Submission Journal, January 1st 5

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Kepada: Miklos Botha, Mag Ioan Valentin

Jum, 8 Jan 2021 jam 21.25

Dear Dr. Miklos,
Here I send our first manuscript journal in 2021:

The growth rate of Banana shrimp(*Fenneropenaeus indicus* H. Milne Edward, 1837) in Seneboy Waters, South Sorong, Papua-Indonesia

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Submission letter

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The growth rate of Banana shrimp (*Fenneropenaeus indicus* H. Milne Edward, 1837) in Seneboy Waters, South Sorong, Papua-Indonesia

Name of the authors: Erick Nugraha

Hereby I would like to submit the manuscript entitled "**article title**" to Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society.

This manuscript was not submitted or published to any other journal. The authors declare that the manuscript is an original paper and contain no plagiarised text. All authors declare that they are not currently affiliated or sponsored by any organization with a direct economic interest in subject of the article. My co-authors have all contributed to this manuscript and approve of this submission.

Corresponding author

Erick Nugraha

Date, January 08, 2021

Kembali Arsipkan Pindahkan Hapus Spam •••

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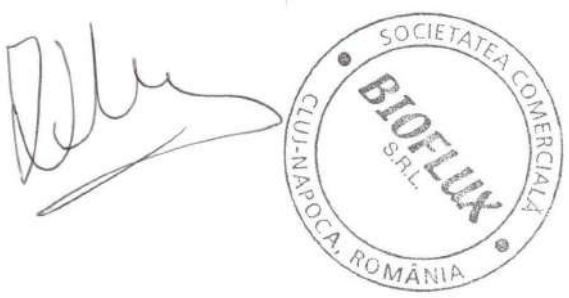

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"The Growth rate of Banana shrimp..."

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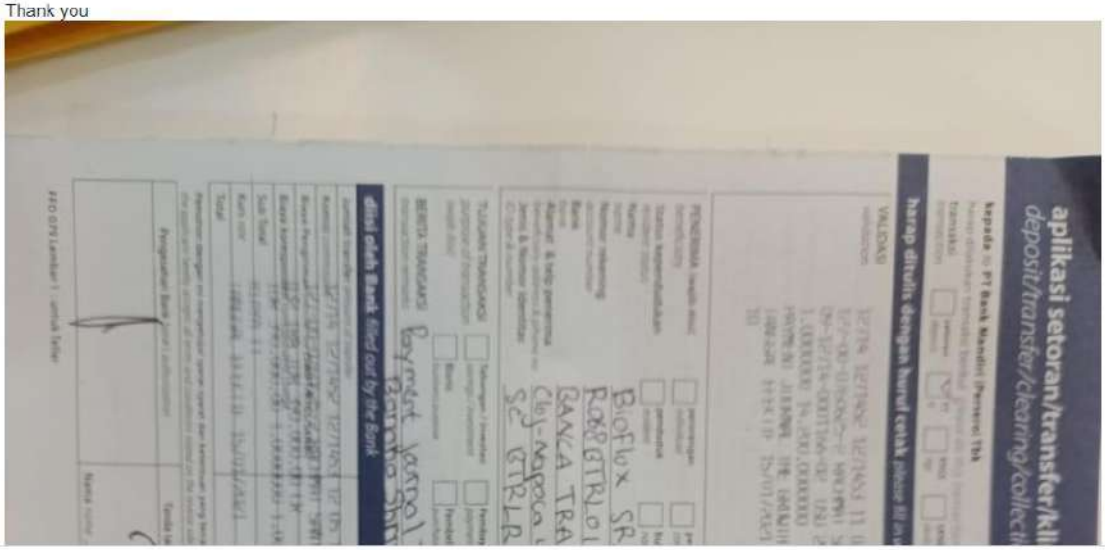

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Dear Erick Nugraha,

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Coming back soon with more info.

Kind regards,

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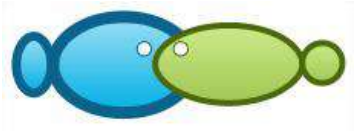

The growth rate of ~~banana shrimp (~~*Fenneropenaeus indicus*~~)~~ in Seneboy Waters, South Sorong, Papua, Indonesia

[1]Helman Nur Yusuf, [1]Ali Suman, [2]Achmad Suhermanto, [3]Adnal Yeka, [3]Indra Syamson, [3]Ratih M. Rahmani, [3]Yulia Fitri, [4]Bongbongan Kusmedy, [4]Erick Nugraha

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Abstract. *Fenneropenaeus indicus* is one of the ~~important~~ economically important ~~types~~ species of shrimp cultivated in South Sorong Seneboy waters and currently its production tends to decrease. Studying its biological aspects provides ~~One of the~~ data and information needed ~~in~~ for assessing its exploitation and managing ~~the level of utilization and basis for its management is the biological aspect~~ its conservation. This study aims to examine the biological aspects of *F. indicus* as a ~~policy~~ material for shrimp fisheries management in the waters of Seneboy, South Kalimantan. The study was conducted in January-November 2017 in the waters of Seneboy. The results showed that the average size of the caught female *F. indicus* ~~caught~~ was 13.2-52.8 mm ~~carapace length (CL), CL~~ with a mode size of 31.1-33 mm CL, ~~carapace length (CL)~~ and the average size of a male shrimp was 16-49.6 mm CL with a mode size 29-31 mm CL. The sex ratio of male and female shrimp is 1:1.8. *F. indicus* spawning season is suspected to last all year and peak in February and October. The average size of the first time caught (Lc~~)~~=31.1 CL) shrimp is smaller than the average size of the first time cooked gonads (Lm~~)~~ ~~(31.1<=~~35 mm ~~CL~~) so that most of the shrimp caught are small and have not spawned. In female *F. indicus*, the g~~G~~rowth rate (K), asymptotic carapace length (CL∞)~~,~~ and age at length 0 (t0)~~of female *F. indicus* at length 0 (t0)~~ were of: 1.1 cm year^{-1}, 54.6 mm CL and -0.14883 years, respectively~~;~~ , while in male they were~~*F. indicus* is~~ of: 1.0 cm year^{-1}~~,~~; 52.6 mm and -0.136202 years, respectively. ~~Natural~~ The natural mortality rate (M), death rate due to capture (F), total death rate (Z)~~,~~ and exploitation rate (E) of female rock lobsters ~~at~~ were 2.64 cm year^{-1}~~;~~ , 1.53 cm year^{-1}~~;~~ , 2.64 year^{-1}~~;~~ and 0.48 year^{-1}, respectively~~.~~ , ~~While~~ while in male *F. indicus* amounted to 2.64 cm year^{-1}~~;~~ , 1.42 cm year^{-1}~~;~~ , 1.22 cm year^{-1}~~;~~ and ~~exploitation of~~ 0.56 cm year^{-1}, corresponding to an~~or optimum~~ optimal utilization of the *F. indicus* resources. The status~~rate of exploitation/exploitation~~ of *F. indicus* in Seneboy waters is "not fully exploited".
Key Words: biology aspect; shrimp fisheries management; sex ratio; spawning season.

Introduction. *Fenneropenaeus indicus* is one of the important commodities in the waters of Seneboy, South Sorong. ~~This type of~~ *F. indicus* has ~~important~~ an economic value and contributes to the improvement of the fishermen's ~~economy~~ life in South Sorong. Seneboy fishermen catch *F. indicus* using a 4 meter nylon trammel net as fishing gear, operated by 3 people from~~with an average tonnage of 3 GT~~ vessels of about 6 m in length, made of wood and fiber, of an average tonnage of 3 GT and a main engine power of 15 HP~~ main engine power~~, ~~as many as 3 people, about 600 m in length in a 4 meter nylon net~~. ~~Mesh~~ The mesh size is of 1.5-7.25 inch, with a polyethylene head ~~PE~~ rope of Ø 8 mm ~~for the head rope~~. The length of the ground rope is 660 m. This effective and environmentally friendly fishing gear

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is ~~an effective and environmentally friendly~~used ~~fishing gear~~ for catching *F. indicus* and other types of demersal fish which are bycatch (BRPL, 2016).

The ~~trammel net fleet in~~ catching time per trip ranges from 6~~-~~ to 9 hours ~~(or start at~~from 07.00 to 16.00 hours~~-(, which is~~ one day fishing~~),~~) and the fishing ground ranges from 1~~-~~ to 20 miles, with a distance of about 1-4 hours from the landing base. ~~Shrimp~~ The shrimp fishing grounds are located around Wawonket Cape, Dua Island, Daram Island, Sibabu Cape, Komokara Cape, Sabuga Island, Sele Cape, Misool Islands, Sinabu Cape, Banana Island and Segeat Island. ~~Shrimp~~ The shrimp fishing season is 12 months with the highest season in July-November, with a catch of around 10-100 kg trip^{-1}. The p~~P~~roduction of shrimp and other crustaceans in South Sorong waters, in the period 2009 to 2016, ~~amounted to~~reached 4,051 tons, with an annual average of 506.42 tons or 38.75% total production. ~~Meanwhile,~~ T~~t~~he annual average production of *F. indicus* is 475.75 tons, with the highest production in 2010 of 557 tons and the lowest in 2013 of 350 tons (DKP Sorong 2017).

Shrimp catching activity in Seneboy, South Sorong, is the main support to meet the economic needs of trammel net ~~fisherman~~ fishermen in Temibuanan Regency. Catching shrimp at this location is carried out very intensively, so that fishing activities need to be ~~controlled~~supervised ~~in its utilization~~. ~~One of the efforts in determining management is by examining several aspects of~~ The biology and population parameters provide the control and management criteria to the marine authorities.

Research on several aspects of biology and population parameters was extensively conducted in several waters in Indonesia~~, namely in the waters of:~~ Arafura (Naamin 1984), Cilacap (Suman 1992; Suman & Boer 2005; ~~Saputra 2005~~ Hargiyatno et al 2013; Saputra & Subiyanto 2007; ~~Hargiyatno et al 2013)~~, Strait Madura (Setyohadi et al 1999), Kotabaru (Suman & Umar 2010), Bone (Kembaren & Ernawati 2015), Tarakan (Kembaren & Suman 2013) and Meulaboh (Yusuf et al 2017).

The study provides information on the exploitation status of shrimp ~~fisheries as a catch target and over exploiting efforts~~, ~~based on~~facing the market~~-~~ demand and an ~~the~~ increasing commercial value ~~of shrimp~~. Rational management actions need to be taken ~~so that~~in order to maintain a sustainable balance of the shrimp resources ~~are in a sustainable-~~ balance. ~~-~~and ~~Estimation~~ the population parameters estimation ~~of population parameters~~ is ~~needed~~ required as supporting data and information ~~in this management, namely evaluating the status of white shrimp increase from year to year so that it can be used sustainably~~. The results of this study are expected to complement and update previous studies, ~~to underlie~~ underlying the management of *F. indicus* resources in the waters of Seneboy, South Sorong, and ~~its~~ surroundings.

Material and Method

Research location and time. *F. indicus* sampling was carried out with a trammel net, obtained from fishermen and shrimp collectors in Seneboy Temibuana, South Sorong, from January to October 2016. The enumerators were taking samples using a random sampling method. The data collected included carapace length (CL), weight, sex, gonad maturity level and fishing area (Figure 1).

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Commented [WU7]: What represents this percentage?

Commented [EN8R7]: Added. Thank you

Commented [WU9]: In the previous phrase it is stated that the total catch is of 506 tons of all species of crustaceans. Are these 475 tons of white shrimp included into the total of 506 tons? White shrimp is *Fenneropenaeus indicus*?

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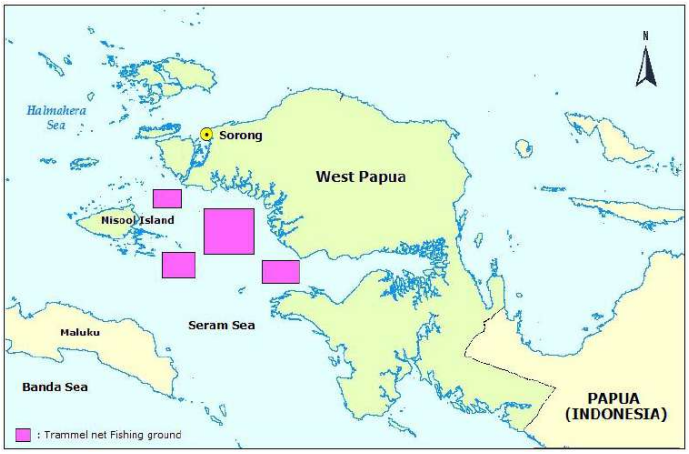

Figure 1. Fishing ground of trammel net in Seneboy, South Sorong (https://www.mapsofworld.com/where-is/sorong.html).

Data analysis. ~~Biological data analysis included the size distribution, sex ratio, gonad maturity level, average size of first caught specimens (Lc) and average size of at the gonad maturation (Lm). The analyzed sis of population parameters data were the growth pattern data (CL∞, K), mortality parameters (Z, M, F) and utilization rate (E).~~ Biological data analysis included the size distribution, sex ratio, gonad maturity level, average size of first caught specimens (Lc). The analyzed population parameters were the growth pattern (CL∞, K), mortality parameters (Z, M, F) and utilization rate (E).

The distribution of carapace length measurements is presented in the form of a bar chart with a length class of 2 mm. The level of maturity of female shrimp gonads was observed visually based on Motoh (1981), namely by looking at the size of the shrimp ovary, located on ~~the~~ its back ~~under the sun~~. Shrimp sex ratios were analyzed using the Chi-square test (Walpole, 1993)

~~The average first time ripening gonad lengthripening (Lm) is obtained by entering the carapace length and P_{Lm} values into a graphical logistic function (King, 1995), with the following equation:~~ The length at first matured (Lm) is obtained by entering the carapace length and P_{Lm} values into a graphical logistic function (King 1995), with the following equation:

$$P_{Lm} = \frac{1}{1 + \exp(aCl + b)}$$

The value of carapace length caught for the first time (Lc) is obtained through a logistic function approach, with the Sparre & Venema (1992) equation:

$$S_L = \frac{1}{1 + \exp(a - b * CL)}$$

~~Where:~~
~~S_{CL} – the fishing gear selectivity;~~
~~a and b – constant;~~

Commented [WU13]: There is a confusion in the manuscript between the lengths: carapace length, total length, length at first catch, length of specimens at first gonad maturity and length of gonads themselves at first maturity. Please clarify this point! At the method section, you declare only "carapace length (cl), weight, sex, gonad maturity level and fishing area" as data collected.

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Commented [WU15]: Where is the gonad length in the equation? What are a and b (at the exponent) and what signifies the probability P_{Lm}? How do you calculate the Lm from the P_{Lm}?

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~~CL - the length of shrimp carapace;~~
~~- the value of CLc - obtained from a/b.~~
Where:
a = the intercept of regression;
b = the slope of regression;
S_L = logistic curve and Lc was determined by a/b.

The method used in the study of population parameters is an analytical model based on the composition of the age structure of the shrimp (Sparre & Venema~~,~~ 1992). The growth parameters of Von Bertalanffy, namely the asymptotic carapace length (CL∞) and the growth coefficient (K) were estimated by the ELEFAN I program in the FISAT II program (Gayanilo et al~~.,~~ 2005). An~~E~~ estimation of the theoretical age (t0) is carried out with the Pauly's (1983) empirical equation, namely:

$$Log\ (-t_0) = (-0.3922) - 0.2752 \log CL\infty - 1.038 \log K$$

The value of the natural mortality (M) is estimated ~~by~~ through the Pauly's equation, by ~~explaining that there is an~~including the effect of the mean water temperature (T) on the mortality rate, based on empirical observations (Pauly et al~~.,~~ 1984):

$$\text{Log M= (-0.0066)-0.279 logCL}\infty\text{+0.6542 logK +0.4634 LogT}$$

The total mortality (Z) value was estimated using the length-converted catch curve method in the FISAT II program package (Pauly~~,~~ 1983; Gayanilo et al~~.,~~ 2005). ~~Capture~~ The capture mortality and exploitation rate are estimated using the Sparre & Venema (1992) equation~~,~~:s:

$$E = \frac{F}{F+M}$$

$$E = \frac{F}{Z}$$

Where:
E - the exploitation rate;
F - the Fishing mortality;
M- natural mortality;
Z - the total mortality;

Results and Discussion

Biological aspects. ~~Samples of~~A number of ~~*F. indicus* obtained during the study were~~ 2,085 *F. indicus*, specimens were collected during the study were~~, consisting of~~: 1,174 females ~~*F. indicus*~~ (56.31%) and 911 males (46.69%). The carapace length of female *F. indicus* ~~ranges~~ ranged from 13.2 ~~–~~to 52.8 mm, ~~with~~ for a weight~~s~~ ranging from 9.6~~–~~ to 88.4 g, with two modes in the ranges of 29-31 and 31.1-33 mm CL. The carapace length of ~~Meanwhile,~~ male *F. indicus* ranged between 16-49.6 mm, for a weight~~s~~ ~~ranged~~ ranging from 15.4~~–~~ to 78.6 g, with a mode in the range of 29-31 mm CL (Figure 2).

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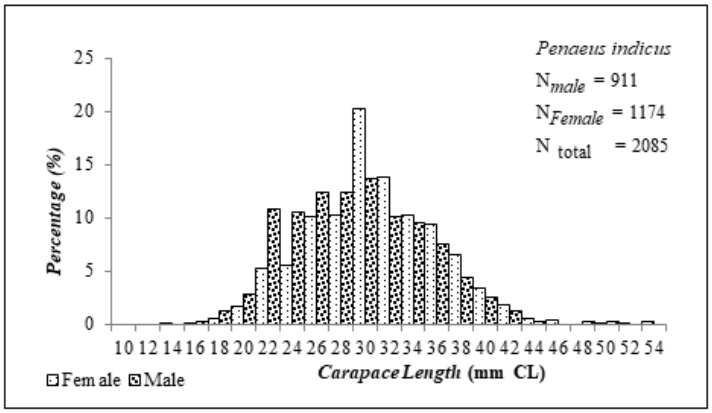

Figure 2. Length frequency of *Fenneropenaeus indicus* in Seneboy waters.

The sex ratio determination of *F. indicus* in the waters of Seneboy South Sorong is based on the chi squared test~~,~~, which indicates an imbalance ~~the condition is not balanced~~ between the ~~number of~~ male ~~shrimp~~ and female shrimp populations~~.~~ : ~~Female~~ in most cases, female shrimp ~~are~~ dominate the catch~~ught more dominantly than males~~. ~~The~~ Although the average sex ratio of *F. indicus* ~~of~~ males and females ~~shrimp~~ is 1: 1.78~~,~~ ~~Meanwhile, the sex ratio of *F. indicus*~~ it showed a balanced ~~condition~~ value of 1:~~1~~1 in February, March, September and October (Table 1).

Table 1

Sex ratio of *Fenneropenaeus indicus* in Seneboy waters, January-October 2016

Months	*Sex ratio of F. indicus*					*Comparison*
(2016)	*Male*	*Female*	*M:F ratio*		*X2*	*P=95%*
January	66	162	1	2.45	40.42	Not balanced
February	100	98	1	1.48	0.02	Balanced
March	94	106	1	1.61	0.72	Balanced
April	78	99	1	1.50	2.49	Not balanced
May	149	97	1	1.47	10.99	Not balanced
June	56	144	1	2.18	38.72	Not balanced
July	100	161	1	2.44	14.26	Not balanced
August	62	138	1	2.09	28.88	Not balanced
September	119	81	1	1.23	7.22	Balanced
October	87	88	1	1.33	0.01	Balanced
Total	911	1174	1	1.78	143.73	Not balanced

The highest proportion of mature female *F. indicus* (the maturity level of gonads III and the maturity level of gonads IV) was in January, February, September and October, with the peak maturing of gonads in October. The proportion of ~~mature~~ females with mature gonads in January, February, September and October was 60, 44, 46 and 40% (Figure 3).

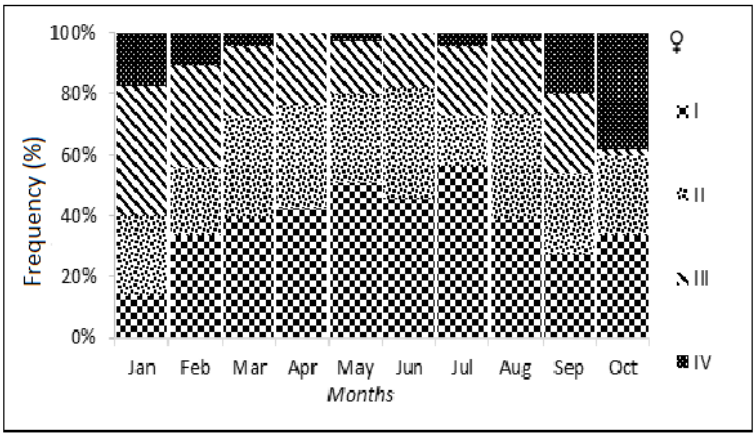

Figure 3. Proportion of ~~gonad maturity stages for female~~ *Fenneropenaeus indicus* females with mature gonads in Seneboy waters, January-October 2016.

The size of the first time capture (Lc) corresponds to the probability level of L50% ~~on~~ of the trammel net selectivity, ~~explaining~~ meaning that the ~~opportunity for the~~catch distribution of *F. indicus* ~~is suitable to be caught~~ can influence~~crease~~ the availability of resources. The logistic function graph with a class interval of 2 mm CL ~~is obtained~~indicates that the average value ~~for~~ at the first ~~time~~ capture (Lc) of *F. indicus* is 31.1 mm CL, with an average value (Lm) of 35 mm CL ~~for~~ at the first ~~time~~ gonad maturation (Figure 4).

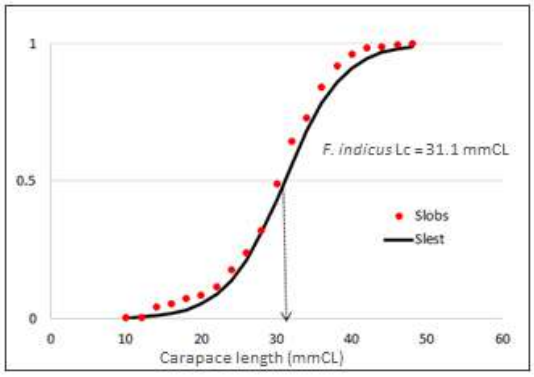

Figure 4. Average length at first *Fenneropenaeus indicus* ~~captured~~ capture with a trammel net of the~~*Fenneropenaeus indicus* with trammel net~~.

Population parameters. ~~The results of the analysis based on the length frequency of female *F. indicus* carapace obtained the~~indicated a ~~value of~~ 1.1 per year for the ~~growth coefficient (K) in Seneboy waters~~ 1.1 per year ~~and 1.0 per year for male *F. indicus* (Figure 5).~~ The Growth parameters of *F. indicus* in the Seneboy waters is processed from long frequency distribution data carapace by tracking any mode shift the distribution of carapace length frequencies in a curved sequence of times Von Bertalanffy's growth. Based on the results of the analysis, it

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Commented [EN28R27]: Corrrected. Thank you

was found that infinitive carapace length (L∞) of female *F. indicus* 54.6 mm, the growth rate (K) is 1.1 year $^{-1}$ and the male is 52.6 mm, the growth rate (K) is 1.0 year^{-1} (Figure 5). From the value of these two parameters agrowth equations and so can be created a key relationship between carapace lengths with aged shrimp by using multiple variation in age value (t).

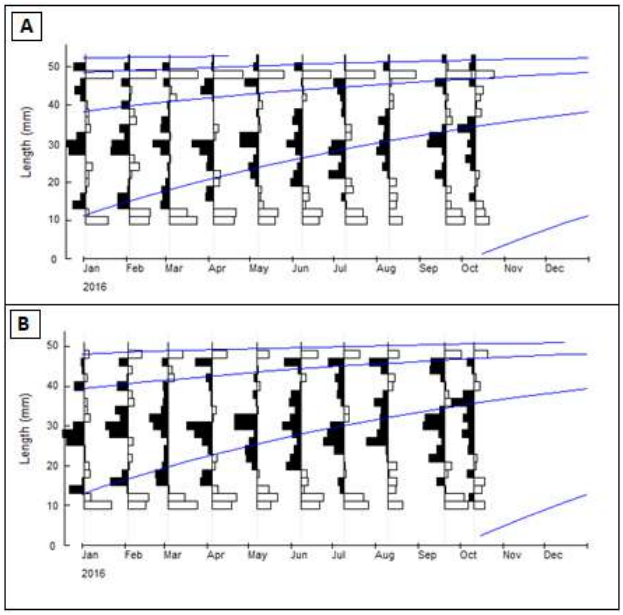

Figure 5. Growth model of male (A) and female (B) *Fenneropenaeus indicus* by ELEFAN I in Seneboy waters.

The asymptotic carapace length (L∞) of female *F. indicus* was 54.6 mm CL and 52.6 mm CL for males, while the age of female *F. indicus* at 0 (t0) was -0.14883 years and -0.136202 for males. So that the equation for the Von Bertalanffy equation for female *F. indicus* is ~~as~~ Lt = 54.6 (1-e-1,100 (t-0.14883)) and for male *F. indicus*, it is Lt = 52.6 (1-e-1,00 (t-0.136202)) (Figure 6). The maximum size range of *F. indicus* is estimated at the age of 1.8 years or around 20 months. The average size of 31.1 mm CL ~~of~~ in caught *F. indicus* ~~caught~~ (Lc) ~~31.1 mmCL~~ was estimated at the age of 7-8 months. The average mature gonad size ~~of~~ in females (Lm) was ~~gonad ripe average (Lm)~~ of 35 mm CL, ~~was estimated~~ at the age of 9-10 months.

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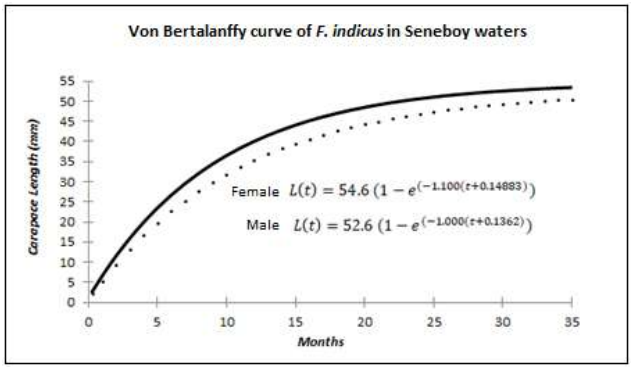

Figure 6. Von Bertalanffy curve of *Fenneropenaeus indicus* in Seneboy waters.

The total mortality rate (Z) of female and male *F. indicus* based on the length-converted catch curve~~length conversion curve with the catch~~ is 3.16 year^{-1}, with a natural mortality rate (M) of 1.64 year^{-1} and the mortality rate due to fishing (F) of 1.53 year^{-1}. The total mortality rate (Z) of male *F. indicus* was 2.64 year^{-1}, the natural mortality rate (M) was 1.42 year^{-1} and the mortality rate due to fishing (F) was 1.22 year^{-1}. Based on these mortality parameters, the utilization rate of ~~female~~ *F. indicus* was 0.48 for females and ~~male was~~ 0.46 for males (Figure 7).

