

Population Dynamics And Spawning Potential Ratio Of Banana Prawn (*Penaeus Merguensis*) In Merauke Waters, Papua, Indonesia

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ABSTRACT

The high market demand for banana prawn (*P. merguensis*) has caused intensive fishing for this resources and tended to threaten their sustainability. Studies of population dynamics and spawning potential ratio are the main foundations for formulating a management for sustainable utilization. The purpose of this study was to determine the population dynamic and spawning potential ratio of banana prawn in Merauke waters, Papua. The study was conducted from 2017 to 2019 using a survey method. The study results revealed that the banana growth pattern was negative allometric and that the ratio of males and females was imbalanced. The spawning season of banana prawn in Merauke waters occurs throughout the year with one peak in August. Based on carapace length measurement, length at first capture (L_c) and length at first maturity (L_m) were 33.5 mm and 32.7 mm respectively. While growth rate (K) and maximum carapace length (L_∞) valued 1.25 per year and 64.85 mm respectively. The estimate total mortality rate (Z) was 3.20 per year, the fishing mortality rate (F) and natural mortality rate (M) were 1.7 per year and 1.49 per year,

respectively. The exploitation rate (E) was 0.53 per year and the spawning potential ratio (SPR) was 15 %. Therefore the stock status was categorized as overfishing. In order to ensure the sustainability of the banana prawn, precautionary approach such as reducing fishing effort by 6 % of the current situation is strongly needed to be applied.

Keywords : Banana prawn, population dynamic, spawning potential ratio, Merauke waters, Papua, Fisheries Management Area (FMA) 718

INTRODUCTION

Banana prawn (*P. merguensis* de Man) is one of penaeid shrimps which is dominantly caught in Merauke waters. These waters are areas that are included in the fisheries management area (FMA 718) which includes the Arafura Sea. Fishermen use bottom gillnet to catch the banana prawn. The production of banana prawn is the first highest after others shrimps such as endeavour shrimp (*Metapenaeus* spp) and others shrimp (*Parapenaeopsis* spp.) (Research Institute for Marine Fisheries/RIMF, 2020).

Exploitation of the banana prawn in Merauke waters has taken place since long time ago (Naamin et al., 1992) and become more intensive in the recent years due to the increasing of local and or foreign market demands. Disruption of banana prawn sustainability in Merauke waters has been indicated by a decrease of stock abundance index (RIMF, 2020).

If this situation continues to occur, sustainability of the shrimp stock will be disturbed in the future. Therefore, comprehensive research (include population dynamic and spawning potential ratio) is needed to reach rational utilization in order to maintain sustainability of the stock for prosperity purpose in the future (Sparre & Venema, 1992).

MATERIAL AND METHOD

This research was carried on in Merauke waters, Papua (Figure 1) from 2017 to 2019 using survey methods. Monthly data collection was done by placing several enumerators in research areas. Banana prawn sample measurements were more than 5,546 samples was conducted in the main places of catches landed of fishermen activity around Merauke areas. The biological aspects observed were carapace length, weight, sex, and gonad maturity.

