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Study on the Biology of the Tiger Prawn (*Penaeus monodon*) Post-Moratorium in the Arafura Sea, Indonesia

Mustasim[1,3], Tri Djoko Lelono[2*], Daduk Setyohadi[2], Edi Susilo[2]

[1]Doctoral Program, Faculty of Fisheries and Marine Sciences, Brawijaya University, Malang 65145, East Java, Indonesia

[2]Faculty of Fisheries and Marine Sciences, Brawijaya University, Malang 65145, East Java, Indonesia

[3]Marine and Fisheries Polytechnic, Sorong 98414, South West Papua, Indonesia

***Corresponding Author: t.djoko@ub.ac.id**

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ABSTRACT

Utilizing measured fisheries is an effective method for ensuring the long-term viability of the tiger prawn (*Penaeus monodon*) populations in the Arafura Sea, particularly following the post-moratorium from 2015 to 2021. Biological factors are a type of information that is considered in the process of making decisions. The objective of this study was to ascertain the pattern of the length-weight relationship, condition factor, sex ratio, gonad maturity stage, first length caught (L50), and first length maturity. The investigation was done in the Arafura Sea from February 2023 to January 2024. The acquired data were examined utilizing Excel software. The findings indicated that the captured tiger prawn (*P. monodon*) varied in size, ranging from 30,2 to 99,8 mmCL. The average length was 62,03 ± 11,70 mmCL, with a mode of 60 mmCL for carapace length. The growth exhibited a negative allometry. The condition factor (K) varied between 0,139 and 3,293, with an average of 1,172 ± 0,611. The sex ratio under balanced conditions was 1,01 males : 1 female. The majority of the catch consists of prawn with fully developed gonads (phase III, IV, and V). The mean length of the tiger prawn captured (Lc) was 61,98 ± 7,87 mmCL, which was larger than the mean length of mature gonads (Lm) at 60,03 ± 7,75 mmCL. The current state of the tiger prawn fishing after the ban is highly favorable and requires careful maintenance and regulated management, including controlling the amount of fishing gear, determining the fishing season, and managing the fishing area, in order to ensure its sustainability.

INTRODUCTION

Penaeus monodon, often known as Windu prawn, is a very valuable crustacean commodity in Indonesia. It serves as a significant source of foreign exchange for the country, as supported by several studies such as those of **Nasution *et al.* (2016)**, **Suman *et al.* (2018)**, **Machmudi (2020)**, **Khademzadeh and Haghi (2021)** and **Aguirre-Pabón *et al.* (2023)**. The species is indigenous to the Indo-Pacific region and is frequently observed in the Arafura Sea of Indonesia **(Russell & Houston, 1989; Purwanto 2017; Tirtadanu *et al.*, 2022)**. Over the past few decades, double rig trawls have been extensively and consistently employed to exploit the tiger prawn. Studies by **Sumiono (2011)**, **Purwanto (2017)**, **Umamah *et al.***

(2017), **Wijopriono *et al*. (2019)** and **Sari *et al*. (2021)** have shown that the tiger prawn in the Arafura Sea are being overfished.

In 2014 – 2015, the Indonesian government, namely the Ministry of Maritime Affairs & Fisheries, implemented a strict policy to enforce a moratorium on prawn fishing using double rig trawls in the Arafura Sea. This decision was supported by many studies conducted by **Arisandi (2016)**, **Adhawati *et al*. (2017)**, **Siar *et al*. (2017)** and **Ulath *et al*. (2018)**. **Siar *et al*. (2017)** and **Sari (2018)** found that the moratorium policy has successfully preserved fisheries resources. However, it did not lead to any increase in people's income. This is in contrast to the findings of **Hikmayani and Rahadian (2015)**, **Nurlaili *et al*. (2016)** and **Sururi *et al*. (2017)**, who concluded that the policy effectively improved the performance of small-scale fisheries businesses.