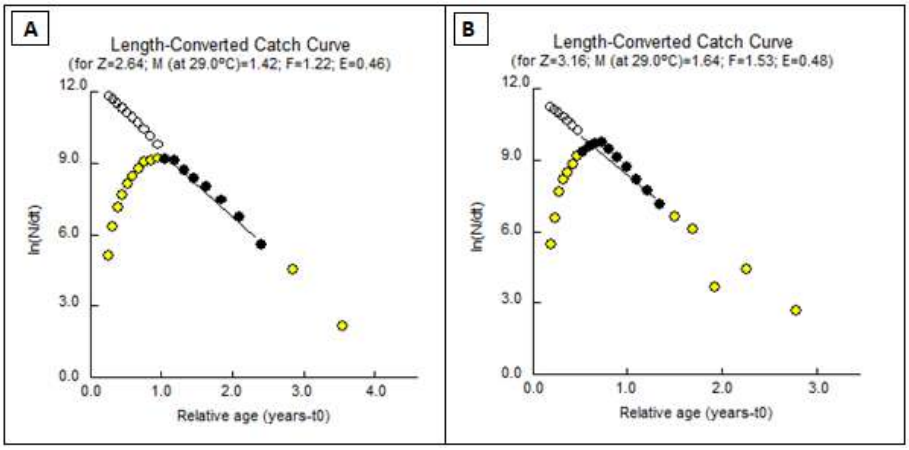

Figure 7. Growth curve of male (A) and female (B) *Fenneropenaeus indicus* in waters of Seneboy.

Discussion. The size distribution of *F. indicus* caught in the study area was greater than ~~that~~ in Kaimana waters, ranging from 25-49 mm, and the average size was 28.98 mm for males and 34.96 for females. The size of *F. indicus* specimens ~~and was not much different from those~~ caught in Meulaboh waters ~~are females with ranges~~ ranged between 17.8~~–~~ and 79.54 mm for females and~~,~~ ~~males~~ between 18.3~~–~~ and 64.36 mm for males. The size of~~Whereas~~ *Penaeus merguensis* in Central Java waters ranged between ~~for males is~~ 20~~–~~ and 62 mm for males and between ~~females~~ 14~~–~~ and 68 mm for females, ~~waters in West Java (~~and averaged

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17 to ~~-~~47 mm in West Java waters~~)~~ (Tirtadanu~~,~~ & Panggabean 2018; Yusuf~~,~~ 2017; Suman et al~~.,~~ 1988). Differences in shrimp size at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al~~.,~~ 2017; Wilson et al~~.,~~ 2010; Matthews~~,~~ 1982; Ogbonna~~,~~ 2001). Given ~~It is suspected that~~ the larger shrimp size in Seneboy waters, it is supposed that ~~is~~ the species is not over-utilized.

The sex ratio of male and female shrimp in the study area was not balanced: ~~with~~ the ~~number of~~ females ~~caught being more dominant~~ dominated ~~than males~~the catch. The unbalanced ~~condition~~ sex ratio is similar to the *F. indicus* caught in Meulaboh waters (Yusuf~~,~~ 2017; Saputra~~,~~ 2008; Saputra et al~~.,~~ 2013; Wedjadmiko & Yulianti~~,~~ 2003; ~~Wedjadmiko~~Wedjatmiko~~,~~ 2009; Suman et al~~.,~~ 1991~~).~~), ~~This condition shows~~suggesting that the fishing pressure of shrimp resources in Seneboy waters has not disturbed the population renewal so that the sustainability of shrimp stocks is still well maintained.

The peak indic~~estim~~ated that a higher frequency~~proportion~~ of mature gonads in ~~ripe~~ *F. indicus* ~~occurs~~ occured in February and October~~.~~, ~~The discovery of mature gonads indicates that this month is~~suggesting the spawning seasons for the shrimp (Martosubroto~~,~~ 1978). ~~The~~ For comparson, the ~~peak~~ spawning peaks occurred in ~~of~~ November for several types of Penaied shrimp~~, including *P. merguiensis* in~~ from the waters of West Kalimantan (including *P. merguiensis*), in January and August for the ~~occurred in November, the peak spawning of~~ *Metapenaeus monoceros* from~~in~~ the Southern Java waters and from September to October for the ~~occurred in January and August and the peak spawning of~~ *Metapenaeus monoceros* ~~in~~ from the Gulf of Carpentaria, Australia ~~occurs from September to October~~ (Kembaren~~,~~ & Suman 2013; Suman et al~~.,~~ 2005; Crocos et al~~.,~~ 2000; Pillai & Thirumilu~~,~~ 2013~~;~~ ~~and~~ Gerami et al~~.,~~ 2013). The spawning season for *F. indicus* in the study area ~~is seen to~~ last~~ed~~ throughout the year, with ~~a~~ peaks in February and October. Therefore, ~~F~~from the perspective of the resources sustainability, it is preferable to suspend the *F. indicus* fishing activities in Seneboy waters ~~that within a period of one year the season closes in~~during February and October ~~for catching *F. indicus* in Seneboy waters~~.

The first catch average size (Lc) ~~for the first time caught (Lc)~~ of *F. indicus* in the study area was of 31.1 mm CL and the mean value ~~for~~ at the first ~~time~~ gonad ~~maturation~~ maturity was 35 mm CL. The results of research conducted in the waters of the Cilacap Segara Anakan Lagoon, ~~with~~ using floating nets, showed an Lc value of 20.2 mm, ~~or at~~ for a total length of about 90 mm (Saputra~~,~~ 2008). Chan (1998) ~~states~~ stated that *F. indicus* females can reach a total length of 230 mm, although t~~hat is~~ey generally measure less than 170 mm. These results are different from the ~~results of~~ research conducted in the waters of North Central Java, where the carapace length of *P. merguensis* ~~is~~ was of 29.4 mm (Tirtadanu & Ernawati~~,~~ 2016); Wedjatmiko & Yulianti~~,~~ 2003; Hargiyatno ~~I.T.~~ & Sumiono ~~B.,~~ 2012). The differences ~~in~~ of Lc values are~~is~~ not only caused by the mesh size of the net used, but ~~is~~ they are also due to the operations duration ~~time~~ and to the location of the fishing ground. According to Susetiono & Setyono (1990), the ~~group of~~ *P. merguensis* ~~in~~ from shallow waters tends to be smaller~~.~~ than in deeper waters~~,~~ (e.g. ~~it is smaller than in the waters of~~ Cilacap), ~~with an average size of first maturation of gonads (Lm) of 51 mm CL (Saputra et al., 2013).~~ with an average size (Lc) of 51 mm CL (Saputra et al 2013). The shrimp size differences ~~in shrimp size in~~ at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al~~.,~~ 2017; Wilson et al~~.,~~ 2010).

According to FAO (2008), the Lm value is 50% of *F. indicus*, at a total length of 130-149 mm. This shows that the value of L50% <Lm50% means that *F. indicus* recruitment is threatened by ~~recruitment~~ overfishing. According to Teikwa & Mgaya's (2003) research ~~(2003)~~, the *F. indicus* carapace length size of the first caught ~~male *F. indicus*~~ males is ~~at~~ of 34 mm ~~carapace length~~ and ~~female shrimp at~~ 39 mm carapace ~~length~~in female shrimps. ~~Melmammblessy's (2011) research (2011) showed that in Arafura's waters the size of the first maturity of the gonads at a carapace length of 60.26 mm.~~ Melmammblessy's (2011) research showed that in Arafura's waters the size of the first catch average size (Lc) at a carapace length of 60.26 mm. The average size ~~for~~ of the *F. indicus* ~~first time~~ caught for the

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first time ~~by *F. indicus*~~ (Lc) in the study area was smaller than the average size at the first maturity of gonads (Lm), indicating that most of the shrimp caught had not spawned ~~so~~. ~~in~~ In the long ~~run~~ term, this situation is~~was not good for~~detrimental to the population's sustainability, ~~because will~~ hampering the shrimps recruitment process ~~of adding these shrimps~~ in the Seneboy waters. In this regard, it is necessary to ~~arrange~~ adjust the size of the mesh ~~so~~ in such a manner that the smallest carapace length~~size~~ of the caught *F. indicus* ~~caught is the smallest at the carapace length of~~ cannot be under 13.2 mm CL.

The growth rate (K) of *F. indicus* in the research area shows that they have a fast growth rate: ~~with a growth value of~~ 1.1 per year in females and 1.0 per year in males, with an asymptotic carapace length (L∞) of 54.6 mm CL for females ~~*F. indicus* 54.6 mmCL~~ and 52, 6 mm CL for males. ~~With the maximum size reached at the age of about 1.8 years or about 20 months. When compared with~~ The growth parameters in different locations~~, the growth rate of *F. indicus* in the study area shows different growth values.~~were: ~~waters of the Segara Anakan Lagoon Cilacap~~ L∞ = 35.7 mm~~;~~ and K = 1.26/year in the waters of the Segara Anakan Lagoon Cilacap, ~~Kota Baru waters was~~ 1.4/year and L∞ 44.3 mm in the Kota Baru waters~~,~~ and ~~in Kaimana waters it was~~ 44.7 mm CL for males and 51.25 mm CL for females in the Kaimana waters.

Table 2

Asymptotic length (L∞), growth rate (K) and exploitation rate (E) of *F. indicus* in some areas

Location	*Sex*	*L_{∞} (mm CL)*	*K*	*t0*	*Authors*
Cilacap, Central Jawa	Combined	35.7	1.26	-	Saputra (2008)
Kota Baru, South Kalimantan	Combined	44.3	1.4	-	Suman et al (2010)
Kaimana, West Papua	Combined	44.7	1.38	-	Tirtadanu & Pangabean 2018)
Cilacap, Central Java	Male	40.7	1	0.56	Suman & Prisantoso (2017)
	Female	54.2	1.1	0.36	
Tarakan, North Kalimantan	Male	45.2	1.55	0.76	Chodrijah & Suman (2017)
	Female	57.6	1.33	0.76	
Sampit, Central Kalimantan	Combined	57.8	1.45	0.66	Nurdin & Kembaren (2015)
Tanal Laut, South Kalimantan	Combined	55	1.05	0.74	Suman et al (2017)
Cenderawasih Bay, Papua	Male	44.5	1.05 1.15	0.66	Kembaren & Ernawati (2015)
	Female	48.7		0.55	
Kaimana, West Papua	Male	44.7	1.4	0.49	Tirtadanu & Panggabean (2018)
	Female	51.25	1.37	0.44	
Seneboy, West Papua	Male	54.6	1.1	0.148	Present research
	Female	52.6	1.0	0.136	

The mortality rate (Z) of *F. indicus* in the Seneboy waters is relatively low, namely 3.16 in males and 2.6 in females. Some Penaeid shrimp in other waters, namely the waters of the Cilacap Segara Anakan Lagoon, obtained an M value of 2.6 cm year^{-1}, an F value of 1.35 cm year^{-1} (*P. meruiensis* in Segara Anakan Lagoon Cilacap is 1.43 cm year^{-1}, the natural mortality rate is 1.85 cm year^{-1} and catching 2.32 cm year^{-1}, Madura waters natural mortality rate of 2.17-2.22 cm year^{-1} and catching 1.11-1.56 cm year^{-1} (Saputra~~,~~ 2008; Kembaren et al~~.,~~ 2012; Setyohadi et al~~.,~~ 1999; Hedianto et al~~.,~~ 2016).

The highest mortality rates (ind year^{-1}) were recorded~~in the waters of Kota Baru~~: 9 for males and 9.47 for females in the waters of Kota Baru, ~~in Kakinada waters~~ 10.58 in the Kakinada waters~~,~~ ~~in Khoozestan waters~~ 7.01 in the Khoozestan waters and ~~Vietnamese waters~~ 5.78 in the Vietnamese waters (Tirtadanu et al~~.,~~ 2017; Devi~~,~~ 1987; Ansari et al~~.,~~ 2014; Dinh et al~~.,~~ 2010). ~~Natural~~ The natural mortality is influenced by several factors such as food

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availability, disease, environment, competition and ~~especially~~ the presence of predatory species (Sparre & Venema 1992; Niamaimandi et al~~.,~~ 2007). Penaeid prawn is the prey of several demersal fish, such as *Lutjanus gibbus*, *Eleutheronema tetradactylum* and *Arius* sp. (Bachok et al 2004; Titrawani et al 2013). Death due to fishing (F) of both male and female *F. indicus* is lower than the natural mortality rate (M), indicating that the *F. indicus* population has not been exploited intensively by fishermen in the waters of Seneboy, West Papua. Garcia (1988) suggests that the average natural mortality rate (M) of penaeid shrimp is 2.4 ± 0.3 year^{-1} for adult shrimp. Naamin (1984) found that the F value of *P. merguensis* in Arafura waters varies according to the development of the fishing effort, ranging from 0.55 year^{-1} (at the start of the exploitation) to 8.99 year^{-1}.

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~~Cultivation~~ In this study, the exploitation rates (E) of female and male *F. indicus* were 0.48 and 0.46. This condition explains that the fishing rate is greater than the natural mortality rate. The optimum exploitation rate stated by Gulland (1983) is 0.5, so that the rate of exploitation of *F. indicus* in Seneboy waters is close to the optimum value and is still sustainable. The level of exploitation of *F. indicus* in several areas has exceeded the optimum limit, namely in the waters of the Segara Anakan Cilacap Lagoon, Meulaboh waters, Tarakan Bay, Tanah Laut and Cenderawasih, where the level of exploitation indicates overfishing (Saputra 2008; Yusuf et al 2017; Chodrijah & Suman 2017; Suman et al~~.,~~ 2017; Kembaren & Ernawati 2015). ~~Utilization~~ The ~~utilization~~ exploitation of *F. indicus* has approached the maximum, ~~on this basis the need for~~suggesting that a reduction of the fishing pressure is required, ~~of about~~with at least 5% of the current total effort.

Conclusions. The average size of ~~male~~ *F. indicus* caught in the waters of Seneboy South Sorong is 16-49.6 mm CL for the males and ~~females~~ 13.2 - 52.8 mm CL for the females. The sex ratio of *F. indicus* ~~*Metapenaeus affinis* shows an unbalanced condition with the ratio of~~is unbalanced: ~~male and female shrimp is~~ 1:1.8, male against female. The spawning season lasts throughout the year with ~~a~~ peaks in February and October. ~~and t~~The ~~average size of first caught (Lc) of shrimp is smaller than the average size of~~ the shrimp at the ~~first time gonads maturity~~ (Lm) ~~(31.1>35 mm CL) The growth rate and mortality rate of *F. indicus* in Seneboy waters were lower with the exploitation rate values (E) 0.48 and 0.46~~. The catch is dominated by adults so that management sets the regulations for the minimum legal size. These results concluded that the arrest of F. indicus can be continued by arranging the arrest effort and stipulating a minimum legal size of 35 mmCL. This indicates that the ~~level of utilization~~ exploitation of *F. indicus* in Seneboy waters is not yet optimal, but leads to overfishing. In order ~~for~~ to maintain the sustainability of the *F. indicus* resources in the waters of Seneboy, West Papua, it is advisable (1) to reduce efforts with about 5% from the current level, by adjusting the mesh ~~so~~ in such a manner that the retained catch size ~~is~~ of *F. indicus* will be of at least 13.2 mm CL and (2) to ~~closing~~ suspend the *F. indicus* fishing ~~season~~ operations in February and October.

Acknowledgements. This paper is part of the research activity "Biological Characteristics of Fisheries, Resource Habitat and Production Potential of Fish Resources in FMA 715 Tomini Bay 2017" which was organized by the Muara Baru Jakarta Marine Fisheries Research Institute.

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Conflict of interest. The authors declare no conflict of interest.

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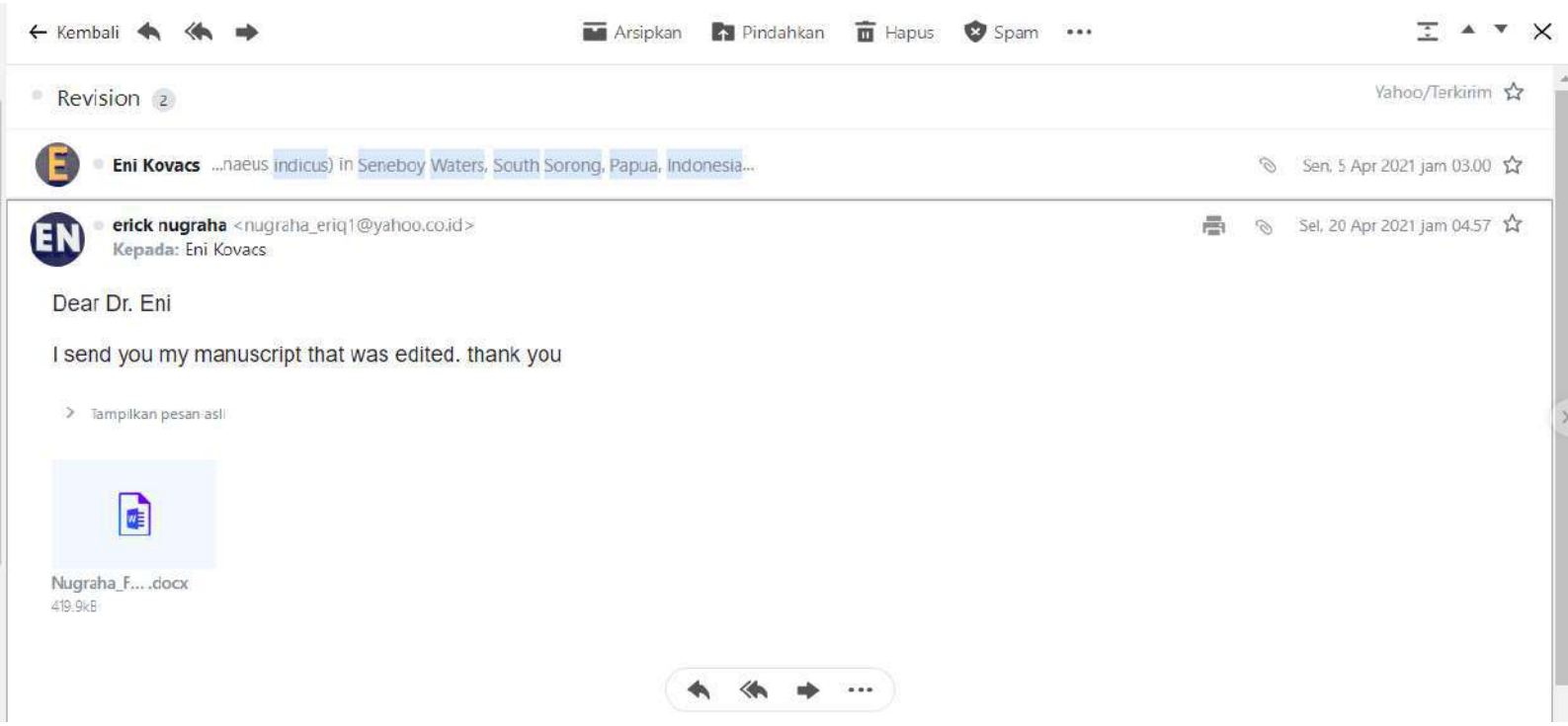
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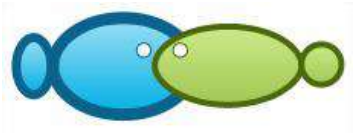

The growth rate of ~~banana shrimp~~ (~~*Fenneropenaeus indicus*~~) in Seneboy Waters, South Sorong, Papua, Indonesia

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Abstract. *Fenneropenaeus indicus* is one of the ~~important~~ economically important ~~types~~ species of shrimp cultivated in South Sorong Seneboy waters and currently its production tends to decrease. Studying its biological aspects provides ~~One of the~~ data and information needed ~~in~~ for assessing its exploitation and managing ~~the level of utilization and basis for its management is the biological aspect~~ its conservation. This study aims to examine the biological aspects of *F. indicus* as a ~~policy~~ material for shrimp fisheries management in the waters of Seneboy, South Kalimantan. The study was conducted in January-November 2017 in the waters of Seneboy. The results showed that the average size of the caught female *F. indicus* ~~caught~~ was 13.2-52.8 mm ~~carapace length (CL), CL~~ with a mode size of 31.1-33 mm CL, ~~carapace length (CL)~~ and the average size of a male shrimp was 16-49.6 mm CL with a mode size 29-31 mm CL. The sex ratio of male and female shrimp is 1:1.8. *F. indicus* spawning season is suspected to last all year and peak in February and October. The average size of the first time caught (Lc~~)~~=31.1 CL) shrimp is smaller than the average size of the first time cooked gonads (Lm~~)~~ ~~(31.1<=~~35 mm ~~CL~~) so that most of the shrimp caught are small and have not spawned. In female *F. indicus*, the g~~G~~rowth rate (K), asymptotic carapace length (CL~~”~~)~~,~~ and age at length 0 (t0)~~of female *F. indicus* at length 0 (t0)~~ were of: 1.1 year^{-1}, 54.6 mm CL and -0.14883 years, respectively~~;~~, while in male they were~~*F. indicus* is~~ of: 1.0 year^{-1},~~;~~ 52.6 mm and -0.136202 years, respectively. ~~Natural~~ The natural mortality rate (M), death rate due to capture (F), total death rate (Z)~~,~~ and exploitation rate (E) of female rock lobsters ~~at~~ were 2.64 year^{-1}~~;~~, 1.53 year^{-1}~~;~~, 2.64 year^{-1}~~;~~ and 0.48 year^{-1}, respectively~~.~~, ~~While~~ while in male *F. indicus* amounted to 2.64 year^{-1}~~;~~, 1.42 year^{-1}~~;~~, 1.22 year^{-1}~~;~~ and ~~exploitation of~~ 0.56 year^{-1}, corresponding to ano~~r~~ ~~optimum~~ optimal utilization of the *F. indicus* resources. The status~~rate of exploitation/exploitation~~ of *F. indicus* in Seneboy waters is “not fully exploited”.
Key Words: biology aspect; shrimp fisheries management; sex ratio; spawning season.

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Introduction. *Fenneropenaeus indicus* is one of the important commodities in the waters of Seneboy, South Sorong. ~~This type of~~ *F. indicus* has ~~important~~ an economic value and contributes to the improvement of the fishermen's ~~economy~~ life in South Sorong. Seneboy fishermen catch *F. indicus* using a 4 meter nylon trammel net as fishing gear, operated by 3 people from~~with an average tonnage of 3 GT~~ vessels of about 6 m in length, made of wood and fiber, of an average tonnage of 3 GT and a main engine power of 15 HP ~~main engine power~~, ~~as many as 3 people, about 600 m in length in a 4 meter nylon net~~. ~~Mesh~~ The mesh size is of 1.5-7.25 inch, with a polyethylene head ~~PE~~ rope of Ø 8 mm ~~for the head rope~~. The length of the ground rope is 660 m. This effective and environmentally friendly fishing gear

is ~~an effective and environmentally friendly~~used ~~fishing gear~~ for catching *F. indicus* and other types of demersal fish which are bycatch.

The ~~trammel net fleet in~~ catching time per trip ranges from 6~~–~~ to 9 hours ~~(or start at~~from 07.00 to 16.00 hours~~(~~, which is one day fishing~~),~~) and the fishing ground ranges from 1~~–~~ to 20 miles, with a distance of about 1-4 hours from the landing base. ~~Shrimp~~ The shrimp fishing grounds are located around Wawonket Cape, Dua Island, Daram Island, Sibabu Cape, Komokara Cape, Sabuga Island, Sele Cape, Misool Islands, Sinabu Cape, Banana Island and Segeat Island. ~~Shrimp~~ The shrimp fishing season is 12 months with the highest season in July-November, with a catch of around 10-100 kg trip^{-1}. The p~~P~~roduction of shrimp and other crustaceans in South Sorong waters, in the period 2009 to 2016, ~~amounted to~~reached 4,051 tons, with an annual average of 506.42 tons or 38.75%. ~~Meanwhile, I~~the annual average production of white shrimp is 475.75 tons, with the highest production in 2010 of 557 tons and the lowest in 2013 of 350 tons (DKP Sorong 2017).

Shrimp catching activity in Seneboy, South Sorong, is the main support to meet the economic needs of trammel net ~~fisherman~~ fishermen in Temibuanan Regency. Catching shrimp at this location is carried out very intensively, so that fishing activities need to be ~~controlled~~supervised ~~in its utilization~~. ~~One of the efforts in determining management is by examining several aspects of~~ The biology and population parameters provide the control and management criteria to the marine authorities.

Research on several aspects of biology and population parameters was extensively conducted in several waters in Indonesia~~, namely in the waters of:~~ Arafura (Naamin 1984), Cilacap (Suman 1992; Suman & Boer 2005; Saputra 2005; Saputra & Subiyanto 2007; Hargiyatno et al 2013), Strait Madura (Setyohadi et al 1999), Kotabaru (Suman & Umar 2010), Bone (Kembaren & Ernawati 2015), Tarakan (Kembaren & Suman 2013) and Meulaboh (Yusuf et al 2017).

The study provides information on the exploitation status of shrimp ~~fisheries as a catch target and over exploiting efforts~~, ~~based on~~facing the market~~–~~ demand and an ~~the~~ increasing commercial value ~~of shrimp~~. Rational management actions need to be taken ~~so that~~in order to maintain a sustainable balance of the shrimp resources ~~are in a sustainable balance.~~ and ~~Estimation~~ the population parameters estimation ~~of population parameters~~ is ~~needed~~ required as supporting data and information ~~in this management, namely evaluating the status of white shrimp increase from year to year so that it can be used sustainably~~. The results of this study are expected to complement and update previous studies, ~~to underlie~~ underlying the management of white shrimp resources in the waters of Seneboy, South Sorong, and ~~its~~ surroundings.

Material and Method

Research location and time. *F. indicus* sampling was carried out with a trammel net, obtained from fishermen and shrimp collectors in Seneboy Temibuana, South Sorong, from January to October 2016. The enumerators were taking samples using a random sampling method. The data collected included carapace length (CL), weight, sex, gonad maturity level and fishing area (Figure 1).

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Commented [WU5]: Scientific species name? Please replace by *F. indicus* in the whole manuscript.

Commented [WU6]: In the previous phrase it is stated that the total catch is of 506 tons of all species of crustaceans. Are these 475 tons of white shrimp included into the total of 506 tons? White shrimp is *Fenneropenaeus indicus*?

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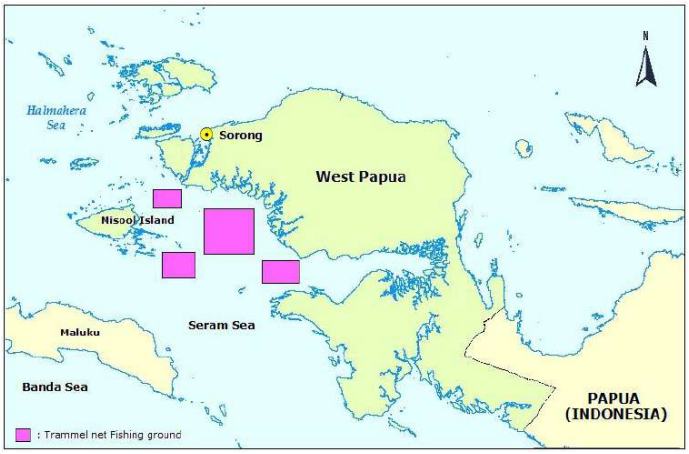

Figure 1. Fishing ground of trammel net in Seneboy, South Sorong (https://www.mapsofworld.com/where-is/sorong.html).

Data analysis. Biological data analysis included the size distribution, sex ratio, gonad maturity level, average size of first caught specimens (Lc) and average size ~~of~~ at the gonad maturation (Lm). The analyzed ~~sis of~~ population parameters ~~data~~ were the growth pattern ~~data~~ (CL∞, K), mortality parameters (Z, M, F) and utilization rate (E).

The distribution of carapace length measurements is presented in the form of a bar chart with a length class of 2 mm. The level of maturity of female shrimp gonads was observed visually based on Motoh (1981), namely by looking at the size of the shrimp ovary, located on ~~the~~ its back ~~under the sun~~. Shrimp sex ratios were analyzed using the Chi-square test (Walpole~~,~~ 1993)

The average first time ripening gonad length~~ripening~~ (Lm) is obtained by entering the carapace length and P_{Lm} values into a graphical logistic function (King~~,~~ 1995), with the following equation:

$$P_{cLm} = \frac{1}{1 + \exp(aCl + b)}$$

The value of carapace length ~~for the first time~~ caught for the first time (Lc) is obtained through a logistic~~al~~ function approach, with the Sparre & Venema (1992) equation:

$$S_{CL} = \frac{1}{1 + \exp(a - B * Cl)}$$

Where:
S_{CL} - the fishing gear selectivity;
a and b - constant;
CL - the length of shrimp carapace;
the value of CLc - obtained from a/b.