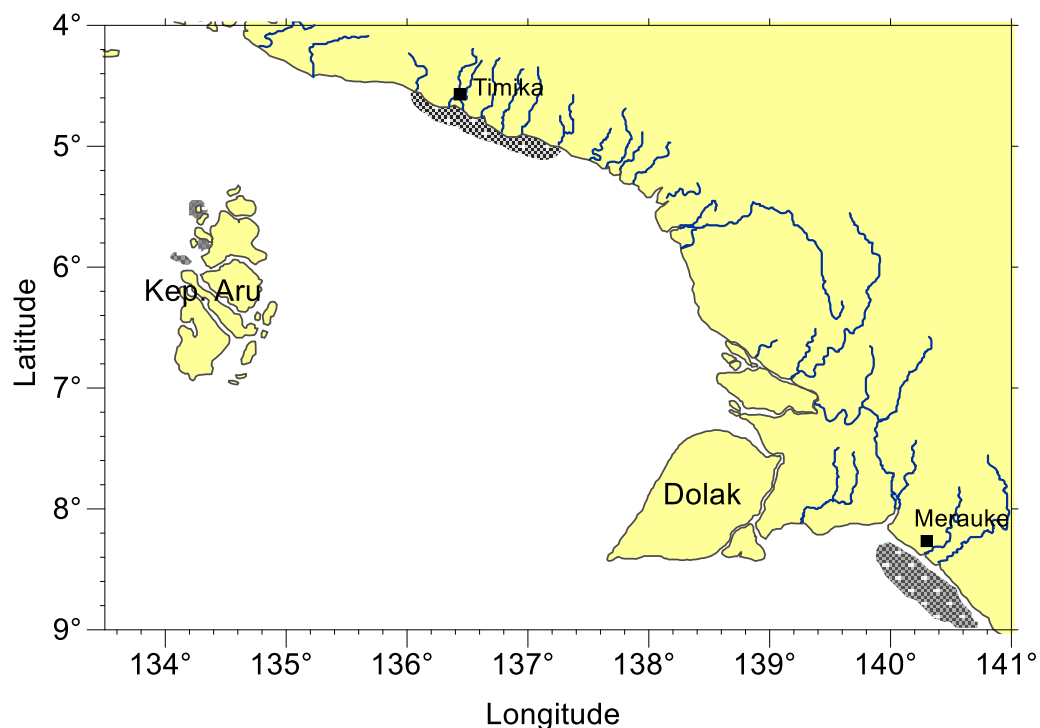


Figure 1. Fishing ground of banana prawn (*P. merguensis*) in Merauke waters, Papua.

In this classification gonad maturity (stage) I and II are classified as immature while stage III, IV and V are mature. The morphologically identified sex maturity stages of shrimp are as follows I : quiescent or undeveloped; II : developing; III : early maturity; IV : ripe; and V : spent (Tuma, 1967 in Naamin, 1984).

Relation of carapace length and weights bodies follow to the equation of $W = a L^b$ (Ball & Rao, 1984), where W is the fish body weight (gram), L is a carapace length of banana prawn (mm), a is a constant value and b is the exponential value. The sex ratio was calculated by comparing the number of male and female and analyzed to know whether the sex ratio is balance or not by using the Chi-square test (Walpole, 1993).

The length at first capture (L_c) is obtained by logistical function's approach with the equation of Sparre & Venema (1992):

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

In which: S_{CL} is selectivity fishing gear, a and b are in constant, CL is fish length and value of L_c obtained from a / b .

While the length at first maturity (L_m) was calculated by entering the carapace width value and P_{Lm} to the logistic function graph (King, 1995), using the following equation:

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

Growth parameter was predicted using von Bertalanffy growth model Sparre & Venema (1992):

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

Where: L_t is carapace length of banana prawn at age t year, L_{∞} is a theoretical of maximum carapace length, K is the growth rate, and t_0 is a theoretical age when zero length of fish. The theoretical of maximum carapace length (L_{∞}) and growth rate (K) were analyzed by using ELEFAN I and FISAT II methods (Gayanilo et al., 2005). While the value of t_0 was predicted based on equation introduced by Pauly (1983):

$$\log(-t_0) = (-0.3922) - 0.2752 \log CL_{\infty} - 1.038 \log K$$

Value of natural mortality (M) was calculated using Pauly equation based on average sea water temperature (Pauly et al., 1984):

$$\log M = (-0.0066) - 0.279 \log CL_{\infty} + 0.6543 \log K + 0.4634 \log T$$

While value of total mortality (Z) was counted based on length converted catch curve assessment on FISAT II program (Pauly, 1983; Gayanilo et al., 2005).

In addition, fishing mortality (F) and exploitation rate (E) was assessed an equation introduced by Sparre & Venema (1992):

$$F = Z - M; \text{ and } E = F/Z$$

Last but not least, value of spawning potential ratio (SPR) was estimated using shrimp carapace length data based (Hordyk et al., 2014). Data input used in SPR analysis was the ratio of M/K , asymptotic carapace length (L_{∞}), the proportion of 50% and 95% mature fish (L_{50} , and L_{95}), and fish length. Finally, estimation of spawning potential ratio (SPR) was based on comparison of mature potential between fished ($SSBR_{\text{fished}}$) and unfished ($SSBR_{\text{unfished}}$) according to equation introduced by Goodyear (1993) :

$$SPR = \frac{SSBR_{\text{fished}}}{SSBR_{\text{unfished}}}$$

RESULT AND DISCUSSION

Result

1. Population dynamics

Length weight relationship analysis illustrated that the banana prawn had allometric negative with $b = 1.48$ to 2.51 (Table 1). It meant that the increase of shrimp carapace length was faster than that of shrimp weight.