In 2021, double rig trawling was allowed to resume based on Regulation No. 18/PERMEN/2021, which was amended by Regulation No. 36/PERMEN/2023. In order to ensure the long-term viability of the tiger prawn resources, it is imperative for the government and stakeholders to prioritize the preservation of their habitat and survival. For effective management, a well-organized and quantifiable governance system is necessary due to the rapid and brief growth cycle of this particular prawn species **(Sumiono, 2012; Günther & Beratan, 2013; Saputra *et al*., 2013; Suman *et al*., 2020)**. In anticipation of the recurrence of overfishing, the president of the Republic of Indonesia has implemented a new program called quota-based measured fishing. The program was initiated under the auspices of Government Regulation Number 11 of 2023 **(Luthfia, 2023)**. The program requires precise data and information on the tiger prawn species, particularly about biological parameters, as the biological dynamics of prawn undergo rapid changes **(Sulaiman *et al*., 2005; Guo *et al*., 2014; Nie *et al*., 2014)**. Several studies documented the biology of the tiger prawn before the implementation of the double rig trawl ban. These studies include those conducted by **Purwanto (2010)**, **Gopalakrishnan *et al*. (2014)**, **Kumari *et al*. (2015)**, **Li *et al*. (2016)**, **Komi and Francis (2017)**, **Mane *et al*. (2019)**, **Solanki *et al*. (2020)**, **Tirtadanu and Chodirjah (2020)** and **Oketoki *et al*. (2024)**.

To effectively and sustainably manage the tiger prawn resources, it is essential to gather information on biological aspects. Hence, the objective of this study was to ascertain the pattern of the length-weight relationship, condition factor, sex ratio, gonad maturity stage, first length caught (L50), and first length maturity the post-moratorium. The study's findings can be used by regional and national stakeholders to inform decisions regarding the future management of tiger prawn fisheries. This includes policies on fishing seasons, such as when to open and when to close them, as well as restrictions on the use of fishing gear.

MATERIALS AND METHODS

This research was conducted from February 2023 to January 2024 in the Arafura Sea, by accompanying a prawn vessel on 6 fishing trips lasting a maximum of 55 days each. The tiger prawn (*Penaeus monodon*) specimens were assessed for carapace length using a caliper with a precision of 0,1mm, and weight measurements were obtained using digital scales with a precision of 1g. Female prawn gonad maturity was assessed using ocular sampling. The sample was conducted by direct observation of randomly selected double rig trawl captures onboard.

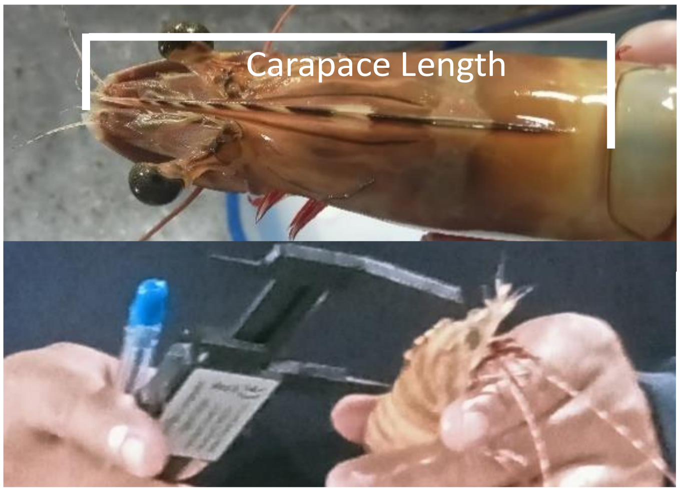

Fig. 1. How to measure the carapace length of a tiger prawn's

The sample size of tiger prawn (*Penaeus monodon*) was 8.004 individuals, comprising 4.023 males and 3.981 females. The data analysis involved examining several parameters such as length frequency, length-weight relationship, condition factor, sex ratio, gonad maturity stage, mean carapace length of gonad mature prawn (Lm), and mean carapace length of caught prawn (Lc) using Microsoft Excel. Length frequency analysis involves the construction of bar graphs that display the length frequency distributions of both males and girls. The measured length of the prawn is referred to as the carapace length. The relationship between prawn length and weight is described by the cubic law, as stated by **Bal and Rao (1990)** and **King (2013)** as follows:

$W = aL^b$ .... (1)

Where, W = weight (grams); L = length of prawn carapace (mm); and a, b = constant regression results.

