9 – 127.7 mm. They was positive allometric pattern. Width weight relationship had equation (all samples) $W=0.0000311\ L^{3.1623}$ and (males) $W = 0.0000249\ L^{3.2202}$ and (females) $W = 0.0000536\ L^{3.0378}$. Lenght at first maturity was 124.74 mm (male) and 113.57 mm (females). The Lm value of all samples was 110.17 mm, and the Lc value was 120.4 mm, it means Lc> Lm, the catch crabs still had a chance to mature and spawn. Investigation, however, on fisheries aspects become important in this case. The present study provides a basic and valuable information for the crab fisheries management and population monitoring.

Keywords: Blue swimmer crab, biology and fisheries aspects, fisheries management, *arad* trawl (local mini trawl)

Introduction
The blue swimmer crabs (*Portunus pelagicus* Linnaeus, 1766) are highly desirable fish for capture by fishermen at Tegalsari Coastal Fisheries Port, Tegal Regency, the Province of Central Java since this commodity has an economic value and constitutes an export commodity with high demand as well as highly price in the market. The production of the crabs heretofore is still relying on catching from the sea, because it can not be supplied from the cultivation. The high economic value of these commodity have led to fishermen to use the efficient fishing gear (*Arad* trawl) to harvest the crabs. This activities is carried out to fulfil the the high market demand and augment the fishermen's daily income (Tito and Alanano, 2008) [30]. These conditions will lead to decline population of the crabs naturally if there is not a proper resource management. Before determining management strategy development to solve the condition, a better understanding of information of biology and fishery aspects (e.g. Sex ratio and fishing gears used in the catch activity) is essential for being the sustainability of swimmer crab exsistence in the future (Oluwatoyin et. all, 2013; Norii et. all, 2015) [23, 22]. The proper knowledge of biology and fishery aspects will drive to a proper conservation and management. Some previous study has investigated blue swimmer crab on biology aspects (Jose, 2011; Hosseini et. all, 2012, La Sara et. all, 2016) [13, 10, 17] but less investigations talk on fishery aspects. As matter a fact, both aspects are important to manage suistainability of existence of the blue swimmer crab. Blue swimmer crab (*Portunus pelagicus*) belongs to the Kingdom Animalia, Phylum Crustaceans, Class Malacostraca, Order Decapoda, Family Portunidae, Genus *Portunus*, Species *Portunus pelagicu* (Kangas, 2000) [14].
In order to the purpose of fishery resource management and conservation of biodiversity, some aspects of morphological characteristics *Portunus pelagicus* (frequency distribution of the

length, width-weight relationship, sex ratio, gonad maturity stages, length at first maturity and first catch) landed at Tegalsari Coastal Fisheries Port need to be investigated since the number of mature individuals in a given population is eventually responsible for the productivity of the future generation (Leme, 2005) [17]. Additionally, the suistainable utilization of this resources is influenced largerly by catch pressure and management of *Portunus p.* population (fishing areas, fishing gears, fishing vessels, fishing methods and fishermen condition as well as the management model of *arad* trawl and fishing crab) can be used as indicators in the proper management of this resource in Tegalsari Coastal Fishing Port.

Material and Methods

This study was conducted at Tegalsari Coastal Fishing Port, Tegal, Central Java showing on figure one. The study was conducted from 1 February 2016 up to 30 May 2016. The study method used was survey method and descriptive analysis through observations at the field on a sample of blue swimmer crabs and interviews.