Table 1. The legth-weight relationship of banana prawn (*P. merguensis*) in Merauke waters.

Year	a	b	r ²	Growth pattern
2017	0.011	2.19	0,93	allometric negative
2018	0.004	2.51	0.91	allometric negative
2019	0.020	2.09	0.80	allometric negative

Another analysis about sex ratio indicated that comparison between male and female is seen to be dominated by male shrimp except in 2017 which was dominated by female shrimp (Table 2). Based on chi-square analysis, it was discovered that the sex ratio was unbalance.

Table 2. Sex ratio of male and female of banana prawn (*P. merguensis*) in Merauke waters, Papua.

Year	Sex Ratio Male : Female
2017	1,0 : 1,1
2018	1,0 : 0,8
2019	1,0 : 0,2

The distribution frequency of female banana prawn in two maturity stages from 2017 to 2019 can be seen in Table 3. Table 3 shows that the highest number of mature female shrimp occurred in August. It shows that peaks of spawning seasons of banana prawn in Merauke waters took place three times, in June, August (east-monsoon) and October (west-monsoon).

Table. 1 Frequency distribution of gonad maturity of female banana prawn (*P. merguensis* de Man) in Merauke waters, Papua.

Month	Maturity Stage (%)		
	2017	2018	2019

	IM	M	IM	M	IM	M
February	-	-	-	-	84	16
March	60	40	34	66	35	65
April	63	37	47	53	37	63
May	57	43	74	26	44	56
June	59	41	49	51	27	73
July	60	40	62	38	71	29
August	-	-	28	72	80	20
September	89	11	41	59	75	25
October	57	43	58	42	89	11
November	64	36	34	66	63	37
December	62	38	33	67	-	-

Legend : IM : immature; M : mature

The length at first capture (Lc) of banana prawn in Merauke waters was about 33.5-34.6 mm (carapace length) and the length at first maturity (Lm) was about 32.7-42.4 mm (carapace length) (Table 3).

Table 3. Length at first capture (Lc) and length at first maturity (Lm) of banana prawn (*P. merguensis*) in Merauke waters, Papua.

Year	Lc (mm)	Lm (mm)
2017	34.6	42.4
2018	33.5	32.7
2019	34.1	34.3

In Table 3 it can be seen that the value of Lc was smaller than that of Lm. This condition indicated that most of the banana prawn have been caught not in their best time to spawn.

Based on length frequency data, it was obtained that the growth rate (K) the banana prawn was 1.1-1.3 per year and carapace length infinity (L_{∞}) reached about 59.4-64.9 mm (Table 4 and Figure 1).

Table 4. Growth rate (K) and carapace length infinity (Loo) of banana prawn (*P. merguensis*) in Merauke waters, Papua.