Based on the constant b and statistically significant differences, the growth pattern was identified as b = 3 for isometric growth (I), b > 3 for positive allometric growth (+), and b less than 3 for negative allometric growth (-) **(Ragheb, 2023)**.

Sex ratio testing was conducted with the Chi Square test **(Steel & Torrie, 1989)**:

$X^2 = \sum_{i-1}^{k} \frac{(oi-ei)^2}{ei}$ .... (2)

Where, Oi = total frequency of male and female prawn; ei = number of expected male and female prawn in the Ith cell; and k = group of observation stations for male and female prawn.

Analysis of prawn condition factors was calculated using the equation of **Effendie (1997)** and **King (2013)** as follows:

$Kt = W/(aL^b)$, ... (3)

Where, Kt = condition factor; W = average prawn weight (gr); and L = average prawn carapace length (mm).

Sex ratio was calculated by comparing the number of male and female tiger prawn. Determination of whether or not the sex ratio of males and females is balanced was done by chi-square test following the method of **Walpole (1993)**.

The analysis of gonad maturity stage was conducted by examining the proportion of mature and immature female prawn in each month. Female prawn gonad maturity can be determined through visual examination of the ovary's color and size, as described by **Motoh (1981)**. The average mature gonad (Lm) was determined by inputting the values of carapace length and PLm into a logistic function graph, as described by **King (2013)**. The equation employed was as follows:

$$P_{Lm} = \frac{1}{1+\exp(aL+b)} \quad \text{.........} \quad (4)$$

The mean carapace length (Lc) of collected prawn was determined using a logistic function technique, as described by **Boutson *et al*. (2009)**, using the equation:

$$S_{LC} = \frac{\exp(a+bL)}{1+\exp(a+bL)} \quad \text{.........} \quad (5)$$

a and b are selectivity curve parameters (a<0 and b>0). The Lc value is obtained from -a/b.

RESULTS

1. Frequency of length and weight

The carapace size of tiger prawn (*Penaeus monodon*) captured by double rig trawl in Arafura sea (>12 nautical miles) varied between 30,2 and 99,8mmCL, with an average length of 62,03±11,70mmCL. The most common carapace length observed was 60 mmCL (Fig. 2).