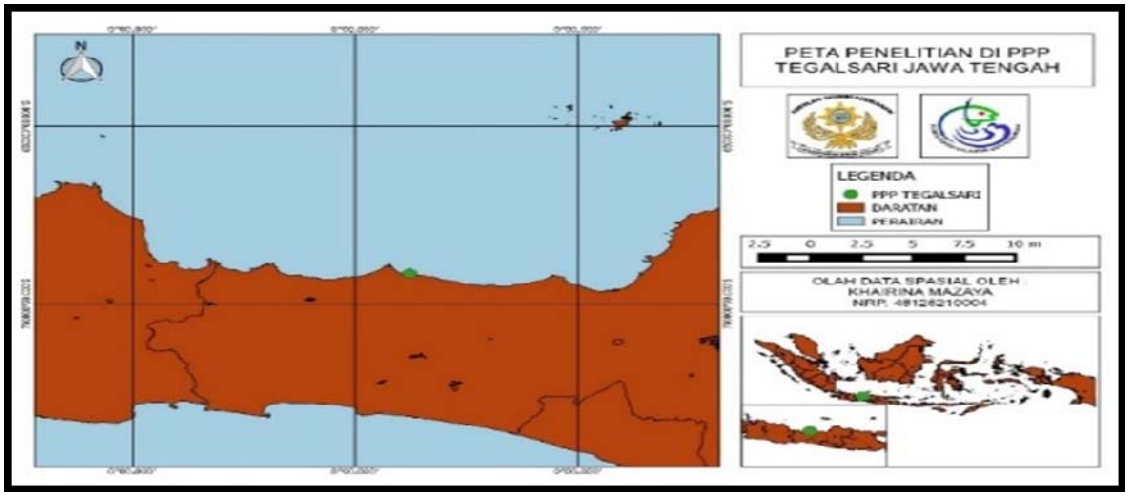

Fig 1: Map of Tegalsari coastal fisheries port, Source: Study result

The data used in this study consisted of primary and secondary data. Primary data were collected by observation and direct measurement of the catch fishermen. The taking process of sampling crabs was performed by using stratified random sampling to represent the size of the crabs and was done with the following steps:

a. Separating crabs with other catch types refering to Hippoidea superfamily identification book (Chan *et al*. 2010)[4];
b. Taking the crabs (*Portunus pelagicus*) from small to large size to be served as observation samples;
c. The number of samples was about 10-15 crabs every day from the ship landing the crabs every day (6 days a week)
d. All the crabs was measured the width and weight as well as identified the sex and gonad maturity stages with the following conditions:

Carapace width

Measurement of the length of each crab using calipers is considered as the carapace width (Corgos and Freire, 2006) [5]. Carapace width is a measurement along the widest part of their back side of the crabs (Thirunavukkarasu and Shanmugam, 2011; Hosseini, 2014) [29 11] shows in figure two. Carapace width is rounded to the nearest number (Hosseini, 2012) [10],(e.g. the carapace having 15.4 mm width will be recorded as 15 mm).

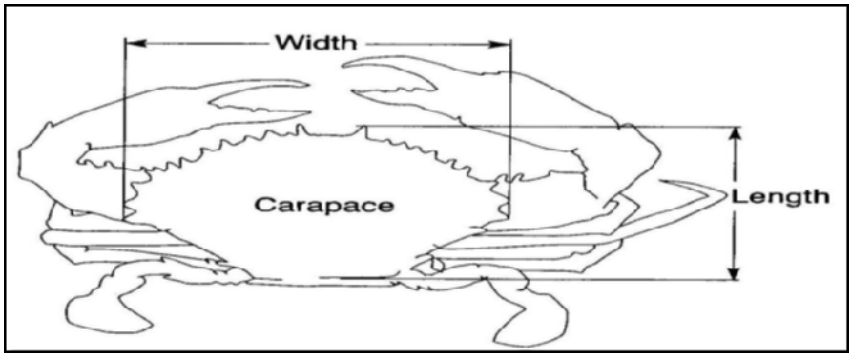

Fig 2: Measurement of width and length of crab, Source: FAO

Total weight

Total weight is an overall weight of crab. The crab weight measurement is performed by using a digital scale to the one point zero gram accuracy (Noori et. al., 2015) [22].

Sex ratio

The crabs are separated according their sex both males and females which can be distinguished by sex characteristics through identifying the shape of the abdomen, the male crabs

have triangular-shaped tapered while the female crabs have triangular shaped widened (Tito and Jonalyn, 2008; Marina, 2012) [30, 20], besides distinguishing through the sex, the crabs can be seen from the color of the carapace. Carapace colour of males of this species are blue with white dots on the shells and females are green-brown (Marshall et. al., 2005) [21]

Selection of Respondents

The selection of respondents is done by purposive sampling. Respondents selected are fishermen who are considered in accordance with the requirements. The secondary data obtained from the archives of Tegal Sari Coastal Fisheries Port, and fisheries office of Tegal Regency. The secondary data collected includes the data of the catch, fishing gear used by fishermen, and general condition of the fishing area.

To analyze the results obtained from the sampling results is used analytic descriptive analysis with simple regression to examine the relationship between variables.

Width frequency distribution

The stages to analyze width frequency distribution are as follows:

1) Determining the amount of class by using the formula:

$\Sigma class = 1 + 3.3 \log n$

Where: n = total number of data

2) Determining the class interval width using the formula:

$CI = \frac{X\,max - X\,min}{\Sigma\,class}$

3) Determining the frequency of each class and enter the frequency of each class by entering the width of each crab sample at a predetermined interval class, $CI = \frac{R}{\Sigma\,class}$,

where: CI = Class interval, R = Range ((Sturges, 1926) [28].

The frequency distribution of the length which has specified in the same interval class is plotted into a graph.