Year	K	Loo (mm)
2017	1.3	59.4
2018	1.3	64.9
2019	1.1	63.9

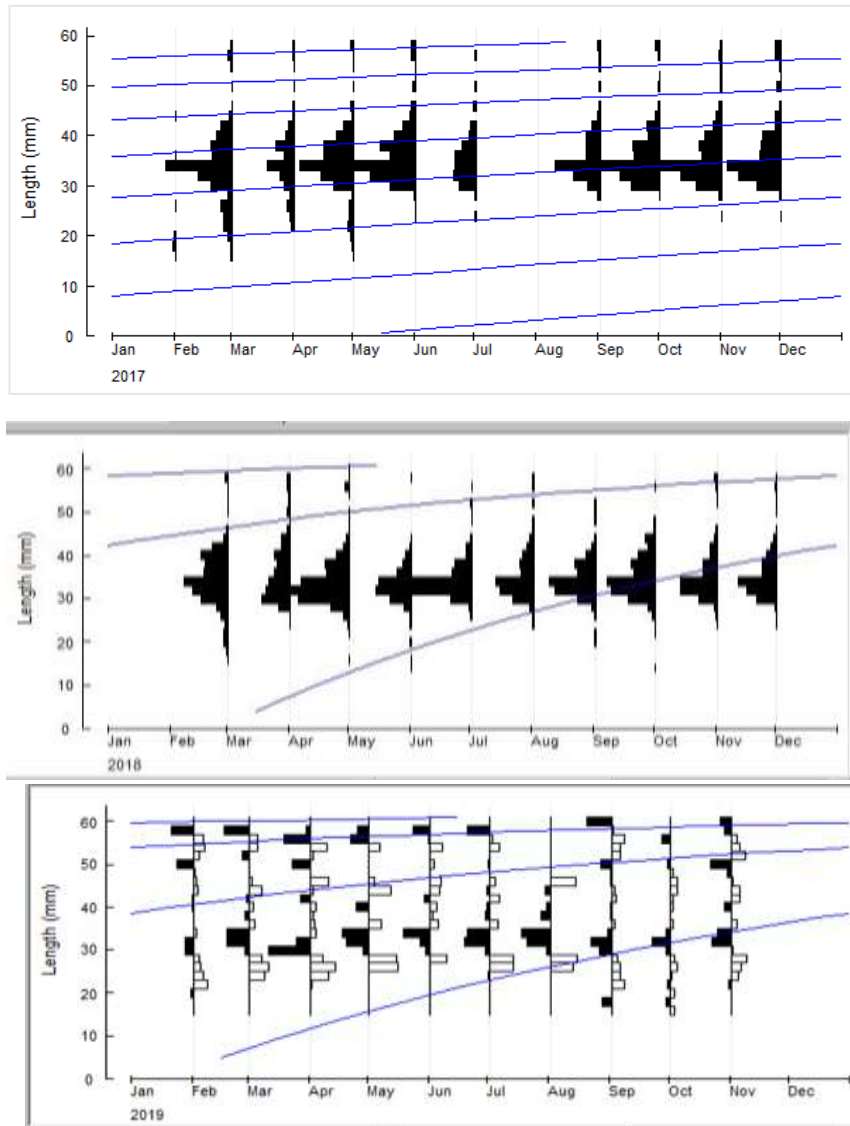


Figure 1. von Bertalanffy growth curve of banana prawn (*P. merguensis*) in Mearuke waters, Papua.

By using the banana prawn growth parameters calculation, catch curve can be performed. It was obtained that estimated values of Z , M , and F (Table 5). Another estimation can be illustrated based on value of fishing mortality rate (F) and total mortality rate (Z), the value of exploitation rate (E) was estimated to be about 0.53-0.62 per year (Table 5). This condition showed that exploitation rate of the banana prawn in Mearuke waters reached overfishing level.

Table 5. Total mortality rate (Z), natural mortality rate (M), fishing mortality rate (F) and exploitation rate (E) of banana prawn (*P. merguensis*) in Mearuke waters, Papua.

Year	Z	M	F	E
2017	3.99	1.75	2.25	0.56
2018	3.20	1.49	1.70	0.53
2019	4.20	1.56	2.64	0.62

2. Spawning Potential Ratio (SPR)

Spawning potential ratio (SPR) method analysis was based on biological and growth parameters data. They were length at first mature (Lm), von Bertalanffy growth equation, length weight relationship, and early cohort. It was found that the SPR of banana prawn was 15 % (<20%) (Table 6 and Figure 2). This value was obtained from extrapolation between carapace length and SPR below and above the Lm value. This result indicated that the status of banana prawn stock has been overfishing.

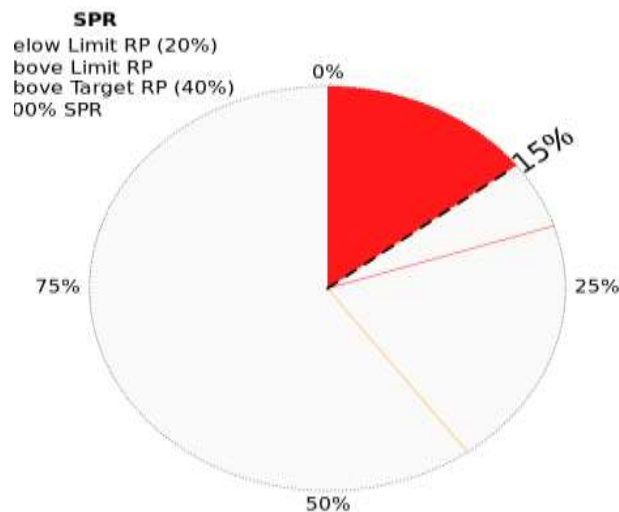


Figure 2. Spawning Potential Ratio (SPR) curve of banana prawn (*P. merguensis*) in Merauke waters, Papua.