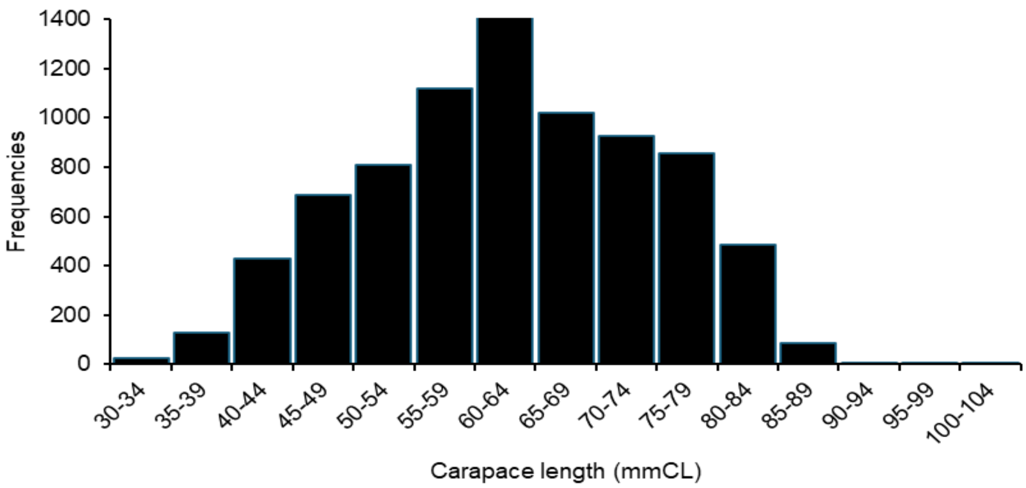

Fig. 2. Carapace length frequencies *Penaeus monodon* in the Arafura Sea

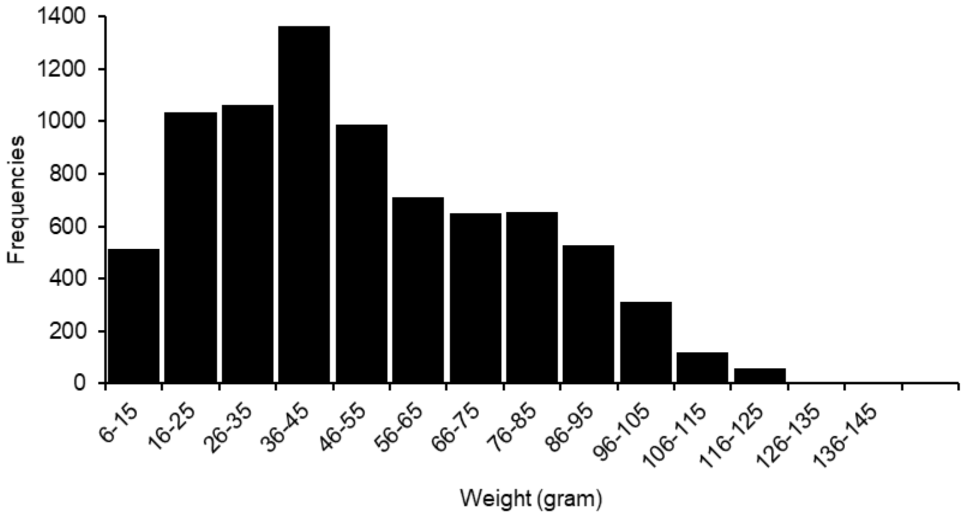

Fig. 3. Weight frequencies *Penaeus monodon* in the Arafura Sea

The captured tiger prawn (*Penaeus monodon*) exhibited a weight range of 6 – 143 grams, with an average weight of 50,77±26,54 grams. The most frequently observed weight was 36 grams, as shown in Fig. (3).

2. Length and weight relationship

Assessing the length-weight relationship is crucial for evaluating the stock of prawn population and its potential for production **(Mohale *et al.*, 2024)**. The length-weight relationship (LWR) is a crucial measure in fisheries biology research as it determines the growth of fish and prawns influenced by genetic and environmental factors **(Aprianti *et al.*, 2024)**. The result of the relationship between the length of the carapace and the weight of tiger prawn (*Penaeus monodon*) revealed that the growth of the tiger prawn may be described

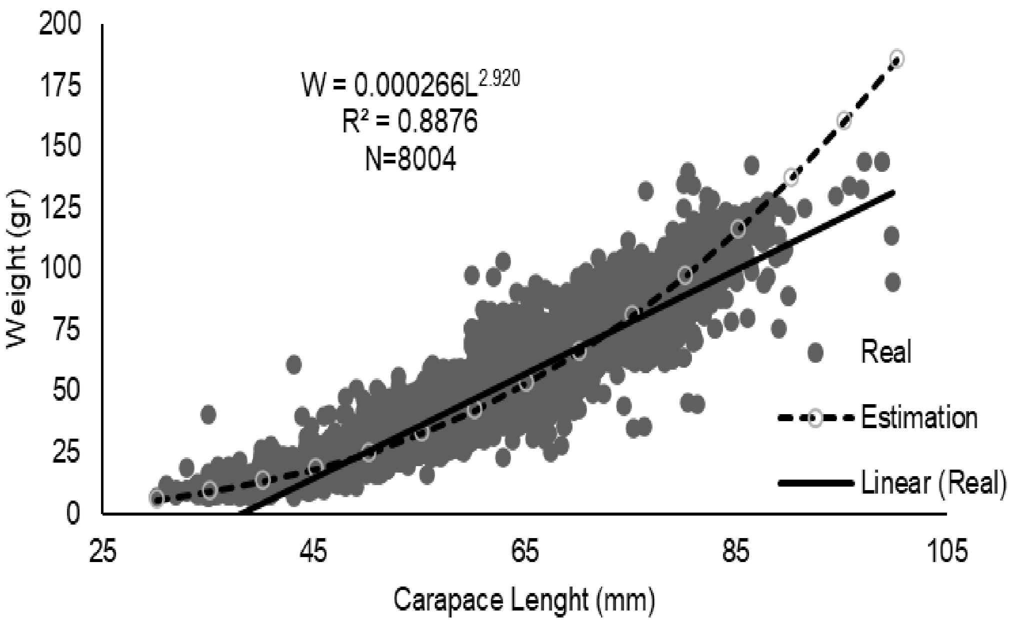

Fig. 4. Length weight relationship of tiger prawn (*P. monodon*) from Arafura Sea

by the equation $W=0{,}000266L^{2{,}920}$ (n=8004, r^2=0,89). The analysis was conducted on a sample size of 8004, and the coefficient of determination (r^2) was found to be 0,89. This information is presented in Fig. (4). The growth pattern of tiger prawn was determined to be negative allometric after conducting a t-test with a 95% confidence level (Q=0,05).