Relations width and weight of crab

The relations width and weight of crab was estimated using the log form of the allometric growth equation:

$W = a L^b$, Where: W = Weight, L = length of the carapace, a and b = Constant (Froese, 2006) [7]. Length-weight relationships allow the conversion of growth-in-length equations to growth-in-weight for use in a stock assessment model (Carmona, 2002) [3]

Sex ratio

The sex ratio of female and male crabs is performed through visual observation of a number of individual males and females obtained as samples at the observation location. The sex ratio determined by using the formula:

X = X / (X + Y) x 100%

Y = Y / (X + Y) x 100%

where: X = the number of male crabs, Y = the number of female crabs

The sex ratio calculation is based on the ratio of male and female crabs observed. To test the uniformity of sex ratio will be used 'Chi-squared' (Aydın Mehmet *et al*., 2012) [1] formula as follows:

$$\chi^2 = \frac{\Sigma(f_0 - f_h)^2}{f_h}$$

dimana:

χ^2 = The calculated value of Chi-squared

f_0 = frequency of male and female fish observed

f_h = frequency of male and female fish expected

Gonad maturity stages

The gonad maturity stage determination is done morphologically by comparing sampled fish gonad traits and crab gonad maturity stage criteria as quoted from (Campbell and Eagles; Tito and Alanano) [2, 30].

Length at first maturity (Lm)

The length at first maturity is calculated by using formula as follows:

$$\log m = xk + \frac{x}{2} - (x \cdot \Sigma Pi)$$

Where :

M	:	log of length at first maturity
Xk	:	log of the fish size of which 100% of sample fish are in maturity
X	:	log of size interval (log size increment)
Pi	:	proportion of gonad maturity fish in the group on the i
Ri	:	the number of gonad maturity fish in the class on the i
Ni	:	number of fish in the class on the i-
Qi	:	1 – pi

a. Length at first catch

To obtain the value of length at first catch, we need to calculate the estimated value of the curve, by the siplified formula of (King, 1995) [15]:

$$SLest = \frac{1}{1 + \exp(S_1 - S_2 * L_{50\%})}$$

$$L_{50\%} = \frac{S_1}{S_2}$$

Where :

SL	=	logistic curve (tool selectivity based on the length)
$L_{50\%}$	=	length / height where 50% of retained fish
S_1&S_2	=	constant in the formula-based logistic curve length
S_1	=	the value of the intercept a (intersection between a linear line with y line)
S_2	=	the value of slope b (angle of slope of the regression line)

Results and Discussion

Biological Aspects

Width frequency distribution

Based on figure 3. The catch crab carapace width size were 56.0 mm - 180.9 mm both on male and female crabs, the range (124.9 mm), the number of class (10.5), class number interval (11.9) and standard deviation (69.684). Frequency distribution was on interval of 115-126.9 mm of 177 individuals.The catch crab (*Portunus pelagicus*) carapaces have an average width of 119.4 mm, but according to Fisheries Minister Regulation number one, the catch crab size allowed >10cm. In the fact, there are still many fisheries catch the crab on the size<10 during the obsevation.

Figure 3. The frequency distribution of crab (*Portunus pelagicus*) carapace width