The method used in the study of population parameters is an analytical model based on the composition of the age structure of the shrimp (Sparre & Venema~~,~~ 1992). The growth parameters of Von Bertalanffy, namely the asymptotic carapace length (CL∞) and the growth coefficient (K) were estimated by the ELEFAN I program in the FISAT II program

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(Gayanilo et al., 2005). An Estimation of the theoretical age (t0) is carried out with the Pauly's (1983) empirical equation, namely:

$$Log\ (-t_0) = (-0.3922) - 0.2752 \log CL\infty - 1.038 \log K$$

The value of the natural mortality (M) is estimated by through the Pauly's equation, by explaining that there is an including the effect of the mean water temperature (T) on the mortality rate, based on empirical observations (Pauly et al., 1984):

$$\text{Log M= (-0.0066)-0.279 logCL}\infty\text{+0.6542 logK +0.4634 LogT}$$

The total mortality (Z) value was estimated using the length-converted catch curve method in the FISAT II program package (Pauly, 1983; Gayanilo et al., 2005). Capture The capture mortality and exploitation rate are estimated using the Sparre & Venema (1992) equation,: s:

$$E = \frac{F}{F+M}$$

$$E = \frac{F}{Z}$$

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Results and Discussion

Biological aspects. Samples ofA number of *F. indicus* obtained during the study were 2,085 *F. indicus* specimens were collected during the study were, consisting of: 1,174 females *F. indicus* (56.31%) and 911 males (46.69%). The carapace length of female *F. indicus* ranges ranged from 13.2 to 52.8 mm, with for a weights ranging from 9.6 to 88.4 g, with two modes in the ranges of 29-31 and 31.1-33 mm CL. The carapace length of Meanwhile, male *F. indicus* ranged between 16-49.6 mm, for a weights ranged ranging from 15.4 to 78.6 g, with a mode in the range of 29-31 mm CL (Figure 2).

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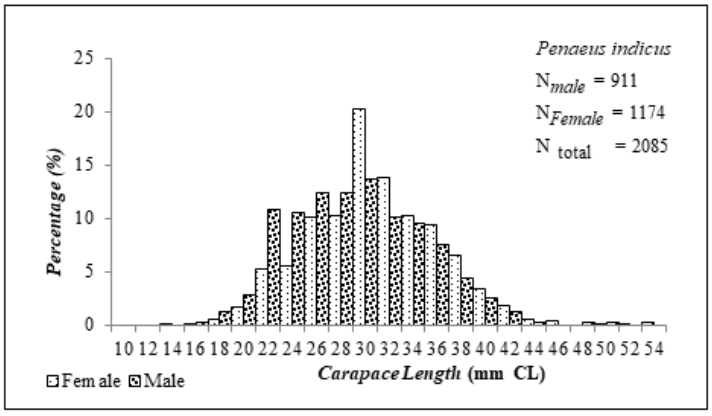

Figure 2. Length frequency of *Fenneropenaeus indicus* in Seneboy waters.

The sex ratio determination of *F. indicus* in the waters of Seneboy South Sorong is based on the chi_squared test~~,~~, which indicates an imbalance ~~the condition is not balanced~~ between the ~~number of~~ male ~~shrimp~~ and female shrimp populations~~.~~ : ~~Female~~ in most cases, female shrimp ~~are~~ dominate the catch~~ught more dominantly than males~~. ~~The~~ Although the average sex ratio of *F. indicus* ~~of~~ males and females ~~shrimp~~ is 1: 1.78~~. , Meanwhile, the sex ratio of F. indicus~~ it showed a balanced ~~condition~~ value of 1:~~-~~1 in February, March, September and October (Table 1).

Table 1

Sex ratio of *Fenneropenaeus indicus* in Seneboy waters, January-October 2016

Months (2016)	*Sex ratio of F. indicus*					*Comparison P=95%*
	Male	*Female*	*M:F ratio*		*X2*	
January	66	162	1	2.45	40.42	Not balanced
February	100	98	1	1.48	0.02	Balanced
March	94	106	1	1.61	0.72	Balanced
April	78	99	1	1.50	2.49	Not balanced
May	149	97	1	1.47	10.99	Not balanced
June	56	144	1	2.18	38.72	Not balanced
July	100	161	1	2.44	14.26	Not balanced
August	62	138	1	2.09	28.88	Not balanced
September	119	81	1	1.23	7.22	Balanced
October	87	88	1	1.33	0.01	Balanced
Total	911	1174	1	1.78	143.73	Not balanced

The highest proportion of mature female *F. indicus* (the maturity level of gonads III and the maturity level of gonads IV) was in January, February, September and October, with the peak maturing of gonads in October. The proportion of ~~mature~~ females with mature gonads in January, February, September and October was 60, 44, 46 and 40% (Figure 3).

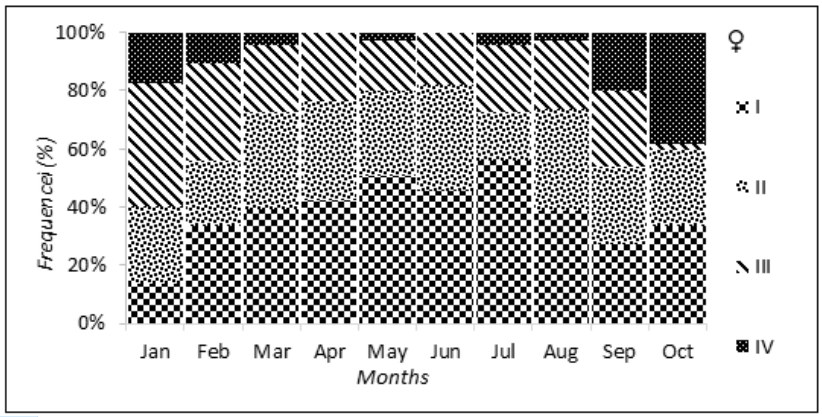

Figure 3. Proportion of ~~gonad maturity stages for female~~ *Fenneropenaeus indicus* females with mature gonads in Seneboy waters, January-October 2016.

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The size of the first time capture (Lc) corresponds to the probability level of L50% ~~on~~ of the trammel net selectivity, ~~explaining~~ meaning that the ~~opportunity for the~~catch distribution of *F. indicus* ~~is suitable to be caught~~ can influence~~crease~~ the availability of resources. The

logistic function graph with a class interval of 2 mm CL ~~is obtained~~indicates that the average value ~~for~~ at the first ~~time~~ capture (Lc) of *F. indicus* is 31.1 mm CL, with an average value (Lm) of 35 mm CL ~~for~~ at the first ~~time~~ gonad maturation (Figure 4).

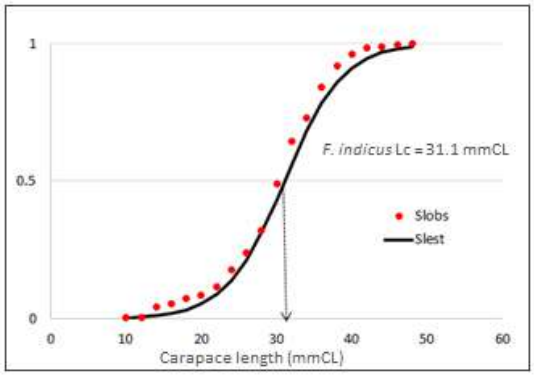

Figure 4. Average length at first *Fenneropenaeus indicus* ~~captured~~ capture with a trammel net of the~~*Fenneropenaeus indicus* with trammel net~~.

Population parameters. The results of the analysis based on the length frequency of female *F. indicus* carapace ~~obtained the~~indicated a value of 1.1 per year for the growth coefficient (K) in Seneboy waters ~~1.1 per year~~ and 1.0 per year for male *F. indicus* (Figure 5).

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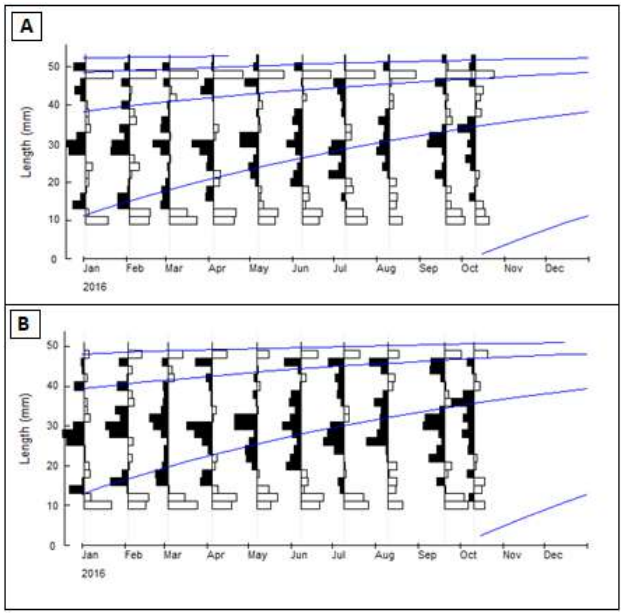

Figure 5. Growth model of male (A) and female (B) *Fenneropenaeus indicus* by ELEFAN I in Seneboy waters.

The asymptotic carapace length (L∞) of female *F. indicus* was 54.6 mm CL and 52.6 mm CL for males, while the age of female *F. indicus* at 0 (t0) was -0.14883 years and -0.136202 for males. So that the equation for the Von Bertalanffy equation for female *F. indicus* is ~~as~~ Lt = 54.6 (1-e-1,100 (t-0.14883)) and for male *F. indicus*, it is Lt = 52.6 (1-e-1,00 (t-0.136202)) (Figure 6). The maximum size range of *F. indicus* is estimated at the age of 1.8 years or around 20 months. The average size of 31.1 mm CL ~~of~~ in caught *F. indicus* ~~caught~~ (Lc) ~~31.1 mmCL~~ was estimated at the age of 7-8 months. The average mature gonad size ~~of~~ in females (Lm) was ~~gonad ripe average (Lm) of~~ 35 mm CL, ~~was estimated~~ at the age of 9-10 months.

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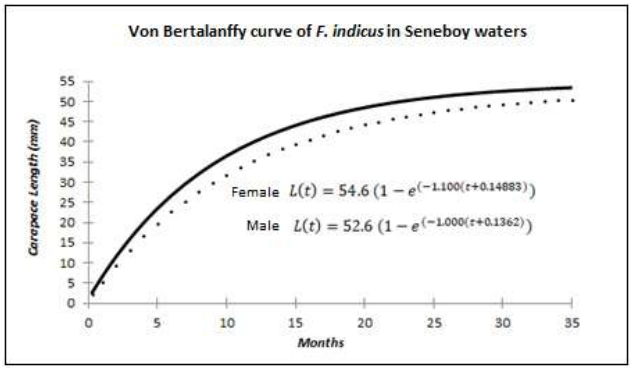

Figure 6. Von Bertalanffy curve of *Fenneropenaeus indicus* in Seneboy waters.

The total mortality rate (Z) of female and male *F. indicus* based on the length-converted catch curve~~length conversion curve with the catch~~ is 3.16 year^{-1}, with a natural mortality rate (M) of 1.64 year^{-1} and the mortality rate due to fishing (F) of 1.53 year^{-1}. The total mortality rate (Z) of male *F. indicus* was 2.64 year^{-1}, the natural mortality rate (M) was 1.42 year^{-1} and the mortality rate due to fishing (F) was 1.22 year^{-1}. Based on these mortality parameters, the utilization rate of ~~female~~ *F. indicus* was 0.48 for females and ~~male was~~ 0.46 for males (Figure 7).

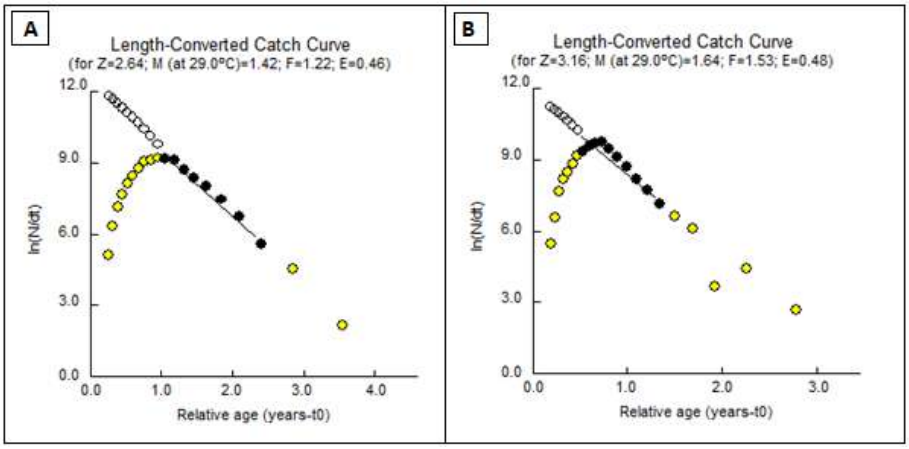

Figure 7. Growth curve of male (A) and female (B) *Fenneropenaeus indicus* in waters of Seneboy.

Discussion. The size distribution of *F. indicus* caught in the study area was greater than ~~that~~ in Kaimana waters, ranging from 25-49 mm, and the average size was 28.98 mm for males and 34.96 for females. The size ~~of~~ *F. indicus* specimens ~~and was not much different from those~~ caught in Meulaboh waters ~~are females with ranges~~ ranged between 17.8- and 79.54 mm for females and~~,~~ ~~males~~ between 18.3- and 64.36 mm for males. The size of~~Whereas~~ *Penaeus merguensis* in Central Java waters ranged between ~~for males is~~ 20- and 62 mm for males and between ~~females~~ 14- and 68 mm for females, ~~waters in West Java (~~and averaged 17 to ~~47~~ mm in West Java waters~~)~~ (Tirtadanu~~,~~& Panggabean 2018; Yusuf~~,~~ 2017; Suman et al~~.,~~ 1988). Differences in shrimp size at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al~~.,~~ 2017; Wilson et al~~.,~~ 2010; Matthews~~,~~ 1982; Ogbonna~~,~~ 2001). Given ~~It is suspected that~~ the larger shrimp size in Seneboy waters, it is supposed that ~~is~~ the species is not over-utilized.

The sex ratio of male and female shrimp in the study area was not balanced: ~~with~~ the ~~number of~~ females ~~caught being more dominant~~ dominated ~~than males~~the catch. The unbalanced ~~condition~~ sex ratio is similar to the *F. indicus* caught in Meulaboh waters (Yusuf~~,~~ 2017; Saputra~~,~~ 2008; Saputra et al~~.,~~ 2013; Wedjadmiko & Yulianti~~,~~ 2003; ~~Wedjadmiko~~Wedjatmiko~~,~~ 2009; Suman et al~~.,~~ 1991~~).~~), ~~This condition shows~~suggesting that the fishing pressure of shrimp resources in Seneboy waters has not disturbed the population renewal so that the sustainability of shrimp stocks is still well maintained.

The peak indic~~estim~~ated that a higher frequency~~proportion~~ of mature gonads in ~~ripe~~ *F. indicus* ~~occurs~~ occured in February and October~~.~~ ~~, The discovery of mature gonads indicates that this month is~~suggesting the spawning seasons for the shrimp (Martosubroto~~,~~ 1978). ~~The~~ For comparson, the ~~peak~~ spawning peaks occurred in ~~of~~ November for several types of Penaied shrimp~~, including *P. merguiensis* in~~ from the waters of West Kalimantan (including *P. merguiensis*), in January and August for the ~~occurred in November, the peak spawning of~~ *Metapenaeus monoceros* from~~in~~ the Southern Java waters and from September to October for the ~~occurred in January and August and the peak spawning of~~ *Metapenaeus monoceros* ~~in~~ from the Gulf of Carpentaria, Australia ~~occurs from September to October~~ (Kembaren~~,~~ & Suman 2013; Suman et al~~.,~~ 2005; Crocos et al~~.,~~ 2000; Pillai & Thirumilu~~,~~ 2013; ~~and~~ Gerami et al~~.,~~ 2013). The spawning season for *F. indicus* in the study area ~~is seen to~~ lasted throughout the year, with ~~a~~ peaks in February and October. Therefore, ~~F~~from the perspective of the resources sustainability, it is preferable to suspend the *F. indicus* fishing

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activities in Seneboy waters ~~that within a period of one year the season closes in~~during February and October ~~for catching *F. indicus* in Seneboy waters~~.

The first catch average size (Lc) ~~for the first time caught (Lc)~~ of *F. indicus* in the study area was of 31.1 mm CL and the mean value ~~for~~ at the first ~~time~~ gonad ~~maturation~~ maturity was 35 mm CL. The results of research conducted in the waters of the Cilacap Segara Anakan Lagoon, ~~with~~ using floating nets, showed an Lc value of 20.2 mm, ~~or at~~ for a total length of about 90 mm (Saputra~~,~~ 2008). Chan (1998) ~~states~~ stated that *F. indicus* females can reach a total length of 230 mm, although t~~hat is~~ey generally measure less than 170 mm. These results are different from the ~~results of~~ research conducted in the waters of North Central Java, where the carapace length of *P. merguensis* ~~is~~ was of 29.4 mm (Tirtadanu & Ernawati~~,~~ 2016), the carapace length of Mayangan waters is 28.9 mm (Wedjatmiko & Yulianti~~,~~ 2003) and Lc in Dolak waters, Arafura Sea is 28.78 mm (Hargiyatno ~~I.T.~~ & Sumiono ~~B.,~~ 2012). The differences ~~in~~ of Lc values are~~is~~ not only caused by the mesh size of the net used, but ~~is~~ they are also due to the operations duration ~~time~~ and to the location of the fishing ground. According to Susetiono & Setyono (1990), the ~~group of~~ *P. merguensis* ~~in~~ from shallow waters tends to be smaller~~.~~ than in deeper waters~~,~~ (e.g. ~~it is smaller than in the waters of~~ Cilacap), with an average size of first maturation of gonads (Lm) of 51 mm CL (Saputra et al~~.,~~ 2013). The shrimp size differences ~~in shrimp size in~~ at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al~~.,~~ 2017; Wilson et al~~.,~~ 2010).

According to FAO (2008), the Lm value is 50% of *F. indicus*, at a total length of 130-149 mm. This shows that the value of L50% <Lm50% means that *F. indicus* recruitment is threatened by ~~recruitment~~ overfishing. According to Teikwa & Mgaya's (2003) research ~~(2003)~~, the *F. indicus* carapace length size of the first caught ~~male *F. indicus*~~ males is ~~at~~ of 34 mm ~~carapace length~~ and ~~female shrimp at~~ 39 mm carapace ~~length~~in female shrimps. Melmammblessy's (2011) research ~~(2011)~~ showed that in Arafura's waters the size of the first maturity of the gonads at a carapace length of 60.26 mm. The average size ~~for~~ of the *F. indicus* ~~first time~~ caught for the first time ~~by *F. indicus*~~ (Lc) in the study area was smaller than the average size at the first maturity of gonads (Lm), indicating that most of the shrimp caught had not spawned ~~so,~~ ~~in~~ In the long ~~run~~ term, this situation is~~was not good for~~detrimental to the population's sustainability, ~~because will~~ hampering the shrimps recruitment process ~~of adding these shrimps~~ in the Seneboy waters. In this regard, it is necessary to ~~arrange~~ adjust the size of the mesh ~~so~~ in such a manner that the smallest carapace length~~size~~ of the caught *F. indicus* ~~caught is the smallest at the carapace length of~~ cannot be under 13.2 mm CL.

The growth rate (K) of *F. indicus* in the research area shows that they have a fast growth rate: ~~with a growth value of~~ 1.1 per year in females and 1.0 per year in males, with an asymptotic carapace length (L∞) of 54.6 mm CL for females ~~*F. indicus* 54.6 mmCL~~ and 52, 6 mm CL for males. ~~With the maximum size reached at the age of about 1.8 years or about 20 months. When compared with~~ The growth parameters in different locations~~, the growth rate of *F. indicus* in the study area shows different growth values.~~were: ~~waters of the Segara Anakan Lagoon Cilacap~~ L∞ = 35.7 mm~~;~~ and K = 1.26/year in the waters of the Segara Anakan Lagoon Cilacap, ~~Kota Baru waters was~~ 1.4/year and L∞ 44.3 mm in the Kota Baru waters~~,~~ and ~~in Kaimana waters it was~~ 44.7 mm CL for males and 51.25 mm CL for females in the Kaimana waters.

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Table 2

title

Location	*Sex*	L_{∞} *(mm CL)*	*K*	*t0*	*Authors*
Cilacap, Central Jawa	Combined	35.7	1.26	-	Saputra (2008)
Kota Baru, South Kalimantan	Combined	44.3	1.4	-	Suman et al (2010)
Kaimana, West Papua	Male Female	44.7	1.38	-	Tirtadanu & Pangabean 2018)
Cilacap, Central Java	Male Female	40.7 54.2	1 1.1	0.56 0.36	Suman & Prisantoso (2017)
Tarakan, North Kalimantan	Male Female	45.2 57.6	1.55 1.33	0.76 0.76	Chodrijah & Suman (2017)
Sampit, Central Kalimantan	Combined	57.8	1.45	0.66	Nurdin & Kembaren (2015)
Tanal Laut, South Kalimantan	Combined	55	1.05	0.74	Suman et al (2017)
Cenderawasih Bay, Papua	Male Female	44.5 48.7	1.05 1.15	0.66 0.55	Kembaren & Ernawati (2015)
Kaimana, West Papua	Male Female	44.7 51.25	1.4 1.37	0.49 0.44	Tirtadanu & Panggabean (2018)
Seneboy, West Papua	Male Female	54.6 52.6	1.1 1.0	0.148 0.136	Present research

The mortality rate (Z) of *F. indicus* in the Seneboy waters is relatively low, namely 3.16 in females and 2.6 in females. Some Penaeid shrimp in other waters, namely the waters of the Cilacap Segara Anakan Lagoon, obtained an M value of 2.6 year^{-1}, an F value of 1.35 year^{-1} (*P. meruiensis* in Segara Anakan Lagoon Cilacap is 1.43 year^{-1}, the natural mortality rate is 1.85 year^{-1} and catching 2.32 year^{-1}, Madura waters natural mortality rate of 2.17-2.22 year^{-1} and catching 1.11-1.56 year^{-1} (Saputra~~,~~ 2008; Kembaren et al~~.,~~ 2012; Setyohadi et al~~.,~~ 1999; Hedianto et al~~.,~~ 2016).

The highest mortality rates (ind year^{-1}) were recorded~~in the waters of Kota Baru~~: 9 for males and 9.47 for females in the waters of Kota Baru, ~~in Kakinada waters~~ 10.58 in the Kakinada waters~~,~~ ~~in Khoozestan waters~~ 7.01 in the Khoozestan waters and ~~Vietnamese waters~~ 5.78 in the Vietnamese waters (Tirtadanu et al~~.,~~ 2017; Devi~~,~~ 1987; Ansari et al~~.,~~ 2014; Dinh et al~~.,~~ 2010). ~~Natural~~ The natural mortality is influenced by several factors such as food availability, disease, environment, competition and ~~especially~~ the presence of predatory species (Sparre & Venema 1992; Niamaimandi et al~~.,~~ 2007). Penaeid prawn is the prey of several demersal fish, such as *Lutjanus gibbus*, *Eleutheronema tetradactylum* and *Arius* sp. (Bachok et al 2004; Titrawani et al 2013). Death due to fishing (F) of both male and female *F. indicus* is lower than the natural mortality rate (M), indicating that the *F. indicus* population has not been exploited intensively by fishermen in the waters of Seneboy, West Papua. Garcia (1988) suggests that the average natural mortality rate (M) of penaeid shrimp is 2.4 ± 0.3 year^{-1} for adult shrimp. Naamin (1984) found that the F value of *P. merguensis* in Arafura waters varies according to the development of the fishing effort, ranging from 0.55 year^{-1} (at the start of the exploitation) to 8.99 year^{-1}.

~~Penaeid parwn is the prey of several demersal fish such as *Lutjanus gibbus*, *Eleutheronema tetradactylum* and *Arius* sp. (Bachok et al 2004; Titrawani et al 2013). Death due to fishing (F) of both male and female *F. indicus* is lower than the natural mortality rate (M) indicating that the utilization of the *F. indicus* population has not been exploited intensively by fishermen in the waters of Seneboy, West Papua. Garcia (1988) suggests that the average natural mortality rate (M) of penaeid shrimp is 2.4 ± 0.3 year^{-1} for adult shrimp. Naamin (1984) found that the F value of *P. merguensis* in Arafura waters varies according to the development of fishing effort, which ranges from 0.55 year^{-1} (at the start of the exploitation) to 8.99 year^{-1}.~~

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~~Cultivation~~ In this study, the exploitation rates (E) of female and male *F. indicus* were 0.48 and 0.46. This condition explains that the fishing rate is greater than the natural mortality rate. The optimum exploitation rate stated by Gulland (1983) is 0.5, so that the rate of exploitation of *F. indicus* in Seneboy waters is close to the optimum value and is still sustainable. The level of exploitation of *F. indicus* in several areas has exceeded the optimum limit, namely in the waters of the Segara Anakan Cilacap Lagoon, Meulaboh waters, Tarakan Bay, Tanah Laut and Cenderawasih, where the level of exploitation indicates overfishing (Saputra 2008; Yusuf et al 2017; Chodrijah & Suman 2017; Suman et al~~.,~~ 2017; Kembaren & Ernawati 2015). ~~Utilization~~ The utilization of *F. indicus* has approached the maximum, ~~on this basis the need for~~suggesting that a reduction of the fishing pressure is required, ~~of about~~with at least 5% of the current total effort.

Conclusions. The average size of ~~male~~ *F. indicus* caught in the waters of Seneboy South Sorong is 16-49.6 mm CL for the males and ~~females~~ 13.2 - 52.8 mm CL for the females. The sex ratio of *F. indicus* ~~*Metapenaeus affinis* shows an unbalanced condition with the ratio of~~is unbalanced: ~~male and female shrimp is~~ 1:1.8, male against female. The spawning season lasts throughout the year with ~~a~~ peaks in February and October, ~~and t~~The average size of first caught (Lc) ~~of~~ shrimp is smaller than the average size of the shrimp at the first~~-time~~ gonads maturity (Lm) (31.1>35 mm CL). The growth rate and mortality rate of *F. indicus* in Seneboy waters were lower with the exploitation rate values (E) 0.48 and 0.46. This indicates that the level of utilization of *F. indicus* in Seneboy waters is not yet optimal, but leads to overfishing. In order ~~for~~ to maintain the sustainability of the *F. indicus* resources in the waters of Seneboy, West Papua, it is advisable (1) to reduce efforts with about 5% from the current level, by adjusting the mesh ~~so~~ in such a manner that the retained catch size ~~is~~ of *F. indicus* will be of at least 13.2 mm CL and (2) to ~~closing~~ suspend the *F. indicus* fishing ~~season~~ operations in February and October.

Acknowledgements. This paper is part of the research activity "Biological Characteristics of Fisheries, Resource Habitat and Production Potential of Fish Resources in FMA 715 Tomini Bay 2017" which was organized by the Muara Baru Jakarta Marine Fisheries Research Institute.

Conflict of interest. The authors declare no conflict of interest.

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Chodrijah U., ~~&~~ Suman A~~.,~~ 2017~~.~~ Some ~~Population~~ population ~~Parameters~~ parameters ~~Of~~ pf ~~White~~ white ~~Shrimp~~ shrimp (*Penaeus merguiensis demann*) ~~In~~ in Tarakan Waters, North Kalimantan~~,~~ Bawal Widya Research~~.~~ 9~~-~~(2):~~-~~85-92.