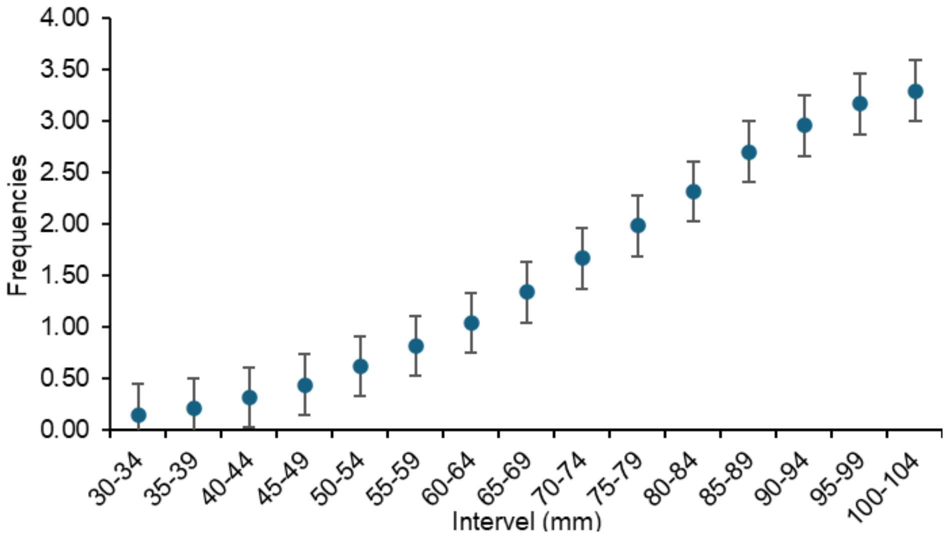

Fig. 5. Condition factor of tiger prawn from Arafura Sea

3. Condition factor

The findings indicated that the condition factor (K) value of the tiger prawn captured from Arafura Sea varied between 0,14 and 3,29, with an average of 1,17 ± 0,61. The condition factor values exhibited a positive correlation with the size and weight of the tiger prawn, as depicted in Fig. (5).

4. Sex ratio

The investigation revealed a sex ratio of 1,01 : 1, indicating a higher population of male prawn compared to female prawn.

5. Stage of gonadal maturation

Table 1. Sex ratio of tiger prawn from Arafura Sea

Month	Total				*Comparison* P=95%
	Male	*Female*	*M:F Ratio*	X^2	
February	188	212	1 : 1,13	1,44	Balanced
March	384	481	1 : 1,25	10,88	Unbalanced
April	291	276	1,05 : 1	0,40	Balanced
May	320	338	1 : 1,06	0,49	Balanced
June	263	239	1,10 : 1	1,15	Balanced
July	250	245	1,02 : 1	0,05	Balanced
August	527	476	1,11 : 1	2,59	Balanced
September	408	289	1,41 : 1	20,32	Unbalanced
October	209	191	1,09 : 1	0,81	Balanced
November	515	358	1,44 : 1	28,23	Unbalanced
December	314	480	1 : 1,53	34,71	Unbalanced
January	312	438	1 : 1,40	21,17	Unbalanced
Total	3981	4023	1 : 1,01	0,22	Balanced

Upon visual examination, it was seen that the majority of the female tiger prawn displayed a high stage of gonadal maturity, specifically falling into categories phase III, IV, and V. This pattern was observed consistently throughout the year. From December to January, there was a rise in the number of the tiger prawn catches that had immature gonads (phase I), as well as an equal distribution between those with immature gonads and those with