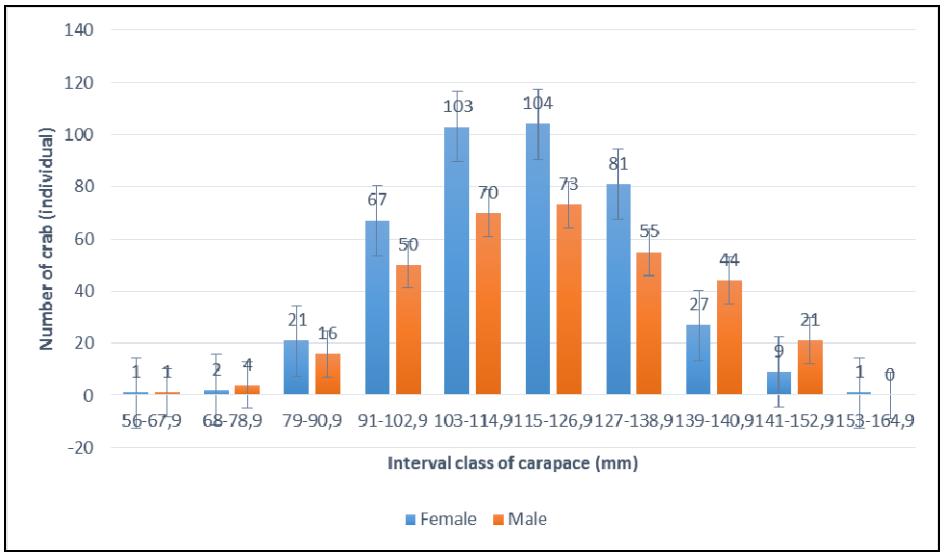

Fig 3: The frequency distribution of crab (*Portunus pelagicus*) carapace width

Crab width-weight relationship

Based on the calculation results of the crab lenght-weight analysis on table 1 showed that the crab width-weight relationship is not different significantly. It can be proved by the calculation in which the value of r (correlation coefficient) is 0.9368. It showed that there was a positive close relationship between the width and weight of crab. It means that if one variable decreases as the other variable decreases, or one variable increases while the other increases. The overall crab weight-width relationship showed the value of a (intercept) is 0.0000311 and b (slope) is 3.1623. The equation is $W = 0.0000311\ L^{3.1623}$. This indicates that the growth pattern of the crabs is positive alometrik (Fig.4).Testing using t-test obtained t score is 3.7735 and 1.9631 t table, then $t_{score} > t_{table}$. This shows that the b_{score} obtained is more than three. Therefore, the all samples crab (*Portunus pelagicus*) is allometric positive type, b_{score}> three which means weight-growth faster than the widht-growth (Hartnoll, 1982) [9].

Table 1: Calculation results of the crab lenght-weight analysis

Crab samples	A	B	R^2	R	N	$W = aL^b$	Growth characteristics
Male	0.0000249	3.2202	0.896	0.9466	415	$W = 0.0000249\ L^{3.2202}$	Positive allometric
Female	0.0000536	3.0378	0.869	0.9325	340	$W = 0.0000536\ L^{3.0378}$	Isometric
All samples	0.0000311	3.1623	0.877	0.9368	755	$W = 0.0000311\ L^{3.1623}$	Positive Allometric

Where :

a	:	Intercept
b	:	slope
r	:	correlation
N	:	number of samples rajungan
W	:	linear equations

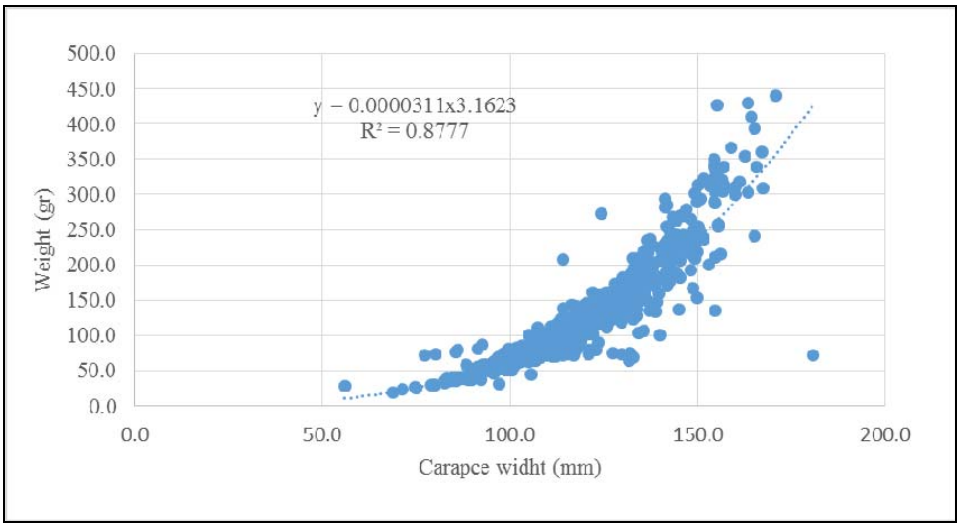

Fig 4: The graph of crab weight-widht relationship (*Portunus pelagicus*) landed at Tegalsari Coastal Fisheries Port

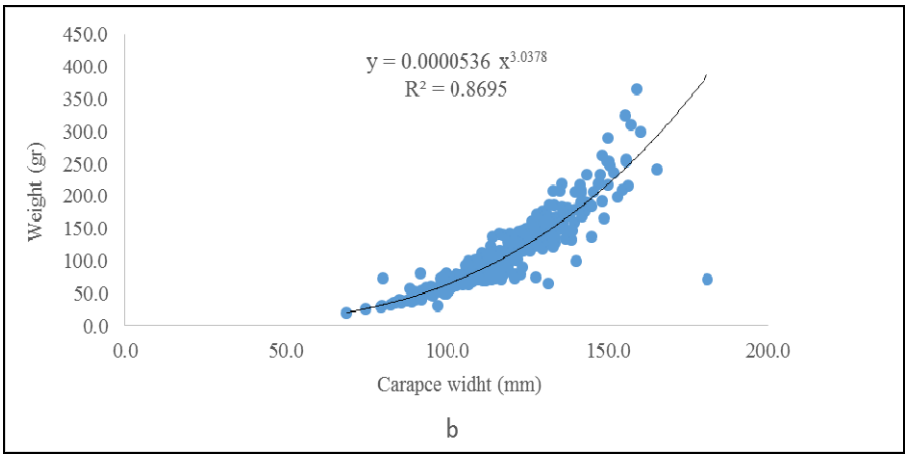

Fig 5: Graph of crab weight-widht relationship (*Portunus pelagicus*) (a) male; (b) females landed at Tegalsari Coastal Fisheries Port