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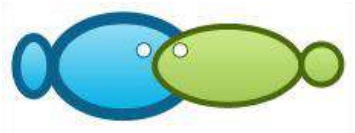

The growth rate of *Fenneropenaeus indicus* in Seneboy Waters, South Sorong, Papua, Indonesia

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Abstract. *Fenneropenaeus indicus* is one of the economically important species of shrimp cultivated in South Sorong Seneboy waters and currently its production tends to decrease. Studying its biological aspects provides data and information needed for assessing its exploitation and managing its conservation. This study aims to examine the biological aspects of *F. indicus* as a material for shrimp fisheries management in the waters of Seneboy, South Kalimantan. The study was conducted between January-November 2017 in the waters of Seneboy. The results showed that the average size of the caught female *F. indicus* was 13.2-52.8 mm carapace length (CL), with a mode size of 31.1-33 mm CL, and the average size of a male shrimp was 16-49.6 mm CL with a mode size 29-31 mm CL. The sex ratio of male and female shrimp is 1:1.8. *F. indicus* spawning season is suspected to last all year and peak in February and October. The average size of the first time caught (Lc=31.1 CL) shrimp is smaller than the average size of the first time cooked gonads (Lm =35 mm) so that most of the shrimp caught are small and have not spawned. In female *F. indicus*, the growth rate (K), asymptotic carapace length (CL) and age at length 0 (t0) were of: 1.1 cm year^{-1}, 54.6 mm CL and -0.14883 years, respectively, while in male they were of: 1.0 cm year^{-1}, 52.6 mm and -0.136202 years, respectively. The natural mortality rate (M), death rate due to capture (F), total death rate (Z) and exploitation rate (E) of female rock lobsters were 2.64 cm year^{-1}, 1.53 cm year^{-1}, 2.64 cm year^{-1} and 0.48 cm year^{-1}, respectively, while in male *F. indicus* amounted to 2.64 cm year^{-1}, 1.42 cm year^{-1}, 1.22 cm year^{-1} and 0.56 cm year^{-1}, corresponding to an optimal utilization of the *F. indicus* resources. The status of *F. indicus* in Seneboy waters is "not fully exploited".
Key Words: biology aspect; shrimp fisheries management; sex ratio; spawning season.

Introduction. *Fenneropenaeus indicus* is one of the important commodities in the waters of Seneboy, South Sorong. *F. indicus* has an economic value and contributes to the improvement of the fishermen's life in South Sorong. Seneboy fishermen catch *F. indicus* using a 4 meter nylon trammel net as fishing gear, operated by 3 people from vessels of about 6 m in length, made of wood and fiber, of an average tonnage of 3 GT and a main engine power of 15 HP. The mesh size is of 1.5-7.25 inch, with a polyethylene head rope of Ø 8 mm. The length of the ground rope is 660 m. This effective and environmentally friendly fishing gear is used for catching *F. indicus* and other types of demersal fish which are bycatch (BRPL 2016).

The catching time per trip ranges from 6 to 9 hours (from 07.00 to 16.00 hours, which is one day fishing) and the fishing ground ranges from 1 to 20 miles, with a distance of about 1-4 hours from the landing base. The shrimp fishing grounds are located around Wawonket Cape, Dua Island, Daram Island, Sibabu Cape, Komokara Cape, Sabuga Island,

Sele Cape, Misool Islands, Sinabu Cape, Banana Island and Segeat Island. The shrimp fishing season is 12 months with the highest season in July-November, with a catch of around 10-100 kg trip^{-1}. The production of shrimp and other crustaceans in South Sorong waters, in the period 2009 to 2016, reached 4,051 tons, with an annual average of 506.42 tons or 38.75%, total production. The annual average production of *F. indicus* is 475.75 tons, with the highest production in 2010 of 557 tons and the lowest in 2013 of 350 tons (DKP Sorong 2017).

Shrimp catching activity in Seneboy, South Sorong, is the main support to meet the economic needs of trammel net fishermen in Temibuanan Regency. Catching shrimp at this location is carried out very intensively, so that fishing activities need to be supervised. The biology and population parameters provide the control and management criteria to the marine authorities.

Research on several aspects of biology and population parameters was extensively conducted in several waters in Indonesia: Arafura (Naamin 1984), Cilacap (Suman 1992; Suman & Boer 2005; Hargiyatno et al 2013; Saputra & Subiyanto 2007), Strait Madura (Setyohadi et al 1999), Kotabaru (Suman & Umar 2010), Bone (Kembaren & Ernawati 2015), Tarakan (Kembaren & Suman 2013) and Meulaboh (Yusuf et al 2017).

The study provides information on the exploitation status of shrimp, facing the market demand and an increasing commercial value. Rational management actions need to be taken in order to maintain a sustainable balance of the shrimp resources and the population parameters estimation is required as supporting data and information. The results of this study are expected to complement and update previous studies, underlying the management of *F. indicus* resources in the waters of Seneboy, South Sorong, and surroundings.

Material and Method

Research location and time. *F. indicus* sampling was carried out with a trammel net, obtained from fishermen and shrimp collectors in Seneboy Temibuana, South Sorong, from January to October 2016. The enumerators were taking samples using a random sampling method. The data collected included carapace length (CL), weight, sex, gonad maturity level and fishing area (Figure 1).

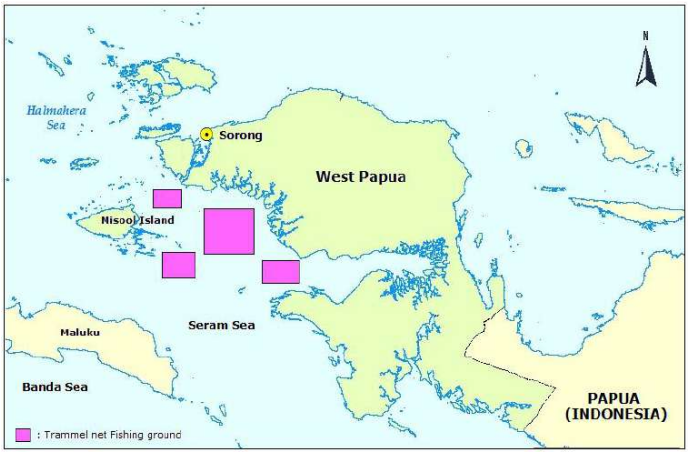

Figure 1. Fishing ground of trammel net in Seneboy, South Sorong (https://www.mapsofworld.com/where-is/sorong.html).

Data analysis. Biological data analysis included the size distribution, sex ratio, gonad maturity level, average size of first caught specimens (Lc). The analyzed population parameters were the growth pattern (CL∞, K), mortality parameters (Z, M, F) and utilization rate (E).

The distribution of carapace length measurements is presented in the form of a bar chart with a length class of 2 mm. The level of maturity of female shrimp gonads was observed visually based on Motoh (1981), namely by looking at the size of the shrimp ovary, located on its back. Shrimp sex ratios were analyzed using the Chi-square test (Walpole 1993)

The length at first matured (Lm) is obtained by entering the carapace length and P_{Lm} values into a graphical logistic function (King 1995), with the following equation:

$$P_{Lm} = \frac{1}{1 + \exp\ (aCl + b)}$$

Where:
P_{LM} –
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The value of carapace length caught for the first time (Lc) is obtained through a logistic function approach, with the Sparre & Venema (1992) equation:

$$S_L = \frac{1}{1 + \exp\ (a - b * CL)}$$

Where:
S_L - logistic curve and Lc was determined by a/b;
a - the intercept of regression;
b - the slope of regression;
CL - the length of shrimp carapace.

The method used in the study of population parameters is an analytical model based on the composition of the age structure of the shrimp (Sparre & Venema 1992). The growth parameters of Von Bertalanffy, namely the asymptotic carapace length (CL∞) and the growth coefficient (K) were estimated by the ELEFAN I program in the FISAT II program (Gayanilo et al 2005). An estimation of the theoretical age (t0) is carried out with the Pauly's (1983) empirical equation, namely:

$$Log\ (-t_0) = (-0.3922) - 0.2752 \log CL\infty - 1.038 \log K$$

The value of the natural mortality (M) is estimated through the Pauly's equation, by including the effect of the mean water temperature (T) on the mortality rate, based on empirical observations (Pauly et al 1984):

$$\text{Log M= (-0.0066)-0.279 log CL}\infty\text{+0.6542 log K +0.4634 Log T}$$

The total mortality (Z) value was estimated using the length-converted catch curve method in the FISAT II program package (Pauly 1983; Gayanilo et al 2005). The capture mortality and exploitation rate are estimated using the Sparre & Venema (1992) equations:

$$E = \frac{F}{F + M}$$

$$E = \frac{F}{Z}$$

Where:
E - the exploitation rate;
F - the Fishing mortality;
M- natural mortality;
Z - the total mortality.

Results and Discussion

Biological aspects. A number of 2,085 *F. indicus* specimens were collected during the study were: 1,174 females (56.31%) and 911 males (46.69%). The carapace length of female *F. indicus* ranged from 13.2 to 52.8 mm, for a weight ranging from 9.6 to 88.4 g, with two modes in the ranges of 29-31 and 31.1-33 mm CL. The carapace length of male *F. indicus* ranged between 16-49.6 mm, for a weight ranging from 15.4 to 78.6 g, with a mode in the range of 29-31 mm CL (Figure 2).

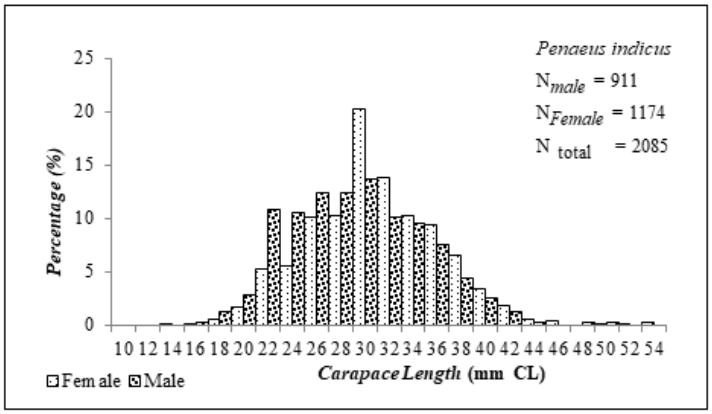

Figure 2. Length frequency of *Fenneropenaeus indicus* in Seneboy waters.

The sex ratio determination of *F. indicus* in the waters of Seneboy South Sorong is based on the chi squared test, which indicates an imbalance between the male and female shrimp populations: in most cases, female shrimp dominate the catch. Although the average sex ratio of *F. indicus* males and females is 1: 1.78, it showed a balanced value of 1:1 in February, March, September and October (Table 1).

Table 1

Sex ratio of *Fenneropenaeus indicus* in Seneboy waters, January-October 2016

Months	*Sex ratio of F. indicus*					*Comparison*
(2016)	*Male*	*Female*	*M:F ratio*		*X2*	*P=95%*
January	66	162	1	2.45	40.42	Not balanced
February	100	98	1	1.48	0.02	Balanced
March	94	106	1	1.61	0.72	Balanced
April	78	99	1	1.50	2.49	Not balanced
May	149	97	1	1.47	10.99	Not balanced

June	56	144	1	2.18	38.72	Not balanced
July	100	161	1	2.44	14.26	Not balanced
August	62	138	1	2.09	28.88	Not balanced
September	119	81	1	1.23	7.22	Balanced
October	87	88	1	1.33	0.01	Balanced
Total	911	1174	1	1.78	143.73	Not balanced

The highest proportion of mature female *F. indicus* (the maturity level of gonads III and the maturity level of gonads IV) was in January, February, September and October, with the peak maturing of gonads in October. The proportion of females with mature gonads in January, February, September and October was 60, 44, 46 and 40% (Figure 3).

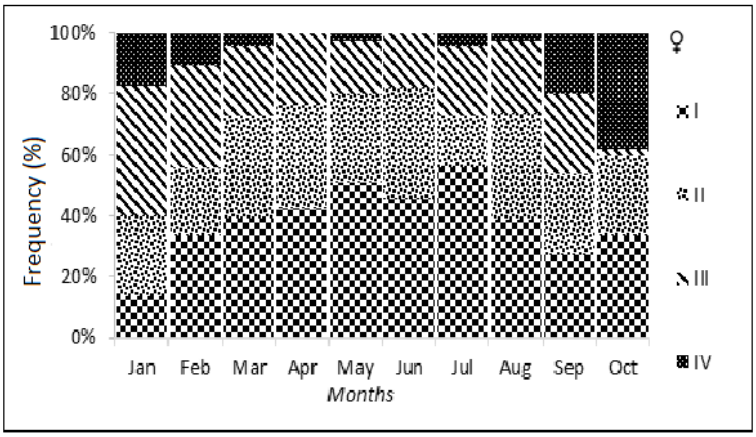

Figure 3. Proportion of *Fenneropenaeus indicus* females with mature gonads in Seneboy waters, January-October 2016.

The size of the first time capture (Lc) corresponds to the probability level of L50% of the trammel net selectivity, meaning that the catch distribution of *F. indicus* can influence the availability of resources. The logistic function graph with a class interval of 2 mm CL indicates that the average value at the first capture (Lc) of *F. indicus* is 31.1 mm CL, with an average value (Lm) of 35 mm CL at the first gonad maturation (Figure 4).

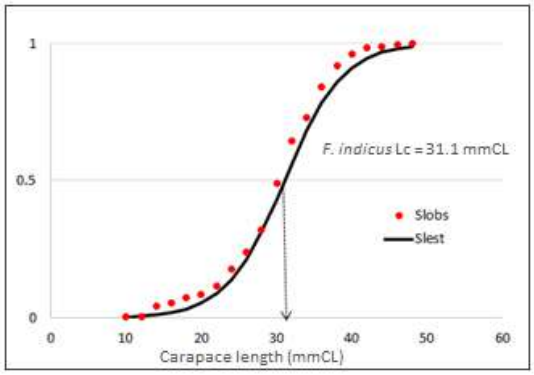

Figure 4. Average length at first *Fenneropenaeus indicus* capture with a trammel net of the.

Population parameters. The growth parameters of *F. indicus* in the Seneboy waters is processed from long frequency distribution data carapace by tracking any mode shift the distribution of carapace length frequencies in a curved sequence of times Von Bertalanffy's growth. Based on the results of the analysis, it was found that infinitive carapace length (L∞) of female *F. indicus* was 54.6 mm, the growth rate (K) was 1.1 year $^{-1}$ and the male was 52.6 mm, the growth rate was 1.0 year^{-1} (Figure 5). From the value of these two parameters a growth equation and a key relationship can be created between carapace lengths with aged shrimp by using multiple variations in age value (t).

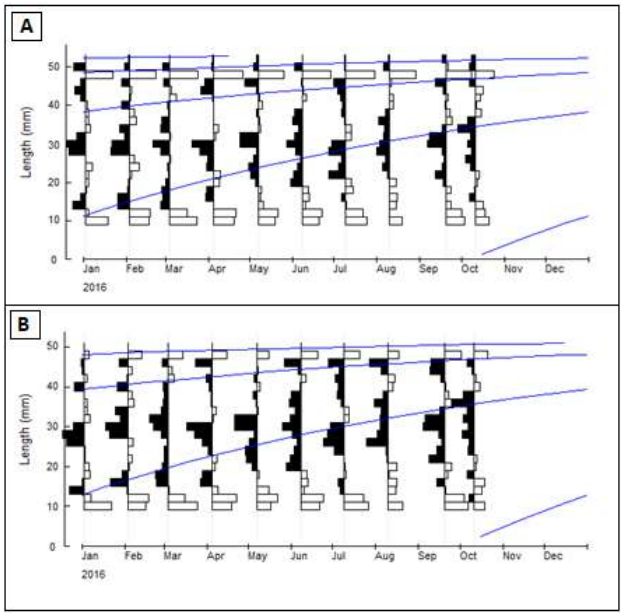

Figure 5. Growth model of male (A) and female (B) *Fenneropenaeus indicus* by ELEFAN I in Seneboy waters.

The asymptotic carapace length (L∞) of female *F. indicus* was 54.6 mm CL and 52.6 mm CL for males, while the age of female *F. indicus* at 0 (t0) was -0.14883 years and -0.136202 for males. So that the equation for the Von Bertalanffy equation for female *F. indicus* is Lt = 54.6 (1-e-1,100 (t-0.14883)) and for male *F. indicus* it is Lt = 52.6 (1-e-1.00 (t-0.136202)) (Figure 6). The maximum size range of *F. indicus* is estimated at the age of 1.8 years or around 20 months. The average size of 31.1 mm CL in caught *F. indicus* (Lc) was estimated at the age of 7-8 months. The average mature gonad size in females (Lm) was of 35 mm CL, at the age of 9-10 months.

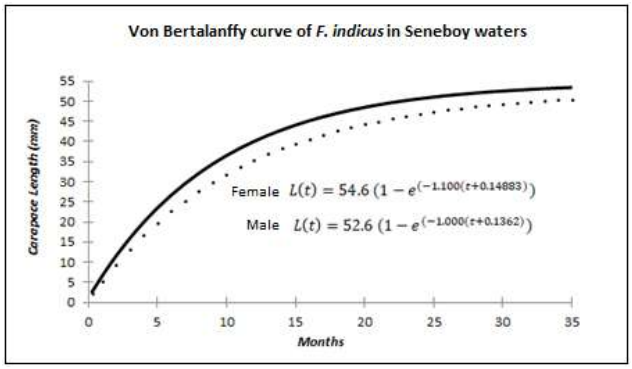

Figure 6. Von Bertalanffy curve of *Fenneropenaeus indicus* in Seneboy waters.

The total mortality rate (Z) of female and male *F. indicus* based on the length-converted catch curve is 3.16 year^{-1}, with a natural mortality rate (M) of 1.64 year^{-1} and the mortality rate due to fishing (F) of 1.53 year^{-1}. The total mortality rate (Z) of male *F. indicus* was 2.64 year^{-1}, the natural mortality rate (M) was 1.42 year^{-1} and the mortality rate due to fishing (F) was 1.22 year^{-1}. Based on these mortality parameters, the utilization rate of *F. indicus* was 0.48 for females and 0.46 for males (Figure 7).

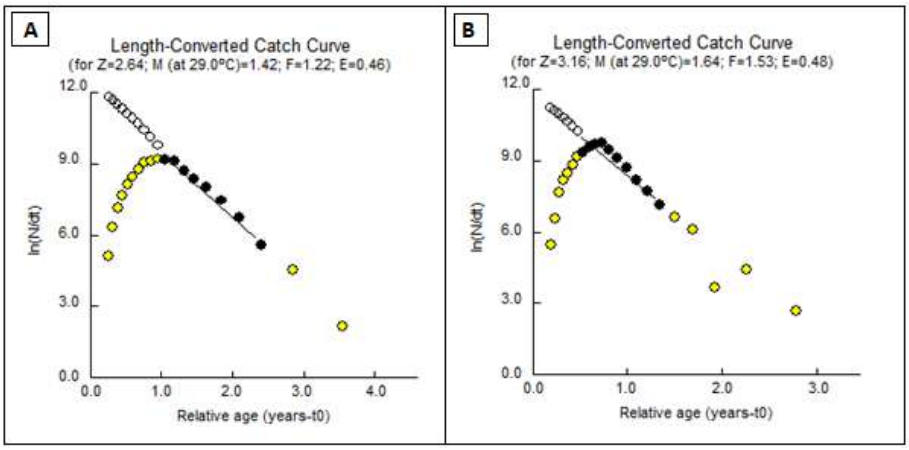

Figure 7. Growth curve of male (A) and female (B) *Fenneropenaeus indicus* in waters of Seneboy.

Discussion. The size distribution of *F. indicus* caught in the study area was greater than in Kaimana waters, ranging from 25-49 mm, and the average size was 28.98 mm for males and 34.96 for females. The size of *F. indicus* specimens caught in Meulaboh waters ranged between 17.8 and 79.54 mm for females and between 18.3 and 64.36 mm for males. The size of *Penaeus merguensis* in Central Java waters ranged between 20 and 62 mm for males and between 14 and 68 mm for females, and averaged 17 to 47 mm in West Java waters (Tirtadanu& Panggabean 2018; Yusuf 2017; Suman et al 1988). Differences in shrimp size at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al 2017; Wilson et al 2010; Matthews 1982; Ogbonna 2001). Given the larger shrimp size in Seneboy waters, it is supposed that the species is not over-utilized.

The sex ratio of male and female shrimp in the study area was not balanced: the females dominated the catch. The unbalanced sex ratio is similar to the *F. indicus* caught in Meulaboh waters (Yusuf 2017; Saputra 2008; Saputra et al 2013; Wedjadmiko & Yulianti 2003; Wedjatmiko 2009; Suman et al 1991), suggesting that the fishing pressure of shrimp resources in Seneboy waters has not disturbed the population renewal so that the sustainability of shrimp stocks is still well maintained.

The peak indicated that a higher frequency of mature gonads in *F. indicus* occured in February and October, suggesting the spawning seasons for the shrimp (Martosubroto 1978). For comparson, the spawning peaks occurred in November for several types of Penaied shrimp from the waters of West Kalimantan (including *P. merguiensis*), in January and August for the *Metapenaeus monoceros* from the Southern Java waters and from September to October for the *Metapenaeus monoceros* from the Gulf of Carpentaria, Australia (Kembaren & Suman 2013; Suman et al 2005; Crocos et al 2000; Pillai & Thirumilu 2013; Gerami et al 2013). The spawning season for *F. indicus* in the study area lasted throughout the year, with peaks in February and October. Therefore, from the perspective of the resources sustainability, it is preferable to suspend the *F. indicus* fishing activities in Seneboy waters during February and October.

The first catch average size (Lc) of *F. indicus* in the study area was of 31.1 mm CL and the mean value at the first gonad maturity was 35 mm CL. The results of research conducted in the waters of the Cilacap Segara Anakan Lagoon, using floating nets, showed an Lc value of 20.2 mm, for a total length of about 90 mm (Saputra 2008). Chan (1998) stated that *F. indicus* females can reach a total length of 230 mm, although they generally measure less than 170 mm. These results are different from the research conducted in the waters of North Central Java, where the carapace length of *P. merguensis* was of 29.4 mm (Tirtadanu & Ernawati 2016), the carapace length of Mayangan waters is 28.9 mm (Wedjatmiko & Yulianti 2003) and Lc in Dolak waters, Arafura Sea is 28.78 mm (Hargiyatno & Sumiono 2012). The differences of Lc values are not only caused by the mesh size of the net used, but they are also due to the operations duration and to the location of the fishing ground. According to Susetiono & Setyono (1990), the *P. merguensis* from shallow waters tends to be smaller than in deeper waters (e.g. Cilacap), with an average size (Lc) of 51 mm CL (Saputra et al 2013). The shrimp size differences at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al 2017; Wilson et al 2010).

According to FAO (2008), the Lm value is 50% of *F. indicus*, at a total length of 130-149 mm. This shows that the value of L50% <Lm50% means that *F. indicus* recruitment is threatened by overfishing. According to Teikwa & Mgaya's (2003) research, the *F. indicus* carapace length size of the first caught males is of 34 mm and 39 mm carapace in female shrimps. Melmammblessy's (2011) research showed that in Arafura's waters the size of the first catch average size (Lc) at a carapace length of 60.26 mm. The average size of the *F. indicus* caught for the first time (Lc) in the study area was smaller than the average size at

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the first maturity of gonads (Lm), indicating that most of the shrimp caught had not spawned. In the long term, this situation is detrimental to the population's sustainability, hampering the shrimps recruitment process in the Seneboy waters. In this regard, it is necessary to adjust the size of the mesh in such a manner that the smallest carapace lengthof the caught *F. indicus* cannot be under 13.2 mm CL.

The growth rate (K) of *F. indicus* in the research area shows that they have a fast growth rate: 1.1 per year in females and 1.0 per year in males, with an asymptotic carapace length (L∞) of 54.6 mm CL for females and 52, 6 mm CL for males. The growth parameters in different locations were: L∞ = 35.7 mm and K = 1.26 year^{-1} in the waters of the Segara Anakan Lagoon Cilacap, 1.4 year^{-1} and L∞ 44.3 mm in the Kota Baru waters and 44.7 mm CL for males and 51.25 mm CL for females in the Kaimana waters.

Table 2

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Asymptotic length (L∞), growth rate (K) and exploitation rate (E) of *Fenneropenaeus indicus* in some areas

Location	*Sexes*	*L∞ (mm CL)*	*K*	*t0*	*Authors*
Cilacap, Central Jawa	Combined	35.7	1.26	-	Saputra (2008)
Kota Baru, South Kalimantan	Combined	44.3	1.4	-	Suman et al (2010)
Kaimana, West Papua	Combined	44.7	1.38	-	Tirtadanu & Pangabean 2018)
Cilacap, Central Java	Male	40.7	1	0.56	Suman & Prisantoso (2017)
	Female	54.2	1.1	0.36	
Tarakan, North Kalimantan	Male	45.2	1.55	0.76	Chodrijah & Suman (2017)
	Female	57.6	1.33	0.76	
Sampit, Central Kalimantan	Combined	57.8	1.45	0.66	Nurdin & Kembaren (2015)
Tanal Laut, South Kalimantan	Combined	55	1.05	0.74	Suman et al (2017)
Cenderawasih Bay, Papua	Male	44.5	1.05	0.66	Kembaren & Ernawati (2015)
	Female	48.7	1.15	0.55	
Kaimana, West Papua	Male	44.7	1.4	0.49	Tirtadanu & Panggabean (2018)
	Female	51.25	1.37	0.44	
Seneboy, West Papua	Male	54.6	1.1	0.148	Present research
	Female	52.6	1.0	0.136	

The mortality rate (Z) of *F. indicus* in the Seneboy waters is relatively low, namely 3.16 in males and 2.6 in females. Some Penaeid shrimp in other waters, namely the waters of the Cilacap Segara Anakan Lagoon, obtained an M value of 2.6 cm year^{-1}, an F value of 1.35 cm year^{-1} (*P. meruiensis* in Segara Anakan Lagoon Cilacap is 1.43 year^{-1}, the natural mortality rate is 1.85 cm year^{-1} and catching 2.32 cm year^{-1}, Madura waters natural mortality rate of 2.17-2.22 cm year^{-1} and catching 1.11-1.56 cm year^{-1} (Saputra 2008; Kembaren et al 2012; Setyohadi et al 1999; Hedianto et al 2016).

The highest mortality rates (ind year^{-1}) were recorded: 9 for males and 9.47 for females in the waters of Kota Baru, 10.58 in the Kakinada waters, 7.01 in the Khoozestan waters and 5.78 in the Vietnamese waters (Tirtadanu et al 2017; Devi 1987; Ansari et al 2014; Dinh et al 2010). The natural mortality is influenced by several factors such as food availability, disease, environment, competition and the presence of predatory species (Sparre & Venema 1992; Niamaimandi et al 2007). Penaeid prawn is the prey of several demersal fish, such as *Lutjanus gibbus*, *Eleutheronema tetradactylum* and *Arius* sp. (Bachok et al 2004; Titrawani et al 2013). Death due to fishing (F) of both male and female *F. indicus* is lower than the natural mortality rate (M), indicating that the *F. indicus* population has not been exploited intensively by fishermen in the waters of Seneboy, West Papua. Garcia (1988) suggests that the average natural mortality rate (M) of penaeid shrimp is 2.4±0.3 year^{-1} for adult shrimp. Naamin (1984) found that the F value of *P. merguensis* in Arafura waters varies according to the development of the fishing effort, ranging from 0.55 year^{-1} (at the start of the exploitation) to 8.99 year^{-1}.

In this study, the exploitation rates (E) of female and male *F. indicus* were 0.48 and 0.46. This condition explains that the fishing rate is greater than the natural mortality rate. The optimum exploitation rate stated by Gulland (1983) is 0.5, so that the rate of exploitation of *F. indicus* in Seneboy waters is close to the optimum value and is still sustainable. The level of exploitation of *F. indicus* in several areas has exceeded the optimum limit, namely in the waters of the Segara Anakan Cilacap Lagoon, Meulaboh waters, Tarakan Bay, Tanah Laut and Cenderawasih, where the level of exploitation indicates overfishing (Saputra 2008; Yusuf et al 2017; Chodrijah & Suman 2017; Suman et al 2017; Kembaren & Ernawati 2015). The exploitation of *F. indicus* has approached the maximum, suggesting that a reduction of the fishing pressure is required, with at least 5% of the current total effort.