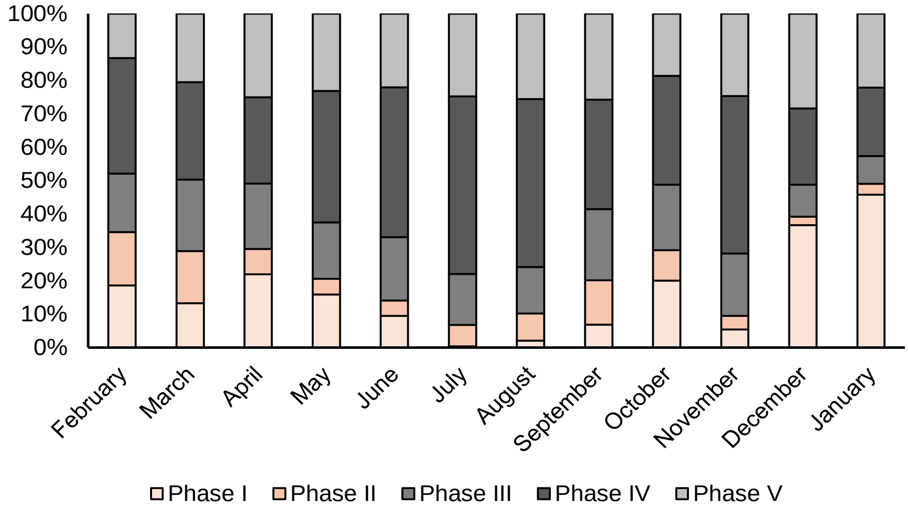

Fig. 6. Gonadal maturity stage of tiger prawn in Arafura Sea

mature gonads. This trend persisted from February to April, encompassing both phase I and

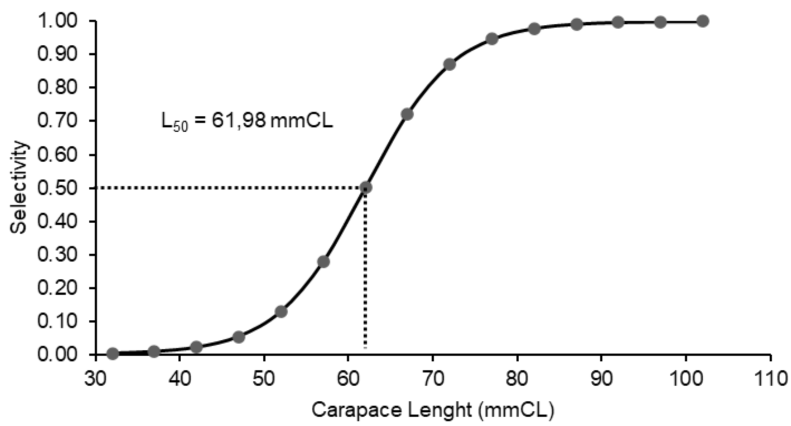

Fig. 7. Mean length carapace at capture (Lc) of *P. monodon* in Arafura Sea

phase II prawn. Based on graph presented, it appears that gonad maturity in phases IV and V has not yet reached 90% but ranges between 70 – 80% (Fig. 6).

6. Average length caught (Lc) and mature gonads (Lm)

The average length of the caught (Lc) and the average of mature gonads (Lm) were determined by inputting each value into a logistic function graph. According to these data, the average length of the outer shell tiger prawn obtained in Arafura Sea more than 12 miles away from the shoreline was 61,98±7,87 mmCL (Fig. 7). Additionally, the average length of the carapace tiger prawn that were sexually mature (Lm) was 60,03±7,75 mmCL (Fig. 8).

DISCUSSION

The size of the tiger prawn discovered in Arafura Sea is comparatively smaller than seen by **Wakida-Kusunoki *et al*. (2016)** in the Yucatan Peninsula, Eastern Mexico. The measurements of the Arafura prawn were 201 and 290mmTL, with weights of 111,6 and 200 grams. Nevertheless, the size of the prawn falls within the range of measurements observed on the South Coast of Nigeria, which varied from 19 to 143,2mm **(Oketoki *et al*., 2024)**. Additionally, the prawn is larger than the tiger prawn caught in Tarakan waters using helicopter trawls, which measured between 21,9 and 63mmCL, as well as the tiger prawn caught in Takalar waters using trammel nets, which measured between 49 and 51mm **(Jamal, 2015; Chodrijah & Faizah, 2018)**. The greatest size of prawn captured in this study in the Arafura Sea was significantly high due to the fishing location being located more than 12 nautical miles away from the coastline. Nonetheless, the utilization of less discriminating fishing equipment resulted in the capture of smaller specimens as well.