The graph in the figure five shows that the results of the regression analysis of the width and weight of crab (*Portunus pelagicus*) are 3.2202 and 0.000249 for males and 3.0378 and 0.0000536 for females. From the calculation, the value of r for males (0.9466) and females (0.9325) in which this indicates that there is positive close relationship between the widht and weight, It means that if one variable decreases as the other variable decreases, or one variable increases while the other increases.

Sex ratio

Determining the sex of crabs can be done directly through visual observation by indentifying the shape of the abdomen (Jose, 2011) [13]. There were 755 samples of observed crab consisting of 340 are males and 415 are females. The sex ratio between crab male and female is 1: 1.2205 or 45.033% male and 54.967% female where the number of female crabs dominated the catches during the months of February to May (Figure. 6).

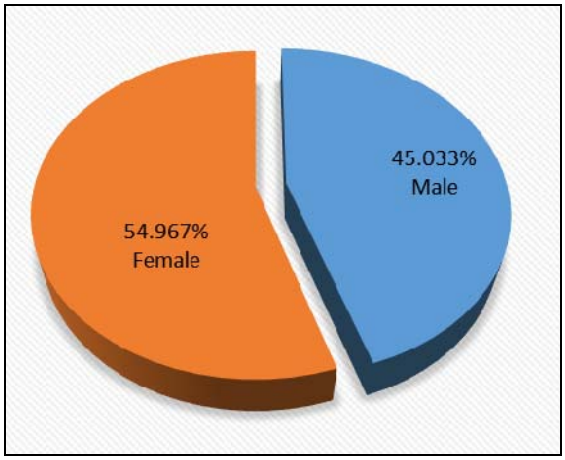

Fig 6: The comparison of sex ratio

Based on these results can be interpreted that there is no real difference of sex ratio between the male and female crabs caught during the study or it can be stated the population of crabs caught during research was balanced. The uniformity of the sexes tested by chi-square test with 95% confidence level ($\alpha = 0.05$), the result of the score is $\chi^2 = 7.450$, while the χ^2 tables = 3.84, it means $\chi^2_{score} > \chi^2_{table}$. This condition indicates that H_o is rejected, H_1 is accepted. It means the ratio between males and females is not equal (one:one)

The gonad maturity stages

The observation of gonad maturity stages for 755 crab samples landed in the Coastal Fisheries Port of Tegalsari consisted of first, second, third, forth and fifth levels. The differences in levels between male and female gonads are presented in Table two.

Table 2: Number of gonad maturity stages of crab landed at Coastal Fisheries Port of Tegalsari

Gonad Maturity Stages	Male's crab		Female' crab		Crab Group of Male and Female	
	Number	%	Number	%	Number	%
I	90	26.47	64	15.42	154	20.397
II	84	24.71	81	19.52	165	21.854
III	66	19.41	78	18.80	144	19.073
IV	55	16.18	127	30.60	182	24.106
V	45	13.24	65	15.66	110	14.570
TOTAL	340	100.00	415	100.00	755	100.00

Based on the data of Table two, it can be indentified that the most catch swimmer crabs landed at Tegalsari coastal fisheries port are in the gonad maturity stage of number four with a percentage of 24.106%. The comparison of the number of gonad maturity stages can be seen in the below diagram:

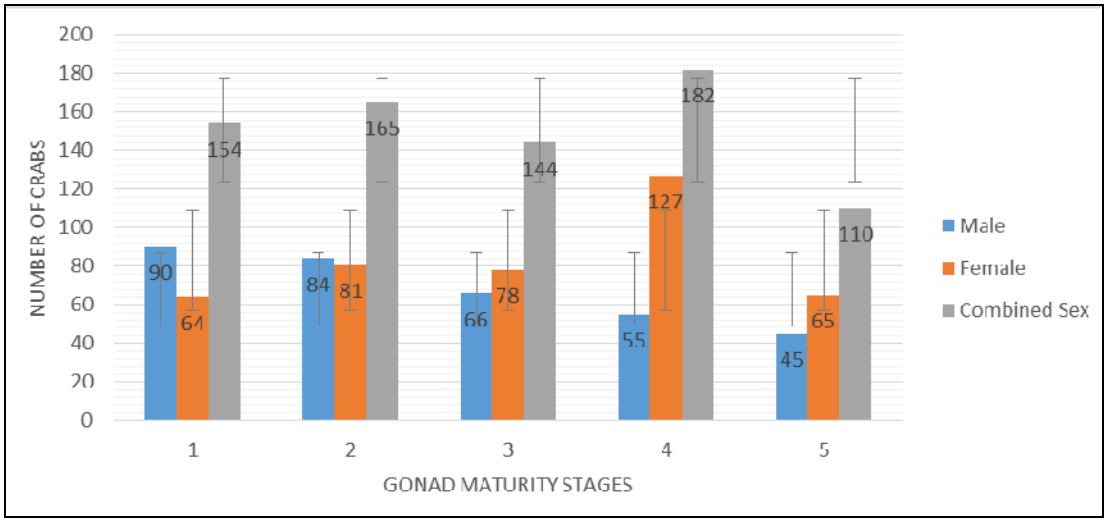

Fig 7: Comparasion of gonad maturity stages

The overall data above showed the comparation between ripe and unripe individuals, 192 : 563 or 25.34% : 74.66%. It means that the crabs caught at Tegalsari coastal fisheries port still have not been gonad maturity (most immature and a priori as juvenile). This condition will cause a population decline.

Length at first maturity (Lm)

The length at first maturity of crab has observed is 110.17 mm, The width range is from 108.45 to 111.92 mm. The male gonad maturity is 124.74 mm, the widht range is 122,45- 127 072 mm. The female gonad maturity is 113.57 mm, the width range is from 111.41 to 115.77 mm. Comparing to Ministerial regulation of fisheries number one in 2015 show that Lm of catch >10 cm. It indicates that the catch crabs was not convinient to the rule. This condition is feared to be able to violate the rule beside and degrade the resource population.

Length at first catch (Lc)

The result of the observation of estimating to the overall size of the lenght at first cacth of crabs in Tegalsari Coastal Fisheries Port were in Fig. 8. The overall size of the crabs being first catch in the waters of the North Sea Java by *arad* trawls at Tegalsari Coastal Fishing Port is 120.4 mm (Figure 8), it is about 2-3 miles at Tegal Regency. The male sex is 140.75 mm and the sex of females is 120.5 mm (Figure 9)

Based on the value of Lm of the overall crabs that have been observed was 110.17 mm, and the Lc value was 120.4 mm, it means Lc> Lm, we can know that the cacht crabs still had a chance to mature and spawn. In this case, investigation on fisheries aspects become important.

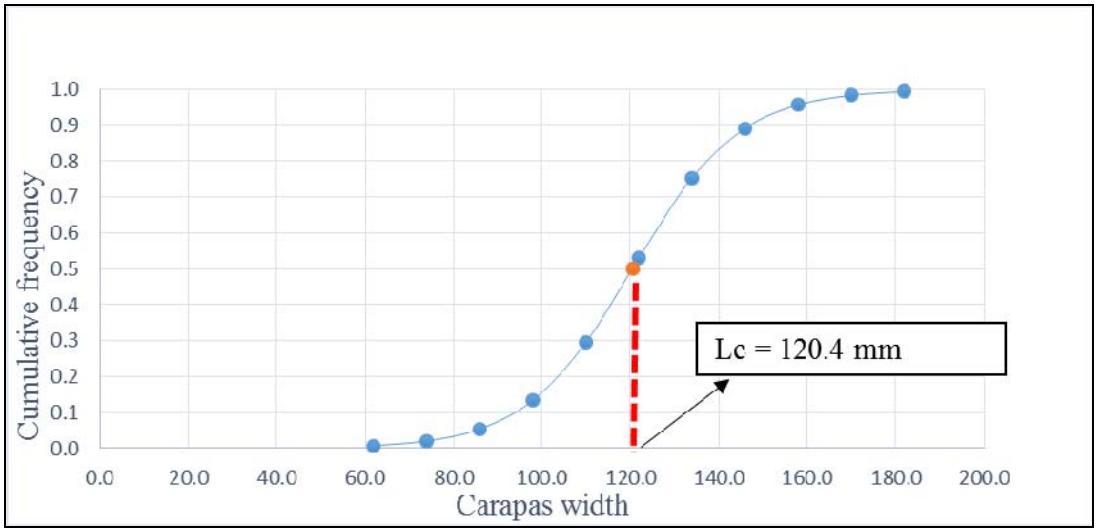

Fig 8: Length at first catch (Lc) (composite)