Conclusions. The average size of *F. indicus* caught in the waters of Seneboy South Sorong is 16-49.6 mm CL for the males and 13.2 - 52.8 mm CL for the females. The sex ratio of *F. indicus* is unbalanced: 1:1.8, male against female. The spawning season lasts throughout the year with peaks in February and October. The catch is dominated by adults so that management sets the regulations for the minimum legal size. These results concluded that the arrest of *F. indicus* can be continued by arranging the arrest effort and stipulating a minimum legal size of 35 mm CL. This indicates that the level of exploitation of *F. indicus* in Seneboy waters is not yet optimal, but leads to overfishing. In order to maintain the sustainability of the *F. indicus* resources in the waters of Seneboy, West Papua, it is advisable (1) to reduce efforts with about 5% from the current level, by adjusting the mesh in such a manner that the retained catch size of *F. indicus* will be of at least 13.2 mm CL and (2) to suspend the *F. indicus* fishing operations in February and October.

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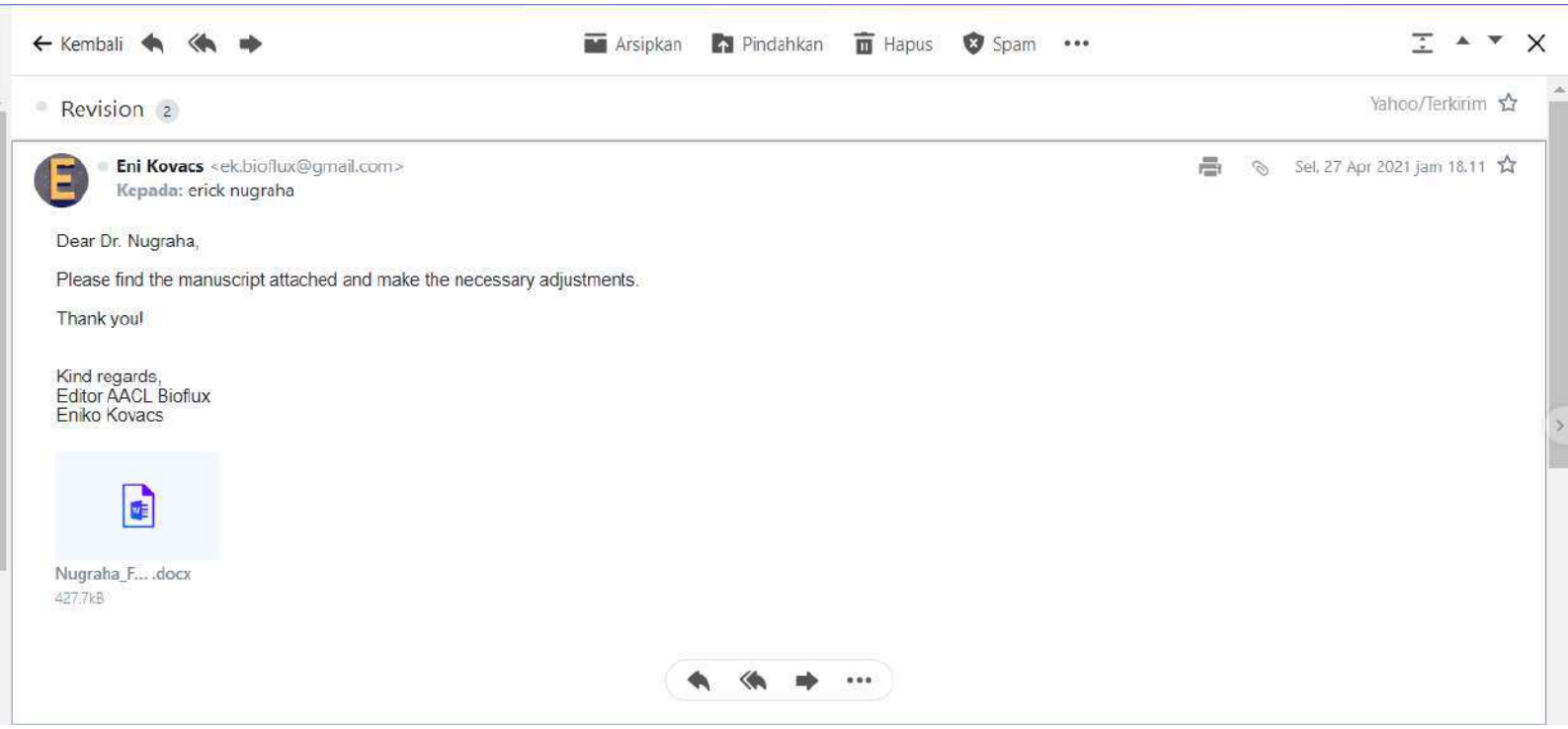
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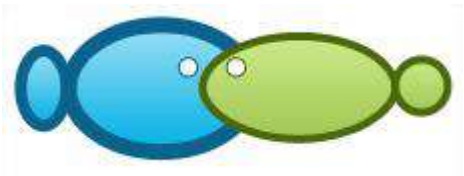

The growth rate of Banana shrimp(*Fenneropenaeus indicus* H. Milne Edward, 1837) in Seneboy Waters, South Sorong, Papua-Indonesia

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Abstract. *F. indicus* is one of the important economical types of shrimp cultivated in South Sorong Seneboy waters and currently its production tends to decrease. One of the data and information needed in assessing the level of utilization and basis for its management is the biological aspect. This study aims to examine the biological aspects of *F. indicus* as a policy material for shrimp fisheries management in the waters of Seneboy, South Kalimantan. The study was conducted in January-November 2017 in the waters of Seneboy. The results showed the average size of female *F. indicus* caught was 13.2 - 52.8 mmCL with a mode size of 31.1-33 mmCL and the average size of a male shrimp was 16-49.6 mm with a mode size 29 - 31 mmCL. The sex ratio of male and female shrimp is 1: 1.8. *F. indicus* spawning season is suspected to last all year and peak in February and October. The average size of the first time caught (Lc) shrimp is smaller than the average size of the first time cooked gonads (Lm) (31.1<35 mmCL) so that most of the shrimp caught are small and have not spawned. Growth rate (K), asymptotic carapace length (CL"), and age of female *F. indicus* at length 0 (t0) were 1.1 per year, 54.6 mmCL and -0.14883 years; while male *F. indicus* is 1.0 per year; 52.6 mm and -0.136202 years. Natural mortality rate (M), death rate due to capture (F), total death rate (Z), and exploitation rate (E) of female rock lobsters at 2.64 per year; 1.53 per year; 2.64 per year; and 0.48 per year. While male *F. indicus* amounted to 2.64 per year; 1.42 per year; 1.22 per year; and exploitation of 0.56 per year or optimum utilization of *F. indicus* resources. The rate of exploitation/exploitation of *F. indicus* in Seneboy waters is not fully exploited.

Keywords: Biology aspec; shrimp fisheries management; sex ratio; spawning season

Introduction. Banana shrimp *(Fenneropenaeus indicus)* is one of the important commodities in the waters of Seneboy, South Sorong. This type of *F. indicus* has important economic value and contributes to the improvement of the fishermen's economy in South Sorong. Seneboy fishermen catch *F. indicus* using trammel net fishing gear with an average tonnage of 3 GT vessels made of wood and fiber, 15 HP main engine power, as many as 3 people, about 600 m in length in a 4 meter nylon net. Mesh size 1.5-7.25 inch, PE rope Ø 8 mm for the head rope. the length of the ground rope is 660 m. This fishing gear is an effective and environmentally friendly fishing gear for catching *F. indicus* and other types of demersal fish which are bycatch.

The trammel net fleet in catching time pertrip ranges from 6-9 hours or start at 07.00 to 16.00 hours (one day fishing), the fishing ground ranges from 1-20 miles with a distance of about 1-4 hours from the landing base. Shrimp fishing ground around Wawonket cape, Dua island, Daram island, Sibabu cape, Komokara cape, Sabuga island, Sele cape, Misool islands, Sinabu cape, Banana islands and Segeat island. Shrimp fishing season is 12 months with the

highest season in July-November with a catch of around 10-100 kg per trip. Production of shrimp and other crustaceans in South Sorong waters in the period 2009 to 2016 amounted to 4,051 tons with an annual average of 506.42 tons or 38.75%. Meanwhile, the annual average production of white shrimp is 475.75 tons, with the highest production in 2010 of 557 tons and the lowest in 2013 of 350 tons (DKP Sorong, 2017).

Shrimp catching activity in Seneboy, South Sorong, is the main support to meet the economic needs of trammel net fisherman in Temibuanan Regency. Catching shrimp at this location is carried out very intensively, so that fishing activities need to be controlled in its utilization. One of the efforts in determining management is by examining several aspects of biology and population parameters.

Research on several aspects of biology and population parameters in several waters in Indonesia, namely in the waters of Arafura (Naamin, 1984), Cilacap (Suman, 1992; Suman & Boer, 2005; Saputra, 2005; Saputra & Subiyanto, 2007; Hargiyatno et al, 2013), Strait Madura (Setyohadi et al., 1999), Kotabaru (Suman & Umar, 2010), Bone (Kembaren & Ernawati, 2015), Tarakan (Kembaren & Suman, 2013) and Meulaboh (Yusuf et al., 2017).

This study provides information on the status of shrimp fisheries as a catch target and over-exploiting efforts, which are based on market demand and the increasing commercial value of shrimp. Rational management actions need to be taken so that shrimp resources are in a sustainable balance. Estimation of population parameters is needed as supporting data and information in this management, namely evaluating the status of white shrimp increase from year to year so that it can be used sustainably. The results of this study are expected to complement and update previous studies, to underlie the management of white shrimp resources in the waters of Seneboy, South Sorong and its surroundings.

Material Methods

Sampling of *F. indicus* caught with trammel net, was obtained from fishermen and shrimp collectors in Seneboy Temibuana, South Sorong, from January to October 2016. The enumerators were taking samples using a random sampling method. The data collected included carapace length (CL), weight, sex, gonad maturity level and fishing area (Figure 1).

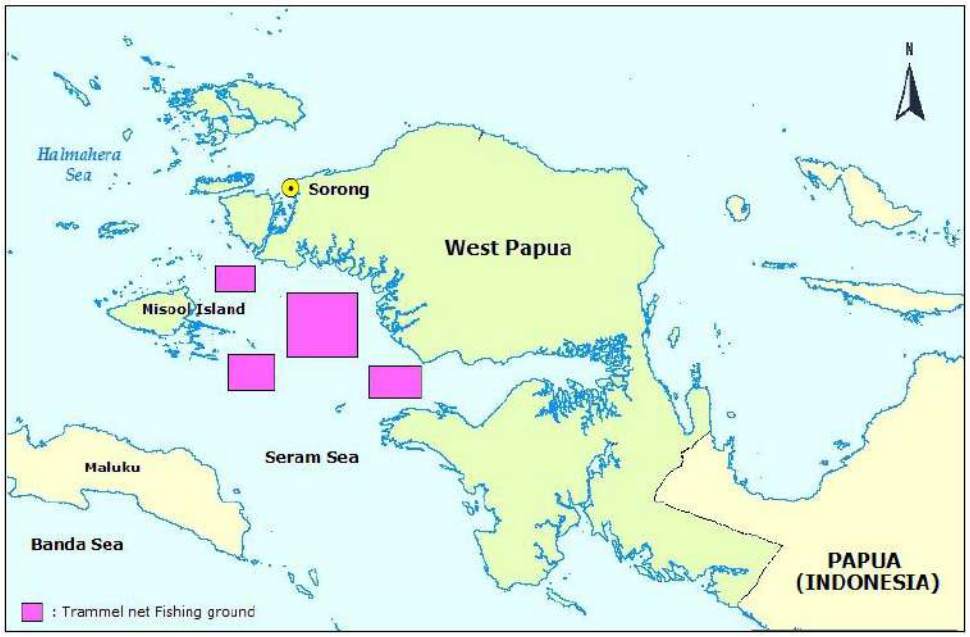

Figure 1. Fishing ground of trammel net in Seneboy, South Sorong (https://www.mapsofworld.com/where-is/sorong.html)

Data Analysis

Biological data analysis included size distribution, sex ratio, gonad maturity level, average size of first caught (Lc) and average size of gonad maturation (Lm). The analysis of population parameter data were growth pattern data (CL∞, K), mortality parameters (Z, M, F) and utilization rate (E).

The distribution of carapace length measurements is presented in the form of a bar chart with a length class of 2 mm. The level of maturity of female shrimp gonads was observed visually based on Motoh (1981), namely by looking at the size of the shrimp ovary on the back under the sun. Shrimp sex ratios were analyzed using the Chi-square test (Walpole, 1993)

The average first time gonad ripening (Lm) is obtained by entering the carapace length and PLm values into a graphical logistic function (King, 1995) with the following equation:

$$P_{cLm} = \frac{1}{1 + \exp(aCl + b)}$$

The value of carapace length for the first time caught (Lc) is obtained through a logistical function approach with the Sparre & Venema equation, (1992):

$$S_{CL} = \frac{1}{1 + \exp(a - B * Cl)}$$

Where: SCL is the fishing gear selectivity, a and b are constant, CL is the length of shrimp carapace and the value of CLc is obtained from a / b.

The method used in the study of population parameters is an analytical model based on the composition of the age structure of the shrimp (Sparre & Venema, 1992). The growth parameters of Von Bertalanffy, namely asymptotic carapace length (CL∞) and growth coefficient (K) were estimated by the ELEFAN I program in the FISAT II program (Gayanilo et al., 2005). Estimation of theoretical age (t0) is carried out with Pauly's (1983) empirical equation, namely:

$$Log\ (-t_0) = (-0{,}3922) - 0{,}2752 \log CL\infty - 1{,}038 \log K$$

The value of natural mortality (M) is estimated by the Pauly equation by explaining that there is an effect of mean water temperature (T) on the mortality rate, based on empirical observations (Pauly et al., 1984):

$$\text{Log M= (-0,0066)-0,279 logCL}\infty\text{+0,6542 logK +0,4634 LogT}$$

The total mortality (Z) value was estimated using the length-converted catch curve method in the FISAT II program package (Pauly, 1983; Gayanilo et al., 2005). Capture mortality and exploitation rate are estimated using the Sparre & Venema (1992) equation,:

$$E = \frac{F}{F + M}$$

$$E = \frac{F}{Z}$$

Results And Discussion

Biological Aspects

Samples of *F. indicus* obtained during the study were 2,085, consisting of 1,174 female *F. indicus* (56.31%) and 911 males (46.69%). The carapace length of female *F. indicus* ranges from 13.2 - 52.8 mm with weights ranging from 9.6-88.4 g with two modes in the range of 29-31 and 31.1-33 mmCL. Meanwhile, male *F. indicus* ranged between 16-49.6 mm, weights ranged from 15.4-78.6 g with mode in the range of 29-31 mmCL (Figure 2).

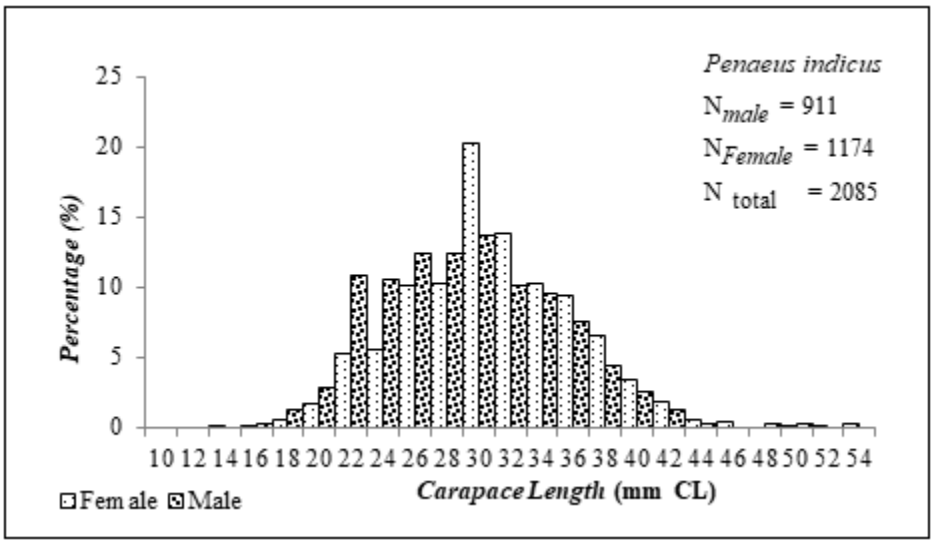

Figure 2. Length Frequency of *F. indicus* in Seneboy waters.

The sex ratio of *F. indicus* in the waters of Seneboy South Sorong is based on the chisquar test, the condition is not balanced between the number of male shrimp and female shrimp. Female shrimp are caught more dominantly than males. The sex ratio of male and female shrimp is 1: 1.78. Meanwhile, the sex ratio of *F. indicus* showed a balanced condition of 1: 1 in February, March, September and October (Table 1).

Table 1

Sex ratio of *F. indicus* in Seneboy waters, January – October 2016.

Months (2016)	Sex ratio of *F. indicus)*					Comparison P = 95%
	Male	Female	M : F Ratio		X2	
January	66	162	1	2.45	40.42	not Balanced
February	100	98	1	1.48	0.02	Balanced
March	94	106	1	1.61	0.72	Balanced
April	78	99	1	1.50	2.49	not Balanced
May	149	97	1	1.47	10.99	not Balanced
June	56	144	1	2.18	38.72	not Balanced
July	100	161	1	2.44	14.26	not Balanced
August	62	138	1	2.09	28.88	not Balanced
September	119	81	1	1.23	7.22	Balanced
October	87	88	1	1.33	0.01	Balanced
Total	911	1174	1	1.78	143.73	not Balanced

The highest proportion of mature female *F. indicus* (the maturity level of gonads III and the maturity level of gonads IV) was in January, February, September and October, with the peak maturing of gonads in October. The proportion of mature female gonads in January, February, September and October was 60%, 44%, 46% and 40% (Figure 3).

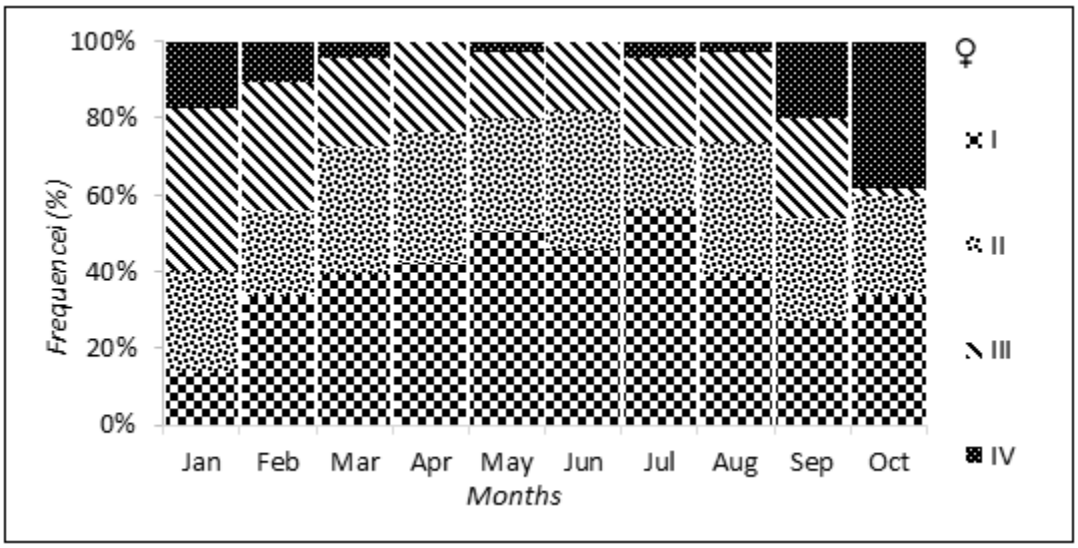

Figure 3. Proportion of gonad maturity stages for female *F. indicus* in Seneboy waters, Januari-October 2016.

The size of the first time capture (Lc) corresponds to the probability level of L50% on the trammel net selectivity, explaining that the opportunity for the distribution of *F. indicus* is suitable to be caught can increase the availability of resources. The logistic function graph with a class interval of 2 mmCL is obtained that the average value for first time capture (Lc) of *F. indicus* is 31.1 mmCL, with an average value (Lm) of 35 mmCL for the first time gonad maturation (Figure 4).

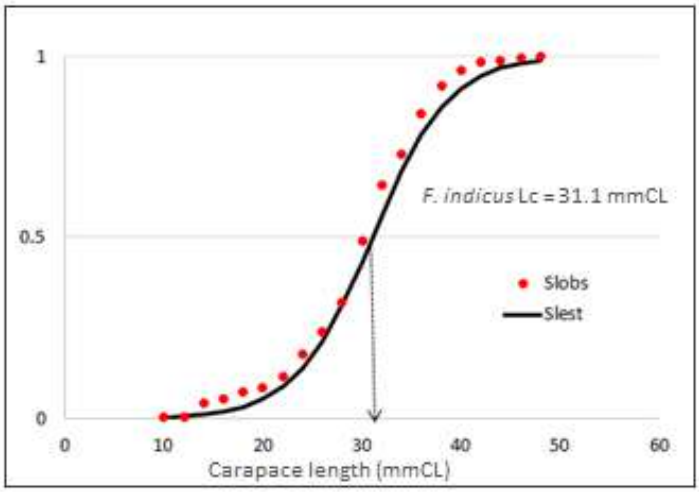

Figure 4. Average length first captured *F. indicus* with trammel net

Population Parameters

The results of the analysis based on the length frequency of female *F. indicus* carapace obtained the value of growth coefficient (K) in Seneboy waters 1.1 per year and 1.0 per year for male *F. indicus* (Figure 5).

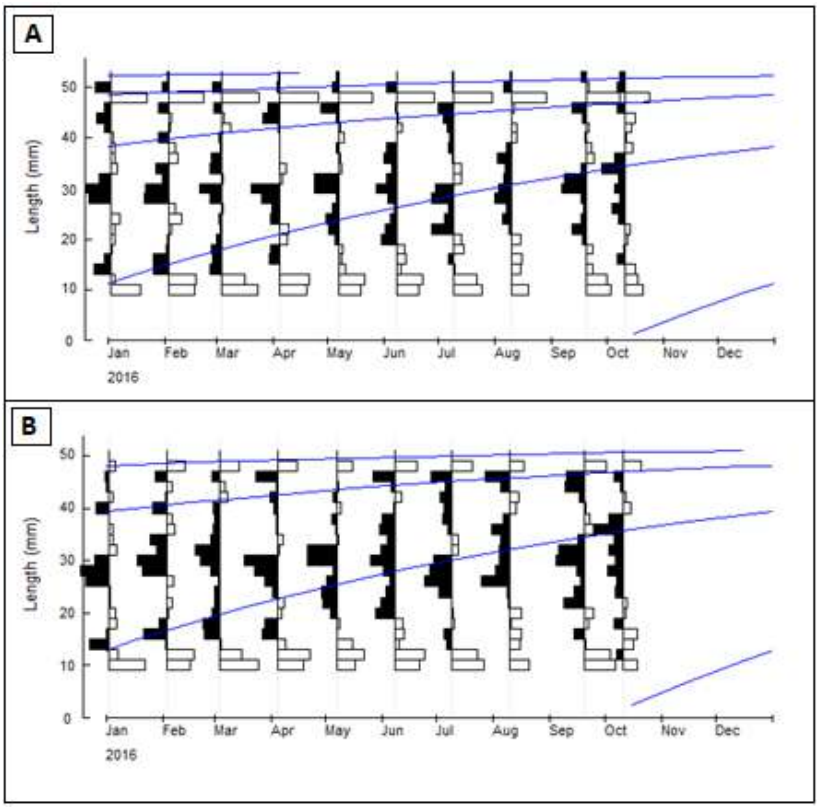

Figure 5. Growth model of male (A) and female (B) *F. indicus* by ELEFAN I in Seneboy waters.

The asymptotic carapace length (L∞) of female *F. indicus* was 54.6 mmCL and 52.6 mmCL for males, while the age of female *F. indicus* at 0 (t0) was -0.14883 years and -0.136202 for males. So that the equation for the Von Bertalanffy equation for female *F. indicus* is as Lt = 54.6 (1-e-1,100 (t-0.14883)) and male Lt = 52.6 (1-e-1,00 (t-0.136202)) (Figure 6). The maximum size range of *F. indicus* is estimated at the age of 1.8 years or around 20 months. The average size of *F. indicus* caught (Lc) 31.1 mmCL was estimated at the age of 7-8 months. The size of female gonad ripe average (Lm) 35 mmCL was estimated at the age of 9-10 months.

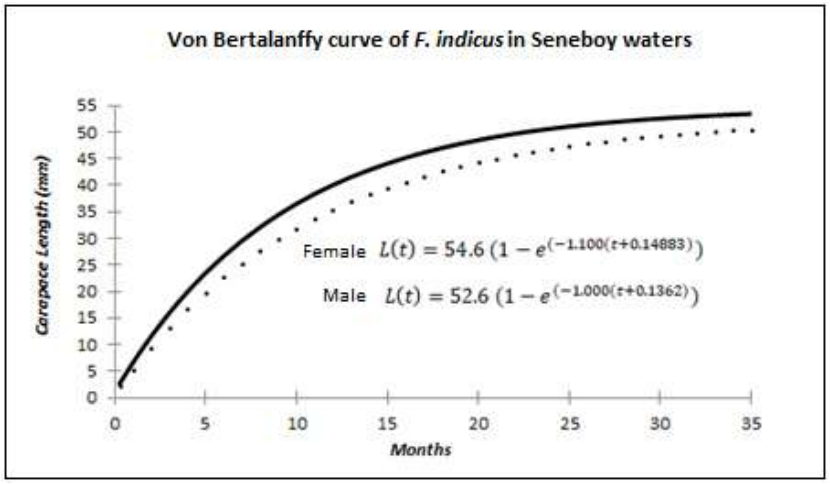

Figure 6. Von Bertalanffy curve of *F. indicus* in Seneboy waters.

The total mortality rate (Z) of female and male *F. indicus* based on the length conversion curve with the catch is 3.16 per year with a natural mortality rate (M) of 1.64 per year and the mortality rate due to fishing (F) of 1.53 per year. The total mortality rate (Z) of male *F. indicus* was 2.64 per year, the natural mortality rate (M) was 1.42 per year and the mortality rate due to fishing (F) was 1.22 per year. Based on these mortality parameters, the utilization rate of female *F. indicus* was 0.48 and male was 0.46 (Figure 7).