Discussion.

Length weight relationship analysis is used to determine the growth pattern of banana prawn in Merauke waters. The results of the t test has been found that the growth pattern of banana prawn is a negative allometric. The pattern of banana prawn's growth shows that the growth of carapace length is faster than the growth of weight. This result is the same as that obtained in the waters of Demak (Wedjatmiko & Yulianti, 2003), Arafura waters (Hargiyatno et al., 2013), North of Central Java waters (Tirtadanu & Ernawati, 2016), Kotabaru waters (Tirtadanu et al., 2017) and Segara Anakan

waters (Wagiyo et al., 2018) The existence of these similarities or differences is because individual growth models depend on food availability and water temperature (Monterio, 2002 in Fauzi et al., 2013). Differences in long growth can also occur due to differences in external factors and internal factors. According to Effendie (2002), internal factors are factors that are generally difficult to control such as heredity, gender, age, and disease. Meanwhile, the main external factors affecting fish growth are temperature and food.

The sex ratio of banana prawn in Merauke waters shows an unbalanced condition, where male of banana prawn is more dominant. The differences phenomenon was also found in Demak waters (Wedjatmiko & Yulianti, 2003), Arafura waters (Hargiyatno et al., 2013), north of Central Java waters (Tirtadanu & Ernawati, 2016), Kotabaru waters (Tirtadanu et al., 2017) and Segara Anakan waters (Wagiyo et al., 2018). According to Ball & Rao (1984), in normal waters the sex ratio is 1.0: 1.0 and differences occur because behaviour is clustered between males and females. The causes of differences in sex ratios can also occur due to influenced by arrest pressure and migration factors (Suman, 2004; Edrus & Syam, 2004).

Spawning season of shrimp in a certain waters can be studied by identifying distribution of egg density or shrimp maturity in the waters (Martosubroto, 1978). The spawning season of banana prawn in Merauke waters occurs throughout the year with one peak in August. In Tanjung Krawang waters, peak of spawning season of banana prawn occurred in March and December (Martosubroto, 1978) while in north coast of West Java waters, peak of spawning season occurred happened in March and April (Suman et al., 1991) and the peak of spawning season in Cilacap waters occurred in January and February (Khamdan, 2015). The existence of these differences is because conditions of environmental and recruitment pattern (Naamin, 1984).

The length at first maturity of banana prawn is important in fisheries management. It meant that exploitation must allow a certain number of adult banana prawn which have the same size or more than the size when reaching maturity to be escaped (Sudjastani, 1974). The length at first maturity (Lm) for banana prawn at Merauke waters is 32.7 mm and looks different than those reported for banana prawn in some area in Indonesian waters (Table 2).

Table 2. The length at first maturity (Lm) of banana prawn (*P. merguensis* de Man) in some area in Indonesian waters.

Waters	Lm (CL-mm)	Source
Bintuni Bay	33.87	Sumiono (1983)
Kupang and Belu	41.80	Suman & Nugroho (1991)
Demak	39.77	Suman & Subani (1994)
Dolak	38.7	Hargiyatno et al. (2013)
Tarakan	33.8	Kembaren & Suman (2013)
Arafura	38,7	Hargiyatno et al. (2013)
Cenderawasih Bay	39,4	Kembaren & Ernawati (2015)
Sampit	38,7	Nurdin & Kembaren (2015)
North of Central Java	42.85	Tirtadanu & Ernawati (2016)
Cilacap	38,3	Suman & Priosantoso (2017)
Tarakan	33,58	Chodriyah & Suman (2017)
Kotabaru	35,3	Tirtadanu et al. (2017)
Segara Anakan	17,15	Wagiyo et al. (2018)

Nikolsky (1963) stated that Lm value is influenced by some factors, such as: depth and type of habitat in association with food availability, temperature, and light. According to Sivakami et al. (2001), the difference in Lm value for each fish is caused by the difference size of samples collected, the maximum and minimum length, and frequency of fish that are gonad-mature.

Meanwhile the length at first capture (Lc) of banana prawn in Merauke waters is 33,5 mm and this Lc values as bigger than the Lm values. This condition is expectable in term of fisheries management because the individuals of banana prawn changes to spawn to maintain its population. In order to ensure the sustainability of the resources, the fishing pattern should allow a number of banana prawn adult stock to escape (Sudjastani, 1974).