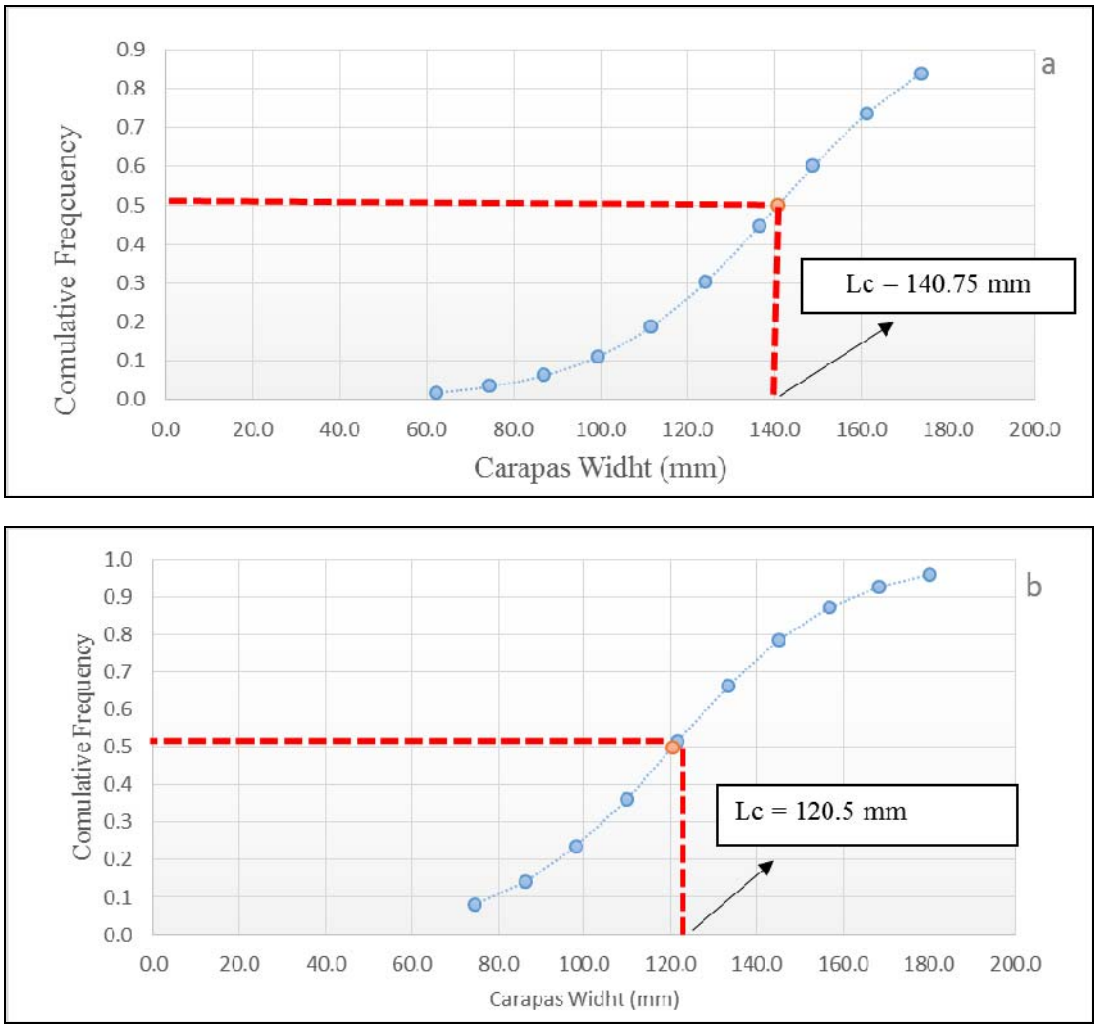

Fig 9: Length at first catch (Lc); (a) Male; (b) Female

Fisheries Aspects

Fishing ground

Fishing ground may also influence the estimation of mean size at maturity of *P. pelagicus* due to emigration habit from estuaries to offshore (De Lestang et. al., 2003; Hall et,. al., 2006; Johnson et. al., 2010) [6 8 12]. The fishing ground as designated areas of the fishermen was Tegal, Brebes and Cirebon waters which are not far from the beach, it is about 2-3 miles to the North, West and East of the mainland. However, there was a tendency during the observation that fishermen must catch the fish further from day to day.

Arad Trawl Fishing Gear, catching method, and fishing vessel

Fishing gears may have also effect the differences in estimated Lm_{50} related to their selectivity, i.e., catches are often biased for determining sexually matured crabs (Smith, 2004) [27]. *Arad* trawl fishing gears driven by using 2-4 GT engine-powered as an efficient fishing gear usually operated in the waters of the North Tegal consistsing of three main parts (wing, body and cod end). The length is from 20-25 meters. The nett material is made of polyethylene (PE) entirely. The operation of the tools is pulled by the boat at the after peak.