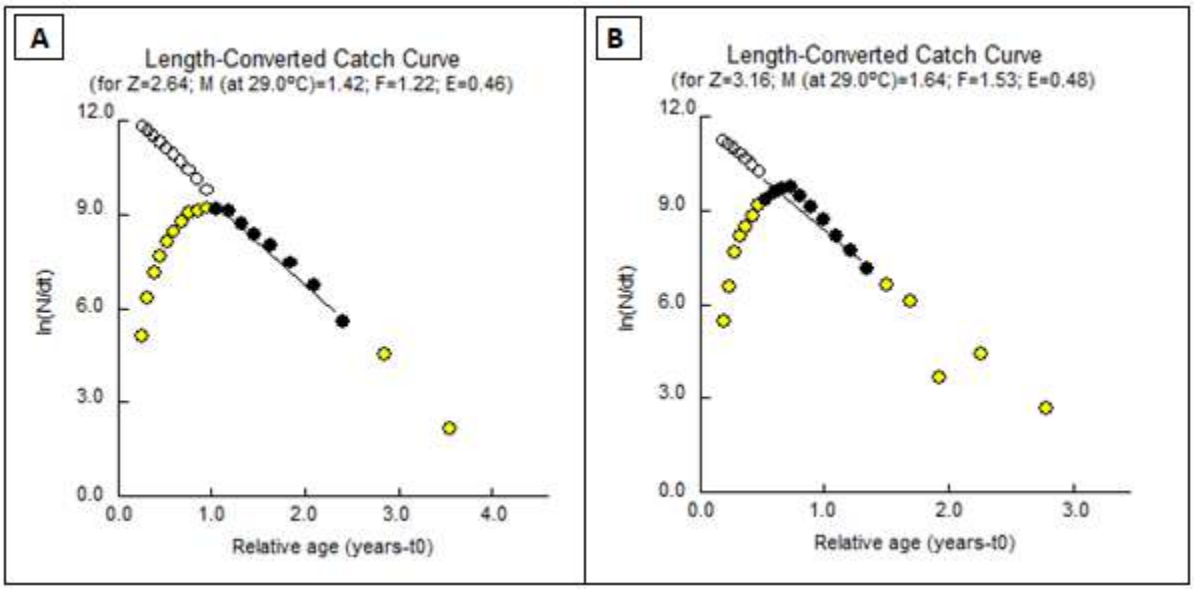

Figure 7. Growth curve of male (A) and female (B) *F. indicus* in waters of Seneboy

Discussion

The size distribution of *F. indicus* caught in the study area was greater than that in Kaimana waters ranging from 25-49 mm and the average size was 28.98 mm for males and 34.96 females and was not much different from those caught in Meulaboh waters are females with ranges between 17.8-79.54 mm, males between 18.3-64.36 mm. Whereas *Penaeus merguensis* in Central Java waters for males is 20-62 mm and females 14-68 mm, waters in West Java (17-47 mm) (Tirtadanu, 2018; Yusuf, 2017; Suman et al., 1988). Differences in

shrimp size at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al., 2017; Wilson et al., 2010; Matthews, 1982; Ogbonna, 2001). It is suspected that the larger shrimp size in Seneboy waters is not over-utilized.

The sex ratio of male and female shrimp in the study area was not balanced with the number of females caught being more dominant than males. The unbalanced condition is similar to the *F. indicus* caught in Meulaboh waters (Yusuf, 2017; Saputra, 2008; Saputra et al., 2013; Wedjadmiko & Yulianti, 2003; Wedjadmiko, 2009; Suman et al., 1991). This condition shows that the fishing pressure of shrimp resources in Seneboy waters has not disturbed population renewal so that the sustainability of shrimp stocks is still well maintained.

The peak estimated proportion of gonad ripe *F. indicus* occurs in February and October. The discovery of mature gonads indicates that this month is the spawning season for shrimp (Martosubroto, 1978). The peak spawning of several types of Penaied shrimp, including *P. merguiensis* in the waters of West Kalimantan occurred in November, the peak spawning of *Metapenaeus monoceros* in Southern Java waters occurred in January and August and the peak spawning of *Metapenaeus monoceros* in the Gulf of Carpentaria, Australia occurs from September to October (Kembaren, 2013; Suman et al., 2005; Crocos et al., 2000; Pillai & Thirumilu, 2013 and Gerami et al., 2013). The spawning season for *F. indicus* in the study area is seen to last throughout the year with a peak in February and October. From the perspective of resource sustainability, it is preferable that within a period of one year the season closes in February and October for catching *F. indicus* in Seneboy waters.

The average size for the first time caught (Lc) of *F. indicus* in the study area was 31.1 mmCL and the mean value for the first time gonad maturation was 35 mmCL. The results of research in the waters of the Cilacap Segara Anakan Lagoon with floating net Lc value of 20.2 mm or at a total length of about 90 mm (Saputra, 2008). Chan (1998) states that *F. indicus* females can reach a total length of 230 mm, although that is generally less than 170 mm. These results are different from the results of research in the waters of North Central Java, the carapace length of *P. merguensis* is 29.4 mm (Tirtadanu & Ernawati, 2016), the carapace length of Mayangan waters is 28.9 mm (Wedjatmiko & Yulianti, 2003) and Lc in Dolak waters, Arafura Sea is 28.78 mm (Hargiyatno I.T. & Sumiono B., 2012) The difference in Lc value is not only caused by the mesh size of the net used is also due to the time and location of the fishing. According to Susetiono & Setyono (1990), the group of *P. merguensis* in shallow waters tends to be smaller. than in deeper waters, it is smaller than in the waters of Cilacap with an average size of first maturation of gonads (Lm) of 51 mmCL (Saputra et al., 2013). The difference in shrimp size in several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al., 2017; Wilson et al., 2010).

According to FAO (2008), the Lm value is 50% of *F. indicus* at a total length of 130-149 mm. This shows that the value of L50% <Lm50% means that *F. indicus* is threatened by recruitment overfishing. According to Teikwa & Mgaya's research (2003), the size of the first male *F. indicus* is at 34 mm carapace length and female shrimp at 39 mm carapace length. Melmammblessy's research (2011) showed that Arafura's waters the size of the first maturity of the gonads at a carapace length of 60.26 mm. The average size for the first time caught by *F. indicus* (Lc) in the study area was smaller than the average size at first maturity of gonads (Lm), indicating that most of the shrimp caught had not spawned so in the long run this was not good for population sustainability because will hamper the process of adding these shrimps in Seneboy waters. In this regard, it is necessary to arrange the size of the mesh so that the size of the *F. indicus* caught is the smallest at the carapace length of 13.2 mmCL.

The growth rate (K) of *F. indicus* in the research area shows that they have fast growth with a growth value of 1.1 per year in females and 1.0 per year, with asymptotic carapace length (L∞) of female *F. indicus* 54.6 mmCL and 52, 6 mmCL for males. With the maximum size reached at the age of about 1.8 years or about 20 months. When compared with growth parameters in different locations, the growth rate of *F. indicus* in the study area shows different growth values. waters of the Segara Anakan Lagoon Cilacap L∞ = 35.7 mm; K =

1.26/year, Kota Baru waters was 1.4/year and L∞ 44.3 mm, in Kaimana waters it was 44.7 mmCL for males and 51.25 mmCL for females.

Location	Sex	L_{∞} (mmCL)	K	t0	Authors
Cilacap, Central Jawa	Combined	35.7	1.26	-	Saputra (2008)
Kota Baru, South Kalimantan	Combined	44.3	1.4	-	Suman *et al* (2010).
Kaimana, West Papua	Male Female	44.7	1.38	-	Tirtadanu & Pangabean 2018)
Cilacap, Central Java	Male Female	40.7 54.2	1 1.1	0.56 0.36	Suman & Prisantoso (2017)
Tarakan, North Kalimantan	Male Female	45.2 57.6	1.55 1.33	0.76 0.76	Chodrijah & Suman (2017)
Sampit, Central Kalimantan	Combined	57.8	1.45	0.66	Nurdin & Kembaren (2015)
Tanal Laut, South Kalimantan	Combined	55	1.05	0.74	Suman et al (2017)
Cenderawasih Bay, Papua	Male Female	44.5 48.7	1.05 1.15	0.66 0.55	Kembaren & Ernawati (2015)
Kaimana, West Papua	Male Female	44.7 51.25	1.4 1.37	0.49 0.44	Tirtadanu & Panggabean (2018)
Seneboy, West Papua	Male Female	54.6 52.6	1.1 1.0	0.148 0.136	Present research

The mortality rate (Z) of *F. indicus* in Seneboy waters is relatively low, namely 3.16 in females and 2.6 in females. Some Penaeid shrimp in other waters, namely the waters of the Cilacap Segara Anakan Lagoon, obtained an M value of 2.6/year, an F value of 1.35/year (*P. meruiensis* in Segara Anakan Lagoon Cilacap is 1.43/year, the natural mortality rate is 1.85 per year and catching 2.32 per year, Madura waters natural mortality rate of 2.17-2.22 per year and catching 1.11-1.56 per year (Saputra, 2008; Kembaren et al., 2012; Setyohadi et al., 1999; Hedianto et al., 2016).

The high mortality rates were in the waters of Kota Baru 9 for males and 9.47 for females, in Kakinada waters 10.58; in Khoozestan waters 7.01 and Vietnamese waters 5.78 (Tirtadanu et al., 2017; Devi, 1987; Ansari et al., 2014; Dinh et al., 2010). Natural mortality is influenced by several factors such as food availability, disease, environment, competition and especially the presence of predatory species (Sparre & Venema 1992; Niamaimandi et al., 2007).

Penaeid parwn is the prey of several demersal fish such as *Lutjanus gibbus*, *Eleutheronema tetradactylum* and *Arius sp*. (Bachok et al 2004; Titrawani et al 2013). Death due to fishing (F) of both male and female *F. indicus* is lower than the natural mortality rate (M) indicating that the utilization of the *F. indicus* population has not been exploited intensively by fishermen in the waters of Seneboy, West Papua. Garcia (1988) suggests that the average natural mortality rate (M) of penaeid shrimp is 2.4 ± 0.3/year for adult shrimp. Naamin (1984) found that the F value of *P. merguensis* in Arafura waters varies according to the development of fishing effort, which ranges from 0.55/year (at the start of the exploitation) to 8.99/year.

Cultivation rates (E) of female and male *F. indicus* were 0.48 and 0.46. This condition explains that the fishing rate is greater than the natural mortality rate. The optimum exploitation rate stated by Gulland (1983) is 0.5 so that the rate of exploitation of *F. indicus* in Seneboy waters is close to the optimum value and is still sustainable. The level of exploitation of *F. indicus* in several areas has exceeded the optimum limit, namely the waters of the Segara Anakan Cilacap Lagoon, Meulaboh waters, Tarakan Bay, Tanah Laut and Cenderawasih the level of exploitation indicates overfishing (Saputra, 2008; Yusuf et al 2017; Chodrijah & Suman 2017; Suman et al., 2017; Kembaren & Ernawati 2015). Utilization of *F. indicus* has approached the maximum, on this basis the need for fishing pressure of about 5% of the current total effort.

Conclusions

The average size of male *F. indicus* caught in the waters of Seneboy South Sorong is 16-49.6 mmCL and females 13.2 - 52.8 mmCL. The sex ratio of *Metapenaeus affinis* shows an unbalanced condition with the ratio of male and female shrimp is 1: 1.8. The spawning season lasts throughout the year with a peak in February and October and the average size of first caught (Lc) of shrimp is smaller than the average size of first-time gonads (Lm) (31.1>35 mmCL). The growth rate and mortality rate of *F. indicus* in Seneboy waters were lower with the exploitation rate values (E) 0.48 and 0.46. This indicates that the level of utilization of *F. indicus* in Seneboy waters is not yet optimal, but leads to overfishing. In order for the sustainability of the *F. indicus* resource in the waters of Seneboy, West Papua, it is advisable to reduce efforts about 5% from the current, adjusting the mesh so that the catch size is at least 13.2 mmCL and closing the fishing season in February and October.

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Eni Kovacs <ek.bioflux@gmail.com>
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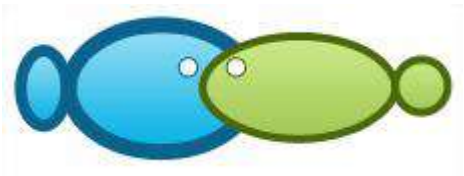

The growth rate of *Fenneropenaeus indicus* in Seneboy Waters, South Sorong, Papua, Indonesia

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Abstract. *Fenneropenaeus indicus* is one of the economically important species of shrimp cultivated in South Sorong Seneboy waters and currently its production tends to decrease. Studying its biological aspects provides data and information needed for assessing its exploitation and managing its conservation. This study aims to examine the biological aspects of *F. indicus* as a material for shrimp fisheries management in the waters of Seneboy, South Kalimantan. The study was conducted between January-November 2017 in the waters of Seneboy. The results showed that the average size of the caught female *F. indicus* was 13.2-52.8 mm carapace length (CL), with a mode size of 31.1-33 mm CL, and the average size of a male shrimp was 16-49.6 mm CL with a mode size 29-31 mm CL. The sex ratio of male and female shrimp is 1:1.8. *F. indicus* spawning season is suspected to last all year and peak in February and October. The average size of the first time caught (Lc=31.1 CL) shrimp is smaller than the average size of the first time cooked gonads (Lm =35 mm) so that most of the shrimp caught are small and have not spawned. In female *F. indicus*, the growth rate (K), asymptotic carapace length (CL) and age at length 0 (t0) were of: 1.1 cm year^{-1}, 54.6 mm CL and -0.14883 years, respectively, while in male they were of: 1.0 cm year^{-1}, 52.6 mm and -0.136202 years, respectively. The natural mortality rate (M), death rate due to capture (F), total death rate (Z) and exploitation rate (E) of female rock lobsters were 2.64 cm year^{-1}, 1.53 cm year^{-1}, 2.64 cm year^{-1} and 0.48 cm year^{-1}, respectively, while in male *F. indicus* amounted to 2.64 cm year^{-1}, 1.42 cm year^{-1}, 1.22 cm year^{-1} and 0.56 cm year^{-1}, corresponding to an optimal utilization of the *F. indicus* resources. The status of *F. indicus* in Seneboy waters is "not fully exploited".
Key Words: biology aspect; shrimp fisheries management; sex ratio; spawning season.

Introduction. *Fenneropenaeus indicus* is one of the important commodities in the waters of Seneboy, South Sorong. *F. indicus* has an economic value and contributes to the improvement of the fishermen's life in South Sorong. Seneboy fishermen catch *F. indicus* using a 4 meter nylon trammel net as fishing gear, operated by 3 people from vessels of about 6 m in length, made of wood and fiber, of an average tonnage of 3 GT and a main engine power of 15 HP. The mesh size is of 1.5-7.25 inch, with a polyethylene head rope of Ø 8 mm. The length of the ground rope is 660 m. This effective and environmentally friendly fishing gear is used for catching *F. indicus* and other types of demersal fish which are bycatch (BRPL 2016).

The catching time per trip ranges from 6 to 9 hours (from 07.00 to 16.00 hours, which is one day fishing) and the fishing ground ranges from 1 to 20 miles, with a distance of about 1-4 hours from the landing base. The shrimp fishing grounds are located around Wawonket Cape, Dua Island, Daram Island, Sibabu Cape, Komokara Cape, Sabuga Island,

Sele Cape, Misool Islands, Sinabu Cape, Banana Island and Segeat Island. The shrimp fishing season is 12 months with the highest season in July-November, with a catch of around 10-100 kg trip^{-1}. The production of shrimp and other crustaceans in South Sorong waters, in the period 2009 to 2016, reached 4,051 tons, with an annual average of 506.42 tons or 38.75%, total production. The annual average production of *F. indicus* is 475.75 tons, with the highest production in 2010 of 557 tons and the lowest in 2013 of 350 tons (DKP Sorong 2017).

Shrimp catching activity in Seneboy, South Sorong, is the main support to meet the economic needs of trammel net fishermen in Temibuanan Regency. Catching shrimp at this location is carried out very intensively, so that fishing activities need to be supervised. The biology and population parameters provide the control and management criteria to the marine authorities.

Research on several aspects of biology and population parameters was extensively conducted in several waters in Indonesia: Arafura (Naamin 1984), Cilacap (Suman 1992; Suman & Boer 2005; Hargiyatno et al 2013; Saputra & Subiyanto 2007), Strait Madura (Setyohadi et al 1999), Kotabaru (Suman & Umar 2010), Bone (Kembaren & Ernawati 2015), Tarakan (Kembaren & Suman 2013) and Meulaboh (Yusuf et al 2017).

The study provides information on the exploitation status of shrimp, facing the market demand and an increasing commercial value. Rational management actions need to be taken in order to maintain a sustainable balance of the shrimp resources and the population parameters estimation is required as supporting data and information. The results of this study are expected to complement and update previous studies, underlying the management of *F. indicus* resources in the waters of Seneboy, South Sorong, and surroundings.

Material and Method

Research location and time. *F. indicus* sampling was carried out with a trammel net, obtained from fishermen and shrimp collectors in Seneboy Temibuana, South Sorong, from January to October 2016. The enumerators were taking samples using a random sampling method. The data collected included carapace length (CL), weight, sex, gonad maturity level and fishing area (Figure 1).

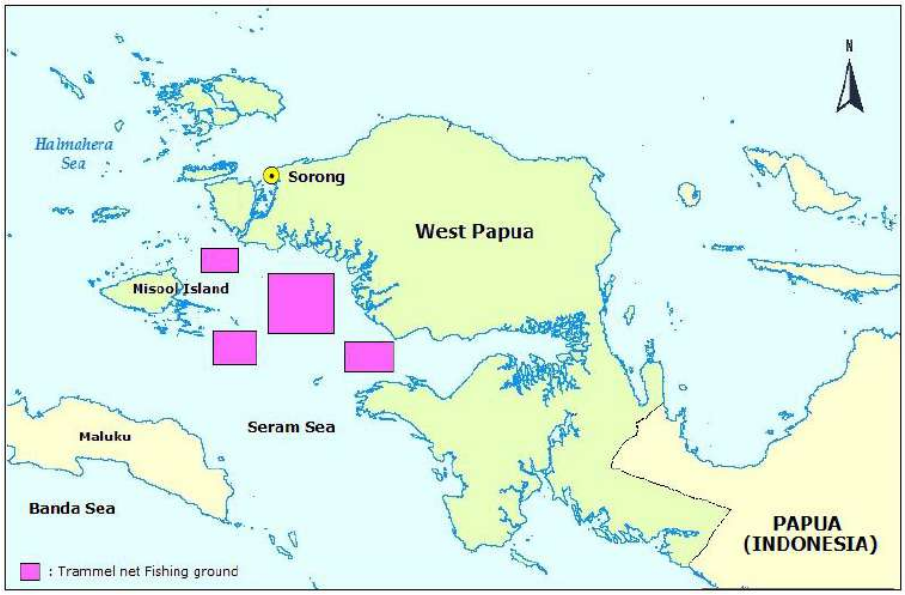

Figure 1. Fishing ground of trammel net in Seneboy, South Sorong (https://www.mapsofworld.com/where-is/sorong.html).

Data analysis. Biological data analysis included the size distribution, sex ratio, gonad maturity level, average size of first caught specimens (Lc). The analyzed population parameters were the growth pattern (CL∞, K), mortality parameters (Z, M, F) and utilization rate (E).

The distribution of carapace length measurements is presented in the form of a bar chart with a length class of 2 mm. The level of maturity of female shrimp gonads was observed visually based on Motoh (1981), namely by looking at the size of the shrimp ovary, located on its back. Shrimp sex ratios were analyzed using the Chi-square test (Walpole 1993)

The length at first matured (Lm) is obtained by entering the carapace length and P_{Lm} values into a graphical logistic function (King 1995), with the following equation:

$$P_{Lm} = \frac{1}{1 + \exp\ (aCl + b)}$$

Where:

P_{Lm} - logistic curve of proportion mature by length, Lm was determined by a/b;

a - the intercept of regression;

b - the slope of regression;

The value of carapace length caught for the first time (Lc) is obtained through a logistic function approach, with the Sparre & Venema (1992) equation:

$$S_L = \frac{1}{1 + \exp\ (a - b * CL)}$$

Where:

S_L - logistic curve and Lc was determined by a/b;

a - the intercept of regression;

b - the slope of regression;

CL - the length of shrimp carapace.

The method used in the study of population parameters is an analytical model based on the composition of the age structure of the shrimp (Sparre & Venema 1992). The growth parameters of Von Bertalanffy, namely the asymptotic carapace length (CL∞) and the growth coefficient (K) were estimated by the ELEFAN I program in the FISAT II program (Gayanilo et al 2005). An estimation of the theoretical age (t0) is carried out with the Pauly's (1983) empirical equation, namely:

$$Log\ (-t_0) = (-0.3922) - 0.2752 \log CL\infty - 1.038 \log K$$

The value of the natural mortality (M) is estimated through the Pauly's equation, by including the effect of the mean water temperature (T) on the mortality rate, based on empirical observations (Pauly et al 1984):

$$\text{Log M= (-0.0066)-0.279 log CL}\infty\text{+0.6542 log K +0.4634 Log T}$$

The total mortality (Z) value was estimated using the length-converted catch curve method in the FISAT II program package (Pauly 1983; Gayanilo et al 2005). The capture mortality and exploitation rate are estimated using the Sparre & Venema (1992) equations:

$$E = \frac{F}{F + M}$$

$$E = \frac{F}{Z}$$

Where:
E - the exploitation rate;
F - the Fishing mortality;
M- natural mortality;
Z - the total mortality.

Results and Discussion

Biological aspects. A number of 2,085 *F. indicus* specimens were collected during the study were: 1,174 females (56.31%) and 911 males (46.69%). The carapace length of female *F. indicus* ranged from 13.2 to 52.8 mm, for a weight ranging from 9.6 to 88.4 g, with two modes in the ranges of 29-31 and 31.1-33 mm CL. The carapace length of male *F. indicus* ranged between 16-49.6 mm, for a weight ranging from 15.4 to 78.6 g, with a mode in the range of 29-31 mm CL (Figure 2).

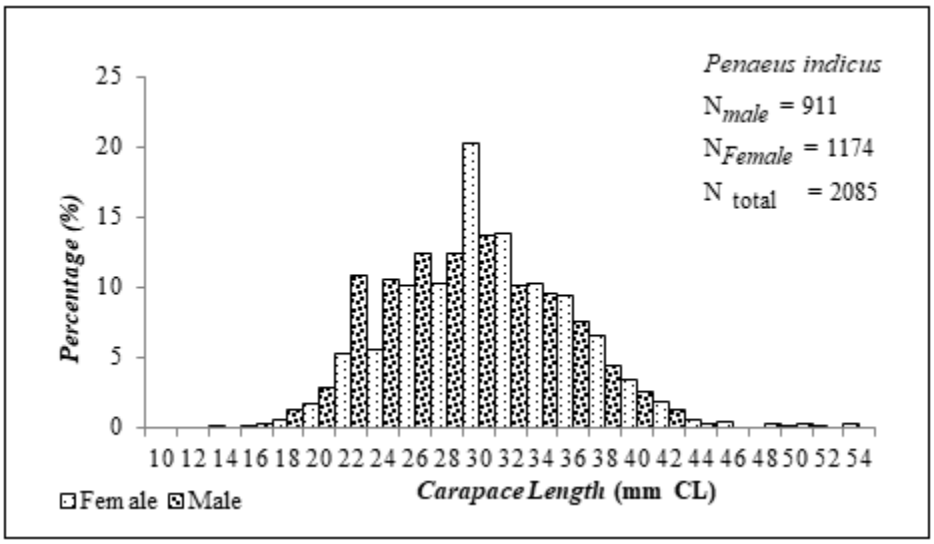

Figure 2. Length frequency of *Fenneropenaeus indicus* in Seneboy waters.

The sex ratio determination of *F. indicus* in the waters of Seneboy South Sorong is based on the chi squared test, which indicates an imbalance between the male and female shrimp populations: in most cases, female shrimp dominate the catch. Although the average sex ratio of *F. indicus* males and females is 1: 1.78, it showed a balanced value of 1:1 in February, March, September and October (Table 1).

Table 1

Sex ratio of *Fenneropenaeus indicus* in Seneboy waters, January-October 2016

Months	*Sex ratio of F. indicus*					*Comparison*
(2016)	*Male*	*Female*	*M:F ratio*		*X2*	*P=95%*
January	66	162	1	2.45	40.42	Not balanced
February	100	98	1	1.48	0.02	Balanced
March	94	106	1	1.61	0.72	Balanced
April	78	99	1	1.50	2.49	Not balanced
May	149	97	1	1.47	10.99	Not balanced

June	56	144	1	2.18	38.72	Not balanced
July	100	161	1	2.44	14.26	Not balanced
August	62	138	1	2.09	28.88	Not balanced
September	119	81	1	1.23	7.22	Balanced
October	87	88	1	1.33	0.01	Balanced
Total	911	1174	1	1.78	143.73	Not balanced

The highest proportion of mature female *F. indicus* (the maturity level of gonads III and the maturity level of gonads IV) was in January, February, September and October, with the peak maturing of gonads in October. The proportion of females with mature gonads in January, February, September and October was 60, 44, 46 and 40% (Figure 3).

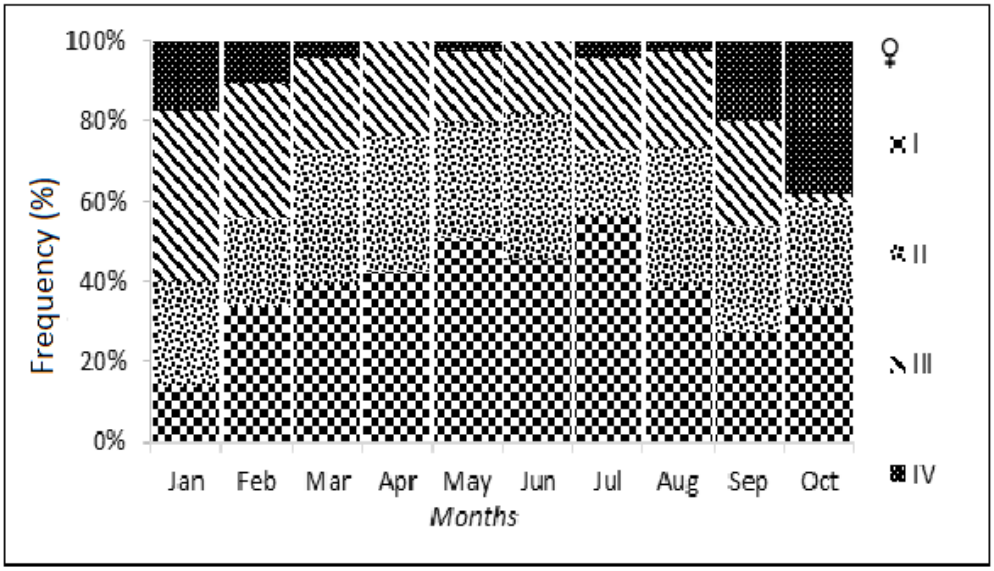

Figure 3. Proportion of *Fenneropenaeus indicus* females with mature gonads in Seneboy waters, January-October 2016.

The size of the first time capture (Lc) corresponds to the probability level of L50% of the trammel net selectivity, meaning that the catch distribution of *F. indicus* can influence the availability of resources. The logistic function graph with a class interval of 2 mm CL indicates that the average value at the first capture (Lc) of *F. indicus* is 31.1 mm CL, with an average value (Lm) of 35 mm CL at the first gonad maturation (Figure 4).

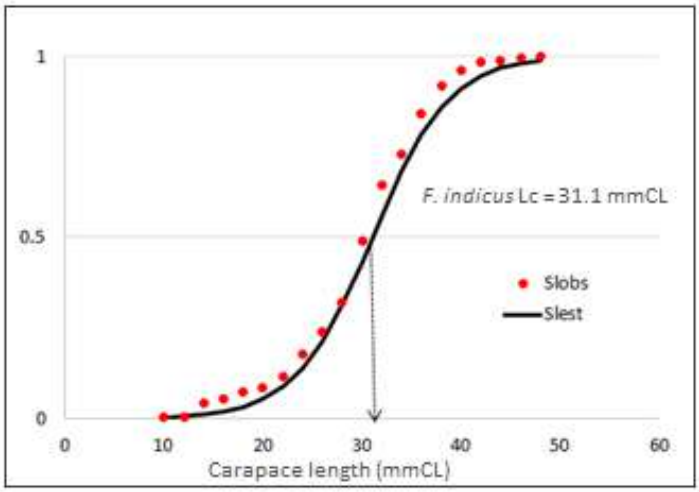

Figure 4. Average length at first *Fenneropenaeus indicus* capture with a trammel net of the.