According to Sparre & Venema (1992), the lower the growth coefficient (K), the longer the species takes to approach the asymptotic length. Conversely, the higher the growth coefficient, the faster the time needed for the species to approach the

asymptotic length. The value of growth rate (K) of banana prawn in Merauke waters is 1.25 per year and L_{∞} is 64.85 mm and this indicates that the growth rate is relatively fast. This phenomenon is different when compared to the results of research in the some area in Indonesia waters (Table 3). Differences in growth parameters can be caused by differences in the maximum length of samples taken and differences in location of waters (Widodo & Suadi, 2006). Knaepkens et al. (2002) and Effendie (2002) state that differences in the values of K and L_{∞} are caused by internal / intrinsic factors and external factors. These influential internal factors include offspring, parasites and diseases, while external factors include food temperature and availability.

Table 3. The growth rate (K) and maximum carapace length (L_{∞}) of banana prawn (*P. merguensis* de Man) in some area in Indonesian waters

Waters	K (per year)	L_{∞} (mm)	Source
Arafura	1,62	50,2	Naamin, 1984
Kotabaru	1,4	44,3	Suman & Umar, (2010)
Sampit	1,45	57,8	Nurdin & Kembaren (2015)
Cenderawasih Bay	1,05	48,7	Kembaren & Ernawati (2015)
Cilacap	1,10	54,2	Suman & Priasantoso (2017)
Tarakan	1,33	57,6	Chodrijah & Suman (2017)
Tanah Laut	1,05	55,0	Suman et al. (2017)
Segara Anakan	1,47	44,6	Wagiyo et al. (2018)

The total mortality rate (Z) is a combination of the natural mortality rate (M) and the rate of death due to arrest (F) (Sparre & Venema, 1992). The M value of banana prawn in Merauke waters looks smaller than the F value, and this shows that most of the banana prawn in Merauke waters died due to capture. Furthermore, by using the F value which is an illustration of capture pressure and Z value which is a picture of total mortality, the banana prawn utilization rate (E) is 0.53 per year. When compared with the criteria from Pauly et al. (1984) which states that the optimal rate of exploitation is 0.5, then the level of utilization of banana prawn in Merauke waters has exceeded the optimal rate. This shows that the utilization rate of banana prawn has reached 106 %, which

means that it is already overfishing. In order to maintain the banana prawn in Merauke waters, the reduction of fishing efforts must be carried out by around 6 % of the current efforts.

The spawning potential ratio (SPR) is the relative reproductive index used to determine the status of shrimp stocks that have been cultivated (Mace & Sissenwine, 1993 in Prince et al., 2015; Walters & Martell, 2004; Prince et al., 2015). SPR is also known as a measure of the level of reproductive capacity of a resource that has declined from its original condition or the condition has not been exploited (Smallwood et al., 2013). The analysis of the SPR of banana prawn in Merauke waters is 15 % and this indicates the stock status of the banana prawn is at the stage of overfishing. This is in accordance with fisheries stock status criteria based on SPR, which are classified into 3 groups, namely under exploited ($SPR > 40\%$), moderate ($20 < SPR < 40\%$), and over exploited / overfishing ($SPR < 20\%$) (Walters & Martell, 2004; Prince et al., 2015).

CONCLUSION AND RECOMMENDATION

Conclusion

The growth pattern of banana prawn (*P. merguensis* de Man) in Merauke waters is negative allometric and this shows that the growth of carapace length is faster than its weight growth. Their sex ratio between male and female was not balance and the spawning season occurs throughout the year with one peak in August. The length at first capture (L_c) is bigger than the length at first maturity (L_m) and in the long run will guarantee the recovery of stock. The growth rate and mortality rate of banana prawn are high, so care must be taken in the management options. The rate of exploitation (E) of banana prawn is 0.53 per year and SPR is 15 %, thus the status of banana prawn stocks in Merauke waters is already at the stage of overfishing.

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Conflict of Interest. The authors declare that there is no conflict of interest.

Recommendation

To ensure the sustainability of banana prawn resources in the Merauke waters, the catch must be reduced by around 6 % of the current catch. To support the proper and sustainable management of the banana prawn stock, comprehensive research in biology, economic, and social aspects would be necessary to do in the future.

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