The operation of *arad* trawl was held from eight to twelve times hauling in a single fishing trip. The fishing operations done in four stages of the activity every season (determination of fishing ground, setting, towing and hauling).

The vessels operated for one day trip used a single machine, whereas the vessels operated for two-three days used three engines put at after peak of the vessel are made of wood. The dimensions of the length vessel are in the ranges of 10-12 meters, the width vessels were in the ranges of 3.0 – 3.5 meters and the depth vessels were in the range of 1.5 to 1.8 meters

The fuel used by fishers is diesel fuel which has price on the spot about Rp 6.500,-per liter. The fuel needed by each vessel is different. Arad trawls that operate one day require about 15-20 liters of diesel fuel per trip, while the Arad trawls that operate two-three days require diesel fuel about 100-200 liters per trip.

It was found from the observation and questionnaire many fishermen do not know about the rules of marine fisheries minister number one and two in 2015 banning the use of *Arad* trawl in catching fish, and restriction to catch small crab.

Fishermen

The fishermen operating *arad* trawl consisted of three-four people. The job description is based on individual ability and status of ownership of the vessel and fishing gear. The officer of the vessel are one helmsman and three crews. Fishermen of *arad* trawl in Tegalsari Coastal Fiheries Port are a local fishermen. These fishermen made the activity to catch the fish as their main job. The majority of vessel owners is people

from Tegal. Division of the catch per trip is 50% for owners and 50% for crews. Based on the data, most of the fishermen are uneducated, their skill coming from their parent directly is very limited. Most of the fishermen are not the owner ship, they are just as workers which certainly have a very small revenue. So most of them live in poverty.

Management efforts

Based on the interviews and direct observations at Tegalsari Coastal Fisheries, *Arad* trawl fishing gear is largely operated by small fishermen. The catch which is sold every day at Tegalsari Coastal Fisheris Port consisted of Snake mackerel, Swangi fish, Threadfin bream, Ray-finned fish, Ribbon fish, Marble sleeper, Shimping mussels, Squid and Crab. The fish bought by collectors then are sold in the local market, or distributed to the other city.

Some fishermen realized that *arad* fishing gear is not environmentally friendly, therefore, some fishermen have modified their net size. The sizes of the net modification are from small to large started from 1 inch, 2 inches, 5 inches, 8 inches until 2 meters, or by adding more float and reducing ballast, but these modifications have not been tested yet academically whether they are environmentally friendly or not.

Based on observations and interviews with fishermen, it has not been found management efforts on the crab biota in particular. It was proved by the lack of information data of catch of the crabs from the relevant authorities and there are still blue swimmer crabs caught by the arad trawl fishing gear on size <10 cm and they are laying.

Conclution

The catch crab (*Portunus pelagicus*) carapaces have an average width of 119.4 mm. The overall crab weight-width relationship ($W = 0.0000311\ L^{3.0623}$), ($r = 0.9368$), Males ($W = 0.0000249\ L^{3.2202}$), ($r = 0.9466$), Females ($W = 0.0000536\ L^{3.0378}$), ($r = 0.9325$).

The sex ratio between male and female crab is 1 : 1.2205, or 45.033% male and 54.967% female where the number of female crabs dominated the catches during the months of February to May, 2016.

The uniformity of the sexes tested by chi-square test with 95% confidence level ($\alpha = 0.05$), the result of the value is $\chi^2 = 7.450$, while the χ^2 tables = 3.84, it means χ^2value>χ^2 table.

The most catch swimmer crabs are in the gonad maturity stage of number four with a percentage of 24.106%. The overall data above showed the comparation between ripe and unripe individuals, 192 : 563 or 25.34% : 74.66%.

The length at first maturity of crab has observed is 110.17 mm, The width range is from 108.45 to 111.92 mm. The male gonad maturity is 124.74 mm, the widht range is 122,45- 127 072 mm. The female gonad maturity is 113.57 mm, the width range is from 111.41 to 115.77 mm. The overall size of the lenght at first cacth of crabs is 120.4 mm. The male sex is 140.75 mm and the sex of females is 120.5 mm. it means Lc> Lm.

There is a tendency during the observation that fishermen must catch the fish, especially blue swimmer crab *P. pelagicus* further from day to day. Many vessels used by fishermen (most of them are not the owner of ship) landed at Tegalsari Coastal Fisheries Port is in small size (L= 10-12m, W= 3-3.5m) use environmentally unfriendly fishing gear (*arad* trawl is one of the banned fishing gear).

It has not been found management efforts on the crab biota in particular yet. It was proved by the lack of information data of catch of the crabs from the relevant authorities and there are still blue swimmer crabs caught by the arad trawl fishing gear on size <10 cm and they are laying

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