Population parameters. The growth parameters of *F. indicus* in the Seneboy waters is processed from long frequency distribution data carapace by tracking any mode shift the distribution of carapace length frequencies in a curved sequence of times Von Bertalanffy's growth. Based on the results of the analysis, it was found that infinitive carapace length (L∞) of female *F. indicus* was 54.6 mm, the growth rate (K) was 1.1 year $^{-1}$ and the male was 52.6 mm, the growth rate was 1.0 year^{-1} (Figure 5). From the value of these two parameters a growth equation and a key relationship can be created between carapace lengths with aged shrimp by using multiple variations in age value (t).

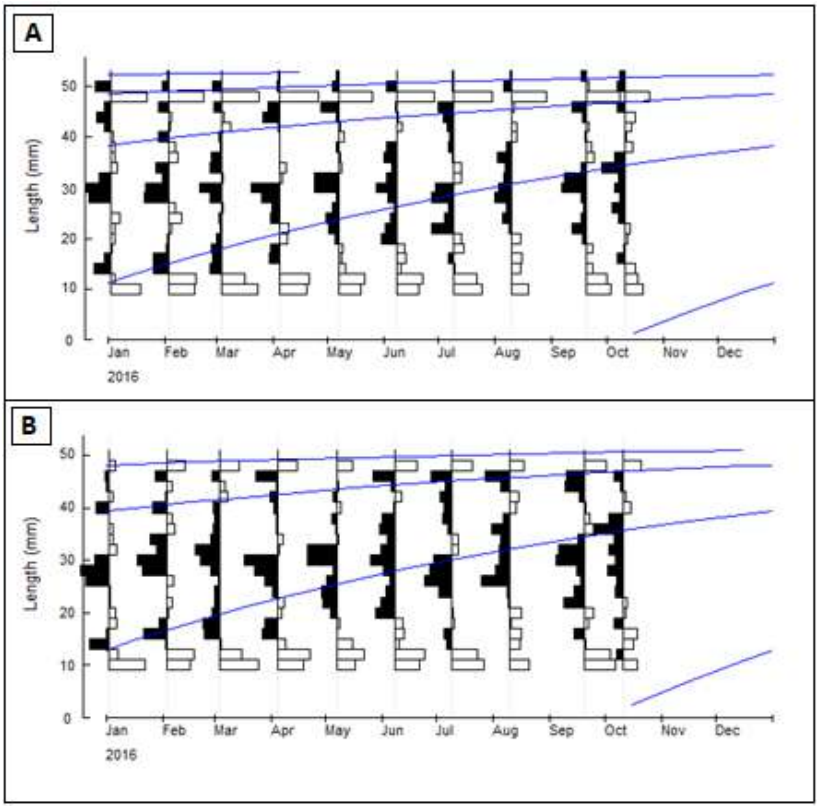

Figure 5. Growth model of male (A) and female (B) *Fenneropenaeus indicus* by ELEFAN I in Seneboy waters.

The asymptotic carapace length (L∞) of female *F. indicus* was 54.6 mm CL and 52.6 mm CL for males, while the age of female *F. indicus* at 0 (t0) was -0.14883 years and -0.136202 for males. So that the equation for the Von Bertalanffy equation for female *F. indicus* is Lt = 54.6 (1-e-1,100 (t-0.14883)) and for male *F. indicus* it is Lt = 52.6 (1-e-1.00 (t-0.136202)) (Figure 6). The maximum size range of *F. indicus* is estimated at the age of 1.8 years or around 20 months. The average size of 31.1 mm CL in caught *F. indicus* (Lc) was estimated at the age of 7-8 months. The average mature gonad size in females (Lm) was of 35 mm CL, at the age of 9-10 months.

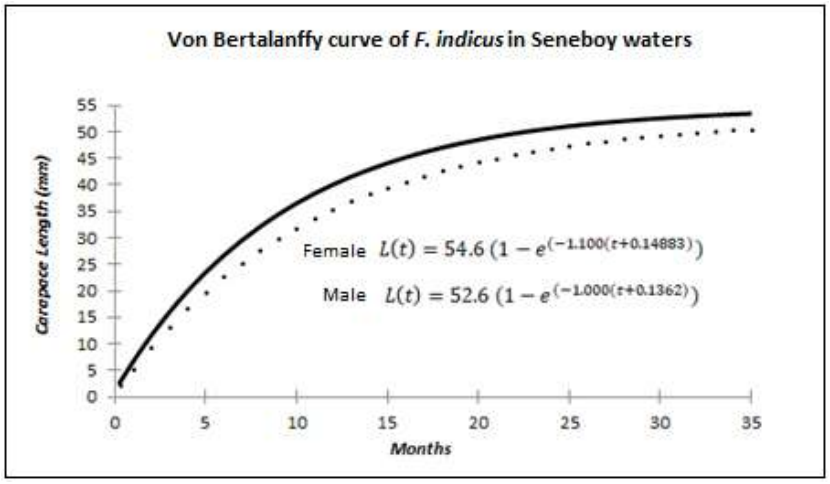

Figure 6. Von Bertalanffy curve of *Fenneropenaeus indicus* in Seneboy waters.

The total mortality rate (Z) of female and male *F. indicus* based on the length-converted catch curve is 3.16 year^{-1}, with a natural mortality rate (M) of 1.64 year^{-1} and the mortality rate due to fishing (F) of 1.53 year^{-1}. The total mortality rate (Z) of male *F. indicus* was 2.64 year^{-1}, the natural mortality rate (M) was 1.42 year^{-1} and the mortality rate due to fishing (F) was 1.22 year^{-1}. Based on these mortality parameters, the utilization rate of *F. indicus* was 0.48 for females and 0.46 for males (Figure 7).

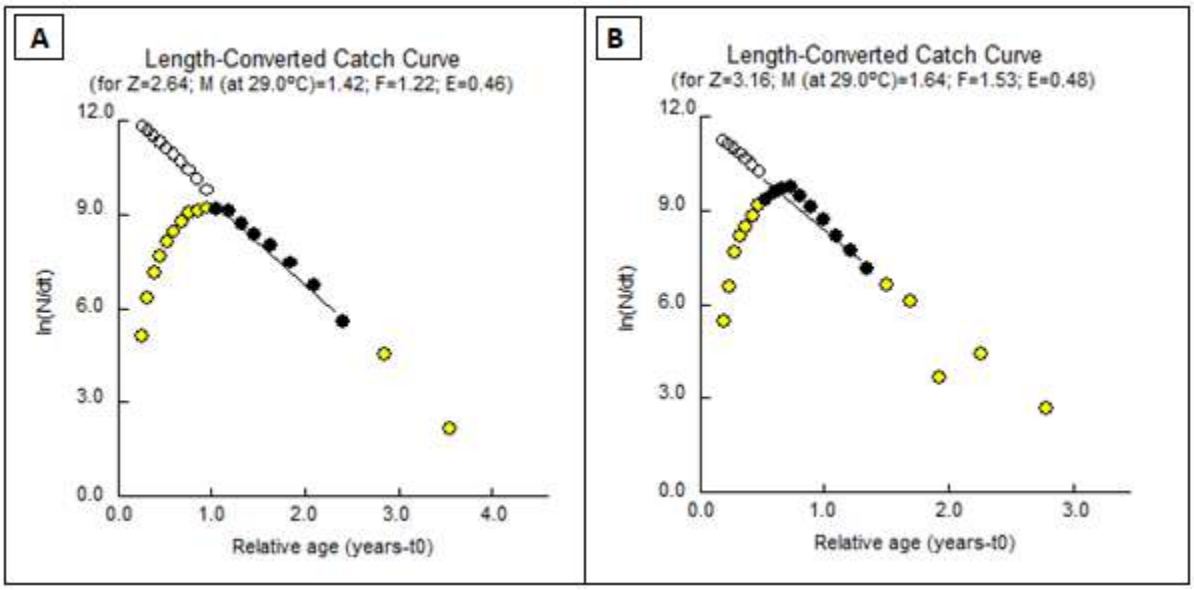

Figure 7. Growth curve of male (A) and female (B) *Fenneropenaeus indicus* in waters of Seneboy.

Discussion. The size distribution of *F. indicus* caught in the study area was greater than in Kaimana waters, ranging from 25-49 mm, and the average size was 28.98 mm for males and 34.96 for females. The size of *F. indicus* specimens caught in Meulaboh waters ranged between 17.8 and 79.54 mm for females and between 18.3 and 64.36 mm for males. The size of *Penaeus merguensis* in Central Java waters ranged between 20 and 62 mm for males and between 14 and 68 mm for females, and averaged 17 to 47 mm in West Java waters (Tirtadanu& Panggabean 2018; Yusuf 2017; Suman et al 1988). Differences in shrimp size at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al 2017; Wilson et al 2010; Matthews 1982; Ogbonna 2001). Given the larger shrimp size in Seneboy waters, it is supposed that the species is not over-utilized.

The sex ratio of male and female shrimp in the study area was not balanced: the females dominated the catch. The unbalanced sex ratio is similar to the *F. indicus* caught in Meulaboh waters (Yusuf 2017; Saputra 2008; Saputra et al 2013; Wedjadmiko & Yulianti 2003; Wedjatmiko 2009; Suman et al 1991), suggesting that the fishing pressure of shrimp resources in Seneboy waters has not disturbed the population renewal so that the sustainability of shrimp stocks is still well maintained.

The peak indicated that a higher frequency of mature gonads in *F. indicus* occured in February and October, suggesting the spawning seasons for the shrimp (Martosubroto 1978). For comparson, the spawning peaks occurred in November for several types of Penaied shrimp from the waters of West Kalimantan (including *P. merguiensis*), in January and August for the *Metapenaeus monoceros* from the Southern Java waters and from September to October for the *Metapenaeus monoceros* from the Gulf of Carpentaria, Australia (Kembaren & Suman 2013; Suman et al 2005; Crocos et al 2000; Pillai & Thirumilu 2013; Gerami et al 2013). The spawning season for *F. indicus* in the study area lasted throughout the year, with peaks in February and October. Therefore, from the perspective of the resources sustainability, it is preferable to suspend the *F. indicus* fishing activities in Seneboy waters during February and October.

The first catch average size (Lc) of *F. indicus* in the study area was of 31.1 mm CL and the mean value at the first gonad maturity was 35 mm CL. The results of research conducted in the waters of the Cilacap Segara Anakan Lagoon, using floating nets, showed an Lc value of 20.2 mm, for a total length of about 90 mm (Saputra 2008). Chan (1998) stated that *F. indicus* females can reach a total length of 230 mm, although they generally measure less than 170 mm. These results are different from the research conducted in the waters of North Central Java, where the carapace length of *P. merguensis* was of 29.4 mm (Tirtadanu & Ernawati 2016); Wedjatmiko & Yulianti 2003; Hargiyatno & Sumiono 2012). The differences of Lc values are not only caused by the mesh size of the net used, but they are also due to the operations duration and to the location of the fishing ground. ~~the carapace length of Mayangan waters is 28.9 mm (Wedjatmiko & Yulianti 2003) and Lc in Dolak waters, Arafura Sea is 28.78 mm (Hargiyatno & Sumiono 2012). The differences of Lc values are not only caused by the mesh size of the net used, but they are also due to the operations duration and to the location of the fishing ground.~~ According to Susetiono & Setyono (1990), the *P. merguensis* from shallow waters tends to be smaller than in deeper waters (e.g. Cilacap), with an average size (Lc) of 51 mm CL (Saputra et al 2013). The shrimp size differences at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al 2017; Wilson et al 2010).

According to FAO (2008), the Lm value is 50% of *F. indicus*, at a total length of 130-149 mm. This shows that the value of L50% <Lm50% means that *F. indicus* recruitment is threatened by overfishing. According to Teikwa & Mgaya's (2003) research, the *F. indicus* carapace length size of the first caught males is of 34 mm and 39 mm carapace in female shrimps. Melmammblessy's (2011)said, ~~research showed that in Arafura's waters the size of~~

~~the first catch average size (Lc) at a carapace length of 60.26 mm.~~ The results of this study indicate that in Arafura waters, the average size of the first catch (Lc) has a carapace length of 60.26 mm. The average size of the *F. indicus* caught for the first time (Lc) in the study area was smaller than the average size at the first maturity of gonads (Lm), indicating that most of the shrimp caught had not spawned. In the long term, this situation is detrimental to the population's sustainability, hampering the shrimps recruitment process in the Seneboy waters. In this regard, it is necessary to adjust the size of the mesh in such a manner that the smallest carapace lengthof the caught *F. indicus* cannot be under 13.2 mm CL.

The growth rate (K) of *F. indicus* in the research area shows that they have a fast growth rate: 1.1 per year in females and 1.0 per year in males, with an asymptotic carapace length (L∞) of 54.6 mm CL for females and 52, 6 mm CL for males. The growth parameters in different locations were: L∞ = 35.7 mm and K = 1.26 year^{-1} in the waters of the Segara Anakan Lagoon Cilacap, 1.4 year^{-1} and L∞ 44.3 mm in the Kota Baru waters and 44.7 mm CL for males and 51.25 mm CL for females in the Kaimana waters. (table 2).

Table 2

Asymptotic length (L∞), growth rate (K) and exploitation rate (E) of *F. indicus* in some areas

Location	*Sexes*	*L_{∞} (mm CL)*	*K*	*t0*	*Authors*
Cilacap, Central Jawa	Combined	35.7	1.26	-	Saputra (2008)
Kota Baru, South Kalimantan	Combined	44.3	1.4	-	Suman et al (2010)
Kaimana, West Papua	Combined	44.7	1.38	-	Tirtadanu & Pangabean 2018)
Cilacap, Central Java	Male	40.7	1	0.56	Suman & Prisantoso (2017)
	Female	54.2	1.1	0.36	
Tarakan, North Kalimantan	Male	45.2	1.55	0.76	Chodrijah & Suman (2017)
	Female	57.6	1.33	0.76	
Sampit, Central Kalimantan	Combined	57.8	1.45	0.66	Nurdin & Kembaren (2015)
Tanal Laut, South Kalimantan	Combined	55	1.05	0.74	Suman et al (2017)
Cenderawasih Bay, Papua	Male	44.5	1.05	0.66	Kembaren & Ernawati (2015)
	Female	48.7	1.15	0.55	
Kaimana, West Papua	Male	44.7	1.4	0.49	Tirtadanu & Panggabean (2018)
	Female	51.25	1.37	0.44	
Seneboy, West Papua	Male	54.6	1.1	0.148	Present research
	Female	52.6	1.0	0.136	

The mortality rate (Z) of *F. indicus* in the Seneboy waters is relatively low, namely 3.16 in males and 2.6 in females. Some Penaeid shrimp in other waters, namely the waters of the Cilacap Segara Anakan Lagoon, obtained an M value of 2.6 cm year^{-1}, an F value of 1.35 cm year^{-1} (*P. meruiensis* in Segara Anakan Lagoon Cilacap is 1.43 year^{-1}, the natural mortality rate is 1.85 cm year^{-1} and catching 2.32 cm year^{-1}, Madura waters natural mortality rate of 2.17-2.22 cm year^{-1} and catching 1.11-1.56 cm year^{-1} (Saputra 2008; Kembaren et al 2012; Setyohadi et al 1999; Hedianto et al 2016).

The highest mortality rates (ind year^{-1}) were recorded: 9 for males and 9.47 for females in the waters of Kota Baru, 10.58 in the Kakinada waters, 7.01 in the Khoozestan waters and 5.78 in the Vietnamese waters (Tirtadanu et al 2017; Devi 1987; Ansari et al 2014; Dinh et al 2010). The natural mortality is influenced by several factors such as food availability, disease, environment, competition and the presence of predatory species (Sparre & Venema 1992; Niamaimandi et al 2007). Penaeid prawn is the prey of several demersal fish, such as *Lutjanus gibbus*, *Eleutheronema tetradactylum* and *Arius* sp. (Bachok et al 2004; Titrawani et al 2013). Death due to fishing (F) of both male and female *F. indicus* is lower than the natural mortality rate (M), indicating that the *F. indicus* population has not been exploited intensively by fishermen in the waters of Seneboy, West Papua.

Garcia (1988) suggests that the average natural mortality rate (M) of penaeid shrimp is 2.4±0.3 year^{-1} for adult shrimp. Naamin (1984) found that the F value of *P. merguensis* in Arafura waters varies according to the development of the fishing effort, ranging from 0.55 year^{-1} (at the start of the exploitation) to 8.99 year^{-1}.

In this study, the exploitation rates (E) of female and male *F. indicus* were 0.48 and 0.46. This condition explains that the fishing rate is greater than the natural mortality rate. The optimum exploitation rate stated by Gulland (1983) is 0.5, so that the rate of exploitation of *F. indicus* in Seneboy waters is close to the optimum value and is still sustainable. The level of exploitation of *F. indicus* in several areas has exceeded the optimum limit, namely in the waters of the Segara Anakan Cilacap Lagoon, Meulaboh waters, Tarakan Bay, Tanah Laut and Cenderawasih, where the level of exploitation indicates overfishing (Saputra 2008; Yusuf et al 2017; Chodrijah & Suman 2017; Suman et al 2017; Kembaren & Ernawati 2015). The exploitation of *F. indicus* has approached the maximum, suggesting that a reduction of the fishing pressure is required, with at least 5% of the current total effort.

Conclusions. The average size of *F. indicus* caught in the waters of Seneboy South Sorong is 16-49.6 mm CL for the males and 13.2 - 52.8 mm CL for the females. The sex ratio of *F. indicus* is unbalanced: 1:1.8, male against female. The spawning season lasts throughout the year with peaks in February and October. The catch is dominated by adults so that management sets the regulations for the minimum legal size. These results concluded that the arrest of *F. indicus* can be continued by arranging the arrest effort and stipulating a minimum legal size of 35 mm CL. This indicates that the level of exploitation of *F. indicus* in Seneboy waters is not yet optimal, but leads to overfishing. In order to maintain the sustainability of the *F. indicus* resources in the waters of Seneboy, West Papua, it is advisable (1) to reduce efforts with about 5% from the current level, by adjusting the mesh in such a manner that the retained catch size of *F. indicus* will be of at least 13.2 mm CL and (2) to suspend the *F. indicus* fishing operations in February and October.

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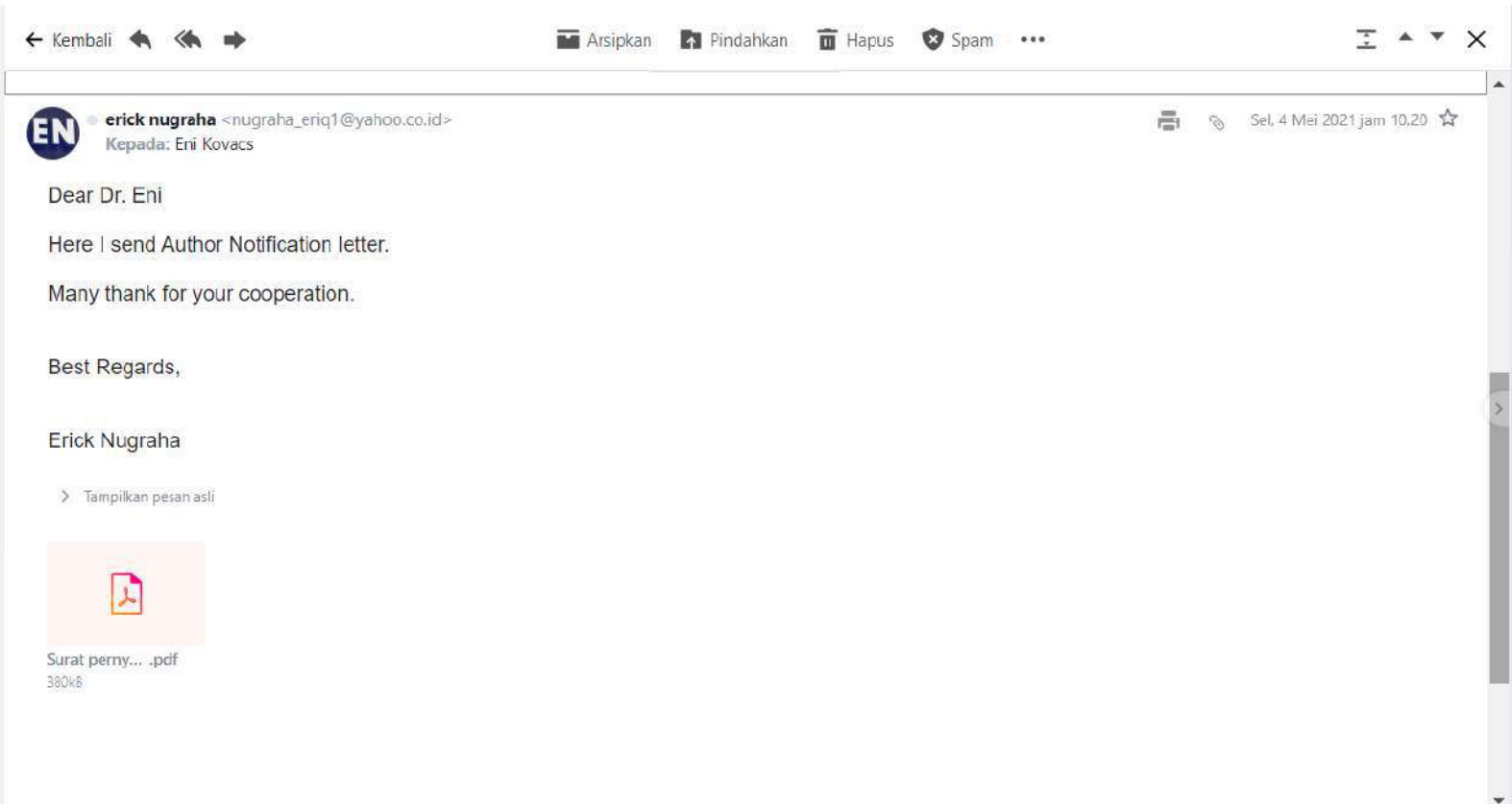
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Here I send Author Notification letter.
Many thank for your cooperation.
Best Regards,
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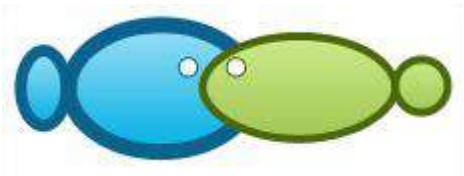

The growth rate of *Fenneropenaeus indicus* in Seneboy Waters, South Sorong, Papua, Indonesia

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Abstract. *Fenneropenaeus indicus* is one of the economically important species of shrimp cultivated in South Sorong Seneboy waters and currently its production tends to decrease. Studying its biological aspects provides data and information needed for assessing its exploitation and managing its conservation. This study aims to examine the biological aspects of *F. indicus* as a material for shrimp fisheries management in the waters of Seneboy, South Kalimantan. The study was conducted between January-November 2017 in the waters of Seneboy. The results showed that the average size of the caught female *F. indicus* was 13.2-52.8 mm carapace length (CL), with a mode size of 31.1-33 mm CL, and the average size of a male shrimp was 16-49.6 mm CL with a mode size 29-31 mm CL. The sex ratio of male and female shrimp was 1:1.8. *F. indicus* spawning season is suspected to last all year and peak in February and October. The average size of the first time caught (Lc=31.1 CL) shrimp was smaller than the average size of the first time cooked gonads (Lm=35 mm), so that most of the shrimp caught were small and had not spawned. In female *F. indicus*, the growth rate (K), asymptotic carapace length (CL) and age at length 0 (t0) were of: 1.1 cm year^{-1}, 54.6 mm CL and -0.14883 years, respectively, while in male they were of: 1.0 cm year^{-1}, 52.6 mm and -0.136202 years, respectively. The natural mortality rate (M), death rate due to capture (F), total death rate (Z) and exploitation rate (E) of female rock lobsters were 2.64 cm year^{-1}, 1.53 cm year^{-1}, 2.64 cm year^{-1} and 0.48 cm year^{-1}, respectively, while in male *F. indicus* amounted to 2.64 cm year^{-1}, 1.42 cm year^{-1}, 1.22 cm year^{-1} and 0.56 cm year^{-1}, corresponding to an optimal utilization of the *F. indicus* resources. The status of *F. indicus* in Seneboy waters is "not fully exploited".
Key Words: biology aspect, shrimp fisheries management, sex ratio, spawning season.

Introduction. *Fenneropenaeus indicus* is one of the important commodities in the waters of Seneboy, South Sorong. *F. indicus* has economic value and contributes to the improvement of the fishermen's life in South Sorong. Seneboy fishermen catch *F. indicus* using a 4 m nylon trammel net as fishing gear, operated by 3 people from vessels of about 6 m in length, made of wood and fiber, of an average tonnage of 3 GT and a main engine power of 15 HP. The mesh size is of 1.5-7.25 inch, with a polyethylene head rope of Ø 8 mm. The length of the ground rope is 660 m. This effective and environmentally friendly fishing gear is used for catching *F. indicus* and other types of demersal fish which are bycatch (BRPL 2016). The catching time per trip ranges from 6 to 9 hours (from 07.00 to 16.00 hours, which is one day fishing) and the fishing ground ranges from 1 to 20 miles, with a distance of about 1-4 hours from the landing base. The shrimp fishing grounds are located around Wawonket Cape, Dua Island, Daram Island, Sibabu Cape, Komokara Cape, Sabuga Island, Sele Cape, Misool Islands, Sinabu Cape, Banana Island and Segeat Island. The shrimp

fishing season is 12 months with the highest season in July-November, with a catch of around 10-100 kg trip^{-1}. The production of shrimp and other crustaceans in South Sorong waters, in the period 2009 to 2016, reached 4,051 tons, with an annual average of 506.42 tons or 38.75%, total production. The annual average production of *F. indicus* was 475.75 tons, with the highest production in 2010 of 557 tons and the lowest in 2013 of 350 tons (DKP Sorong 2017).

Shrimp catching activity in Seneboy, South Sorong, is the main support to meet the economic needs of trammel net fishermen in Temibuanan Regency. Catching shrimp at this location is carried out very intensively, so that fishing activities need to be supervised. The biology and population parameters provide the control and management criteria to the marine authorities. Research on several aspects of biology and population parameters was extensively conducted in several waters in Indonesia: Arafura (Naamin 1984), Cilacap (Suman 1992; Suman & Boer 2005; Hargiyatno et al 2013; Saputra & Subiyanto 2007), Strait Madura (Setyohadi et al 1999), Kotabaru (Suman & Umar 2010), Bone (Kembaren & Ernawati 2015), Tarakan (Kembaren & Suman 2013) and Meulaboh (Yusuf et al 2017).

The study provides information on the exploitation status of *F. indicus*, facing the market demand and an increasing commercial value. Rational management actions need to be taken in order to maintain a sustainable balance of the shrimp resources and the population parameters estimation is required as supporting data and information. The results of this study are expected to complement and update previous studies, underlying the management of *F. indicus* resources in the waters of Seneboy, South Sorong, and surroundings.

Material and Method

Research location and time. *F. indicus* sampling was carried out with a trammel net, obtained from fishermen and shrimp collectors in Seneboy Temibuana, South Sorong, from January to October 2016. The enumerators were taking samples using a random sampling method. The data collected included carapace length (CL), weight, sex, gonad maturity level and fishing area (Figure 1).

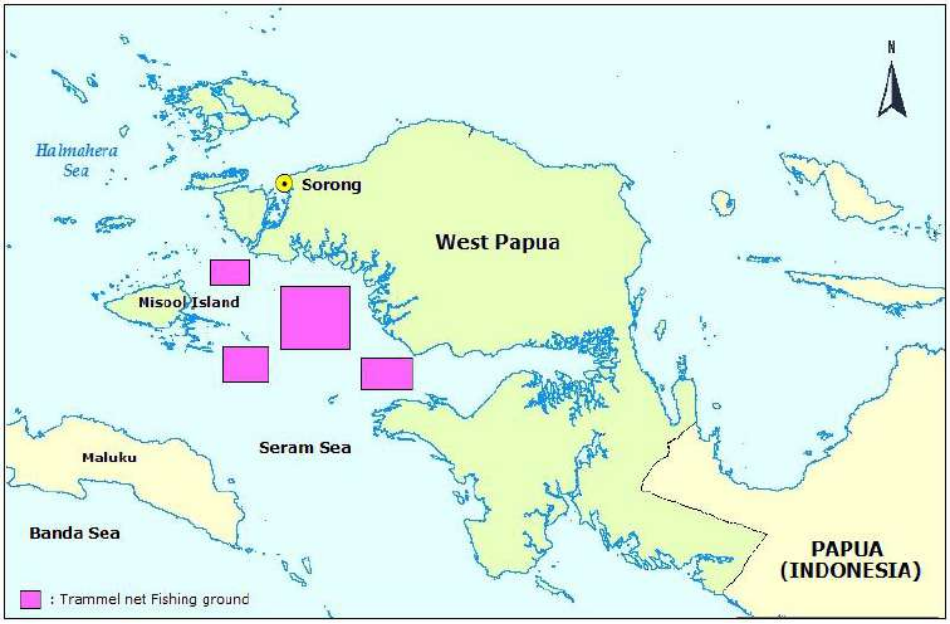

Figure 1. Fishing ground of trammel net in Seneboy, South Sorong (https://www.mapsofworld.com/where-is/sorong.html).

Data analysis. Biological data analysis included the size distribution, sex ratio, gonad maturity level, average size of first caught specimens (Lc). The analyzed population parameters were the growth pattern (CL∞, K), mortality parameters (Z, M, F) and utilization rate (E). The distribution of carapace length measurements is presented in the form of a bar chart with a length class of 2 mm. The level of maturity of female *F. indicus* gonads was observed visually based on Motoh (1981), namely by looking at the size of the shrimp ovary, located on its back. Shrimp sex ratios were analyzed using the Chi-square test (Walpole 1993)

The length at first matured (Lm) is obtained by entering the carapace length and P_{Lm} values into a graphical logistic function (King 1995), using the following equation:

$$P_{Lm} = \frac{1}{1 + \exp\ (aCl + b)}$$

Where:
P_{LM} – logistic curve of proportion mature by length, Lm was determined by a/b;
a - the intercept of regression;
b - the slope of regression;
CL - the length of shrimp carapace.

The value of carapace length caught for the first time (Lc) is obtained through a logistic function approach, with the Sparre & Venema (1992) equation:

$$S_L = \frac{1}{1 + \exp\ (a - b * CL)}$$

Where:
S_L - logistic curve and Lc was determined by a/b;
a - the intercept of regression;
b - the slope of regression;
CL - the length of shrimp carapace.

The method used in the study of population parameters is an analytical model based on the composition of the age structure of the shrimp (Sparre & Venema 1992). The growth parameters of Von Bertalanffy, namely the asymptotic carapace length (CL∞) and the growth coefficient (K) were estimated by the ELEFAN I program in the FISAT II program (Gayanilo et al 2005). An estimation of the theoretical age (t0) was carried out with the Pauly's (1983) empirical equation, namely:

$$Log\ (-t_0) = (-0.3922) - 0.2752 \log CL\infty - 1.038 \log K$$

The value of the natural mortality (M) is estimated through the Pauly's equation, by including the effect of the mean water temperature (T) on the mortality rate, based on empirical observations (Pauly et al 1984):

$$\text{Log M= (-0.0066)-0.279 log CL}\infty\text{+0.6542 log K +0.4634 Log T}$$

The total mortality (Z) value was estimated using the length-converted catch curve method in the FISAT II program package (Pauly 1983; Gayanilo et al 2005). The capture mortality and exploitation rate are estimated using the Sparre & Venema (1992) equations:

$$E = \frac{F}{F + M}$$

$$E = \frac{F}{Z}$$

Where:
E - the exploitation rate;
F - the Fishing mortality;
M- natural mortality;
Z - the total mortality.

Results and Discussion

Biological aspects. A number of 2,085 *F. indicus* specimens were collected during the study were: 1,174 females (56.31%) and 911 males (46.69%). The carapace length of female *F. indicus* ranged from 13.2 to 52.8 mm, for a weight ranging from 9.6 to 88.4 g, with two modes in the ranges of 29-31 and 31.1-33 mm CL. The carapace length of male *F. indicus* ranged between 16-49.6 mm, for a weight ranging from 15.4 to 78.6 g, with a mode in the range of 29-31 mm CL (Figure 2).

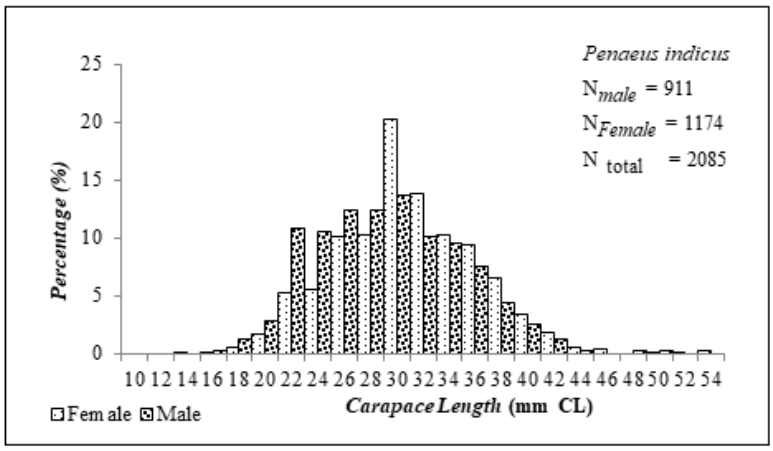

Figure 2. Length frequency of *Fenneropenaeus indicus* in Seneboy waters.

The sex ratio determination of *F. indicus* in the waters of Seneboy South Sorong is based on the chi squared test, which indicates an imbalance between the male and female shrimp populations: in most cases, female shrimp dominate the catch. Although the average sex ratio of *F. indicus* males and females was 1:1.78, it showed a balanced value of 1:1 in February, March, September and October (Table 1).

Table 1

Sex ratio of *Fenneropenaeus indicus* in Seneboy waters, January-October 2016

Months	*Sex ratio of F. indicus*					*Comparison*
(2016)	*Male*	*Female*	*M:F ratio*		*X2*	*P=95%*
January	66	162	1	2.45	40.42	Not balanced
February	100	98	1	1.48	0.02	Balanced
March	94	106	1	1.61	0.72	Balanced
April	78	99	1	1.50	2.49	Not balanced
May	149	97	1	1.47	10.99	Not balanced
June	56	144	1	2.18	38.72	Not balanced
July	100	161	1	2.44	14.26	Not balanced
August	62	138	1	2.09	28.88	Not balanced
September	119	81	1	1.23	7.22	Balanced
October	87	88	1	1.33	0.01	Balanced
Total	911	1174	1	1.78	143.73	Not balanced

The highest proportion of mature female *F. indicus* (the maturity level of gonads III and the maturity level of gonads IV) was in January, February, September and October, with the peak maturing of gonads in October. The proportion of females with mature gonads in January, February, September and October was 60, 44, 46 and 40% (Figure 3).

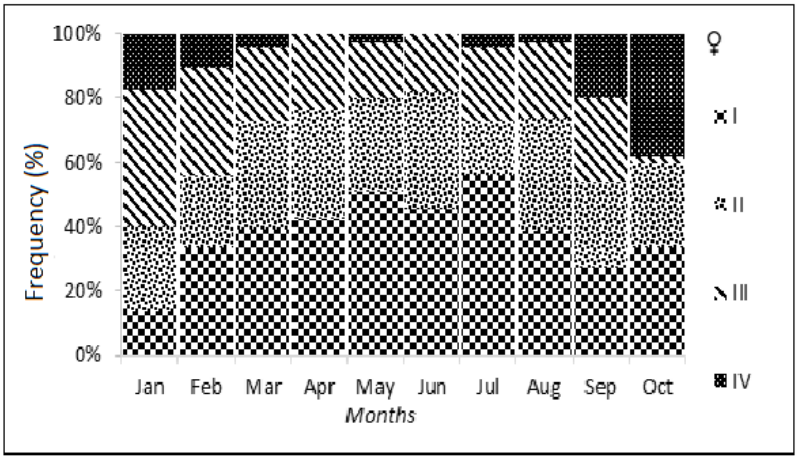

Figure 3. Proportion of *Fenneropenaeus indicus* females with mature gonads in Seneboy waters, January-October 2016.

The size of the first time capture (Lc) corresponds to the probability level of L50% of the trammel net selectivity, meaning that the catch distribution of *F. indicus* can influence the availability of resources. The logistic function graph with a class interval of 2 mm CL indicates that the average value at the first capture of *F. indicus* is 31.1 mm CL, with an average value (Lm) of 35 mm CL at the first gonad maturation (Figure 4).

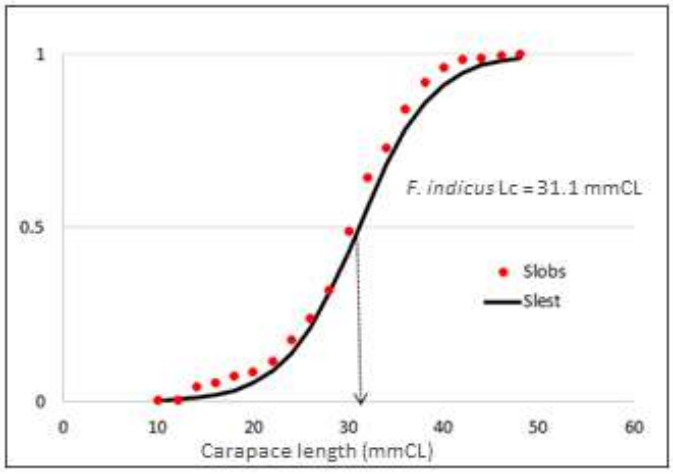

Figure 4. Average length at first *Fenneropenaeus indicus* capture with a trammel net.

Population parameters. The growth parameters of *F. indicus* in the Seneboy waters is processed from long frequency distribution data carapace by tracking any mode shift the distribution of carapace length frequencies in a curved sequence of times Von Bertalanffy's growth. Based on the results of the analysis, it was found that infinitive carapace length (L∞) of female *F. indicus* was 54.6 mm, the growth rate (K) was 1.1 year $^{-1}$ and the male was 52.6 mm, the growth rate was 1.0 year^{-1} (Figure 5). From the value of these two parameters a growth equation and a key relationship can be created between carapace lengths with aged shrimp by using multiple variations in age value (t).

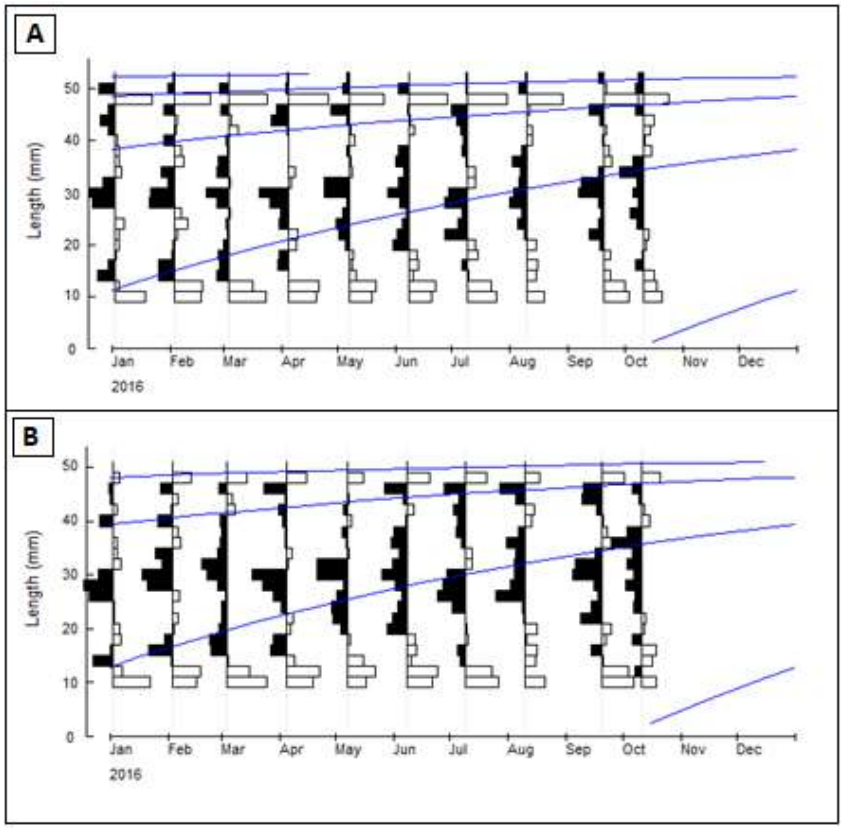

Figure 5. Growth model of male (A) and female (B) *Fenneropenaeus indicus* by ELEFAN I in Seneboy waters.

The asymptotic carapace length (L∞) of female *F. indicus* was 54.6 mm CL and 52.6 mm CL for males, while the age of female *F. indicus* at 0 (t0) was -0.14883 years and -0.136202 for males. So that the equation for the Von Bertalanffy equation for female *F. indicus* is Lt=54.6 (1-e-1,100 (t-0.14883)) and for male it is Lt=52.6 (1-e-1.00 (t-0.136202)) (Figure 6). The maximum size range of *F. indicus* is estimated at the age of 1.8 years or around 20 months. The average size of 31.1 mm CL in caught *F. indicus* (Lc) was estimated at the age of 7-8 months. The average mature gonad size in females (Lm) was of 35 mm CL, at the age of 9-10 months.

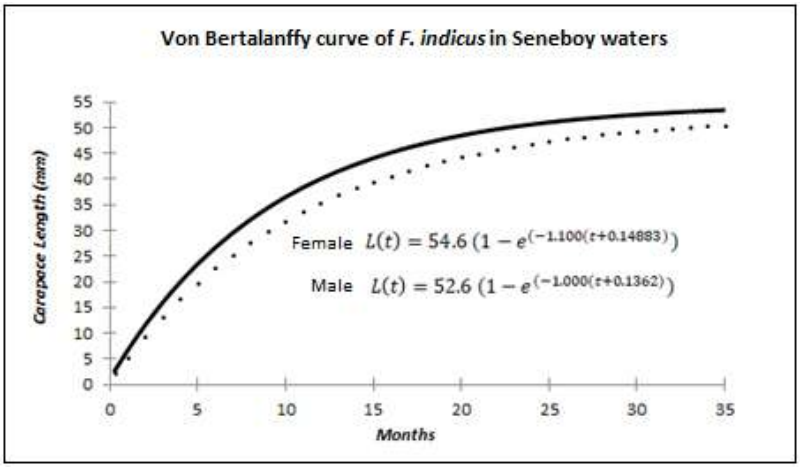

Figure 6. Von Bertalanffy curve of *Fenneropenaeus indicus* in Seneboy waters.

The total mortality rate (Z) of female and male *F. indicus* based on the length-converted catch curve is 3.16 year^{-1}, with a natural mortality rate (M) of 1.64 year^{-1} and the mortality rate due to fishing (F) of 1.53 year^{-1}. The total mortality rate of male *F. indicus* was 2.64 year^{-1}, the natural mortality rate was 1.42 year^{-1} and the mortality rate due to fishing was 1.22 year^{-1}. Based on these mortality parameters, the utilization rate of *F. indicus* was 0.48 for females and 0.46 for males (Figure 7).

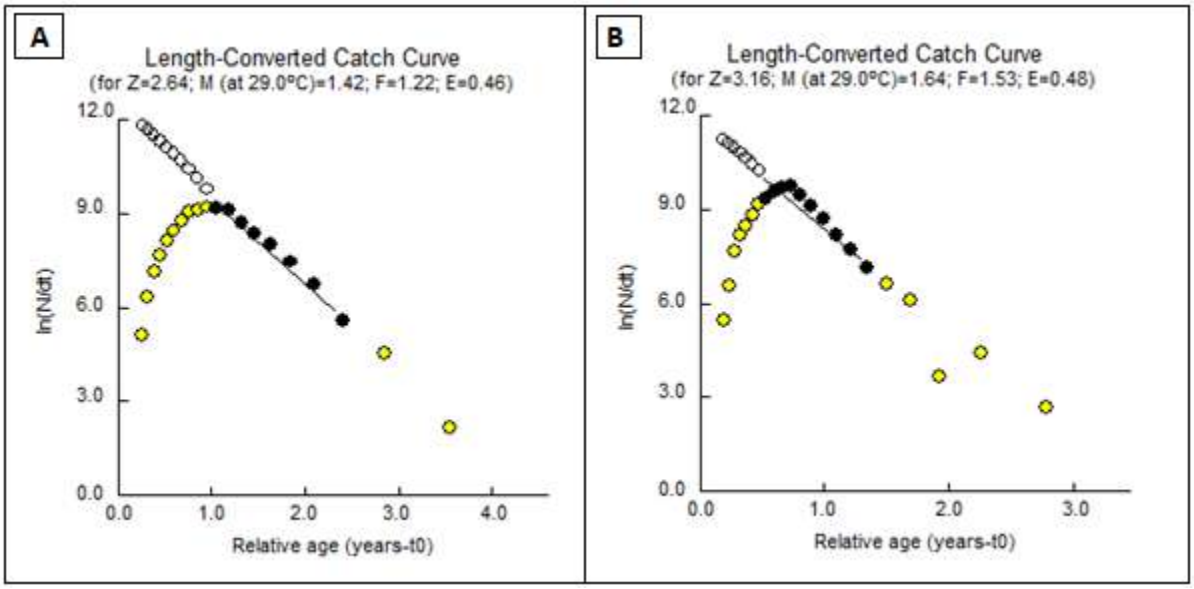

Figure 7. Growth curve of male (A) and female (B) *Fenneropenaeus indicus* in waters of Seneboy.

Discussion. The size distribution of *F. indicus* caught in the study area was greater than in Kaimana waters, ranging from 25-49 mm, and the average size was 28.98 mm for males and 34.96 for females. The size of *F. indicus* specimens caught in Meulaboh waters ranged between 17.8 and 79.54 mm for females and between 18.3 and 64.36 mm for males. The size of *Penaeus merguensis* in Central Java waters ranged between 20 and 62 mm for males and between 14 and 68 mm for females, and averaged 17 to 47 mm in West Java waters (Tirtadanu& Panggabean 2018; Yusuf 2017; Suman et al 1988). Differences in shrimp size at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al 2017; Wilson et al 2010; Matthews 1982; Ogbonna 2001). Given the larger shrimp size in Seneboy waters, it is supposed that the species is not over-utilized.

The sex ratio of male and female shrimp in the study area was not balanced: the females dominated the catch. The unbalanced sex ratio is similar to the *F. indicus* caught in Meulaboh waters (Yusuf 2017; Saputra 2008; Saputra et al 2013; Wedjadmiko & Yulianti 2003; Wedjatmiko 2009; Suman et al 1991), suggesting that the fishing pressure of shrimp resources in Seneboy waters has not disturbed the population renewal so that the sustainability of shrimp stocks is still well maintained.

The peak indicated that a higher frequency of mature gonads in *F. indicus* occured in February and October, suggesting the spawning seasons for the shrimp (Martosubroto 1978). For comparson, the spawning peaks occurred in November for several types of Penaied shrimp from the waters of West Kalimantan (including *P. merguiensis*), in January and August for the *Metapenaeus monoceros* from the Southern Java waters and from September to October for the *M. monoceros* from the Gulf of Carpentaria, Australia (Kembaren & Suman 2013; Suman et al 2005; Crocos et al 2000; Pillai & Thirumilu 2013; Gerami et al 2013). The spawning season for *F. indicus* in the study area lasted throughout the year, with peaks in February and October. Therefore, from the perspective of the

resources sustainability, it is preferable to suspend the *F. indicus* fishing activities in Seneboy waters during February and October.

The first catch average size (Lc) of *F. indicus* in the study area was of 31.1 mm CL and the mean value at the first gonad maturity was 35 mm CL. The results of research conducted in the waters of the Cilacap Segara Anakan Lagoon, using floating nets, showed an Lc value of 20.2 mm, for a total length of about 90 mm (Saputra 2008). Chan (1998) stated that *F. indicus* females can reach a total length of 230 mm, although they generally measure less than 170 mm. These results are different from the research conducted in the waters of North Central Java, where the carapace length of *P. merguensis* was of 29.4 mm (Tirtadanu & Ernawati 2016), the carapace length in the Mayangan waters was 28.9 mm (Wedjatmiko & Yulianti 2003) and the Lc in the Dolak waters, Arafura Sea was 28.78 mm (Hargiyatno & Sumiono 2012). The differences of Lc values are not only caused by the mesh size of the net used, but they are also due to the operations duration and to the location of the fishing ground. The differences of Lc values are not only caused by the mesh size of the net used, but they are also due to the operations duration and to the location of the fishing ground. According to Susetiono & Setyono (1990), the *P. merguensis* from shallow waters tends to be smaller than in deeper waters (e.g. Cilacap), with an average size (Lc) of 51 mm CL (Saputra et al 2013). The shrimp size differences at several locations can be caused by different gears, environmental conditions and fishing pressure (Olin et al 2017; Wilson et al 2010).

According to FAO (2008), the Lm value is 50% of *F. indicus*, at a total length of 130-149 mm. This shows that the value of L50% <Lm50% means that *F. indicus* recruitment is threatened by overfishing. According to Teikwa & Mgaya's (2003) research, the *F. indicus* carapace length size of the first caught males is of 34 mm and 39 mm carapace in female shrimps. The results of a study conducted by Melmammblessy (2011) indicated that in the Arafura waters, the average size of the first catch (Lc) had a carapace length of 60.26 mm. The average size of the *F. indicus* caught for the first time (Lc) in the study area was smaller than the average size at the first maturity of gonads (Lm), indicating that most of the shrimp caught had not spawned. In the long term, this situation is detrimental to the population's sustainability, hampering the shrimp's recruitment process in the Seneboy waters. In this regard, it is necessary to adjust the size of the mesh in such a manner that the smallest carapace length of the caught *F. indicus* cannot be under 13.2 mm CL.

The growth rate (K) of *F. indicus* in the research area shows that they have a fast growth rate: 1.1 per year in females and 1.0 per year in males, with an asymptotic carapace length (L∞) of 54.6 mm CL for females and 52, 6 mm CL for males. The growth parameters in different locations were: L∞=35.7 mm and K=1.26 $year^{-1}$ in the waters of the Segara Anakan Lagoon Cilacap, 1.4 $year^{-1}$ and L∞ 44.3 mm in the Kota Baru waters and 44.7 mm CL for males and 51.25 mm CL for females in the Kaimana waters (Table 2).

The mortality rate (Z) of *F. indicus* in the Seneboy waters is relatively low, namely 3.16 in males and 2.6 in females. Some Penaeid shrimp in other waters, namely the waters of the Cilacap Segara Anakan Lagoon, obtained an M value of 2.6 cm $year^{-1}$, an F value of 1.35 cm $year^{-1}$ (*P. meruiensis* in Segara Anakan Lagoon Cilacap is 1.43 $year^{-1}$, the natural mortality rate is 1.85 cm $year^{-1}$ and catching 2.32 cm $year^{-1}$, Madura waters natural mortality rate of 2.17-2.22 cm $year^{-1}$ and catching 1.11-1.56 cm $year^{-1}$ (Saputra 2008; Kembaren et al 2012; Setyohadi et al 1999; Hedianto et al 2016).

The highest mortality rates (ind $year^{-1}$) were recorded: 9 for males and 9.47 for females in the waters of Kota Baru, 10.58 in the Kakinada waters, 7.01 in the Khoozestan waters and 5.78 in the Vietnamese waters (Tirtadanu et al 2017; Devi 1987; Ansari et al 2014; Dinh et al 2010). The natural mortality is influenced by several factors such as food availability, disease, environment, competition and the presence of predatory species (Sparre & Venema 1992; Niamaimandi et al 2007). Penaeid prawn is the prey of several demersal fish, such as *Lutjanus gibbus*, *Eleutheronema tetradactylum* and *Arius* sp. (Bachok et al 2004; Titrawani et al 2013). Death due to fishing (F) of both male and female *F.*

indicus is lower than the natural mortality rate (M), indicating that the *F. indicus* population has not been exploited intensively by fishermen in the waters of Seneboy, West Papua. Garcia (1988) suggests that the average natural mortality rate (M) of penaeid shrimp is 2.4±0.3 year^{-1} for adult shrimp. Naamin (1984) found that the F value of *P. merguensis* in Arafura waters varies according to the development of the fishing effort, ranging from 0.55 year^{-1} (at the start of the exploitation) to 8.99 year^{-1}.

Table 2

Asymptotic length (L∞), growth rate (K) and exploitation rate (E) of *Fenneropenaeus indicus* in some areas

Location	*Sexes*	$L_{\infty\ (mm\ CL)}$	*K*	*t0*	*Authors*
Cilacap, Central Jawa	Combined	35.7	1.26	-	Saputra (2008)
Kota Baru, South Kalimantan	Combined	44.3	1.4	-	Suman et al (2010)
Kaimana, West Papua	Combined	44.7	1.38	-	Tirtadanu & Pangabean 2018)
Cilacap, Central Java	Male	40.7	1	0.56	Suman & Prisantoso (2017)
	Female	54.2	1.1	0.36	
Tarakan, North Kalimantan	Male	45.2	1.55	0.76	Chodrijah & Suman (2017)
	Female	57.6	1.33	0.76	
Sampit, Central Kalimantan	Combined	57.8	1.45	0.66	Nurdin & Kembaren (2015)
Tanal Laut, South Kalimantan	Combined	55	1.05	0.74	Suman et al (2017)
Cenderawasih Bay, Papua	Male	44.5	1.05	0.66	Kembaren & Ernawati (2015)
	Female	48.7	1.15	0.55	
Kaimana, West Papua	Male	44.7	1.4	0.49	Tirtadanu & Panggabean (2018)
	Female	51.25	1.37	0.44	
Seneboy, West Papua	Male	54.6	1.1	0.148	Present research
	Female	52.6	1.0	0.136	

In this study, the exploitation rates (E) of female and male *F. indicus* were 0.48 and 0.46. This condition explains that the fishing rate is greater than the natural mortality rate. The optimum exploitation rate stated by Gulland (1983) is 0.5, so that the rate of exploitation of *F. indicus* in Seneboy waters is close to the optimum value and is still sustainable. The level of exploitation of *F. indicus* in several areas has exceeded the optimum limit, namely in the waters of the Segara Anakan Cilacap Lagoon, Meulaboh waters, Tarakan Bay, Tanah Laut and Cenderawasih, where the level of exploitation indicates overfishing (Saputra 2008; Yusuf et al 2017; Chodrijah & Suman 2017; Suman et al 2017; Kembaren & Ernawati 2015). The exploitation of *F. indicus* has approached the maximum, suggesting that a reduction of the fishing pressure is required, with at least 5% of the current total effort.

Conclusions. The average size of *F. indicus* caught in the waters of Seneboy South Sorong is 16-49.6 mm CL for the males and 13.2-52.8 mm CL for the females. The sex ratio of *F. indicus* is unbalanced: 1:1.8, male against female. The spawning season lasts throughout the year with peaks in February and October. The catch is dominated by adults so that management sets the regulations for the minimum legal size. These results concluded that the arrest of *F. indicus* can be continued by arranging the arrest effort and stipulating a minimum legal size of 35 mm CL. This indicates that the level of exploitation of *F. indicus* in Seneboy waters is not yet optimal, but leads to overfishing. In order to maintain the sustainability of the *F. indicus* resources in the waters of Seneboy, West Papua, it is advisable (1) to reduce efforts with about 5% from the current level, by adjusting the mesh in such a manner that the retained catch size of *F. indicus* will be of at least 13.2 mm CL and (2) to suspend the *F. indicus* fishing operations in February and October.

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Bay 2017" which was organized by the Muara Baru Jakarta Marine Fisheries Research Institute.

Conflict of interest. The authors declare no conflict of interest.

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STATEMENT LETTER

Hereby we declare our article with the title:

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It has gone through several editing processes and we agreed to publish it. Thank you.

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