The growth trend of tiger prawn in Arafura sea exhibits negative allometry, indicating that the increase in length of the prawn is more pronounced than its weight. This aligns with the findings of research conducted by **Gopalakrishnan *et al*. (2014)** and **Mohale *et al*. (2024)** on the Southeast coast of Tamil Nadu in South India. It is also supported by several other researchers, including **Amani *et al*. (2015)**, **Faye *et al*. (2015)**, **Uddin *et al*., (2015)**, **Hhademzadeh and Haghi (2017)**, **Hasan *et al*. (2020)**, **Siagian *et al*. (2020)**, **Ranjan Das *et al*. (2021)** and **Ukpatu (2021)**. However, in contrast to **Piratheepa *et al*., (2013)**, who conducted research in the waters of Kakkaithevu - Sri Lanka, as well as **Chodrijah and Faizah (2018)**, who conducted research in Tarakan, Kalimantan - Indonesia and found that the growth pattern of the tiger prawn is isometric. The diversity in development patterns observed in the tiger prawn indicates that growth is a relative phenomenon, meaning that it

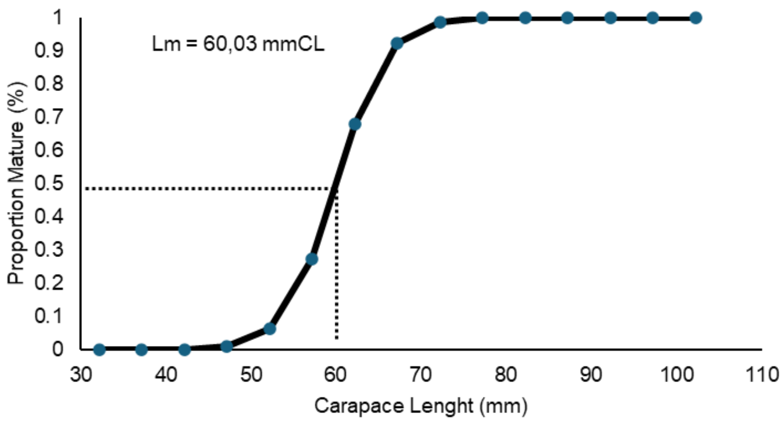

Fig. 8. Mean carapace length at gonad maturity (Lm) of *P. monodon* in Arafura Sea

can fluctuate over time due to influences from environmental variables (such as oceanographic factors) and the availability of food. **Gokce *et al*. (2007)** found that the number of samples measured had an impact on the accuracy of the value, with a higher number of samples resulting in greater accuracy. Furthermore, factors such as water conditions, seasons, sex, gonadal development stage, and habit sustainability also have an impact **(Sparre & Venemma, 1992)**. Condition factors can offer insights into the precise growth conditions of prawn in a general sense **(Solanki *et al*., 2020)**. The condition factor of the tiger prawn in Odisha waters was found to be greater than 1.0 **(Kumari *et al*., 2015)**; while in Mahararastra waters, it ranged from 0.92 to 1.09 **(Mane *et al*., 2019)**. However, the tiger prawn in Southeast Nigeria **(Udoinyang, 2016)**, Gujarat India **(Solanki *et al*., 2020)**, and Southern Nigeria **(Ukpatu, (2021)** were in poor condition, with condition factor values less than 1.0. The mean value of K in this study suggests that the tiger prawn in Arafura Sea exhibited significant growth and demonstrated an increase in reproductive activity during both the moratorium and post-moratorium periods. **Weatherley *et al*. (1987)** and **Senen *et al*. (2011)** suggested that a high condition factor value may be indicative of an elevated level of breeding activity. The condition factor values in this study exhibited extensive intervals, which can be attributed to the use of non-selective gear (double rig trawl) that allowed for the capture of various sizes of fish, resulting in differences in size and weight.

The sex ratio observed in Arafura sea indicated a higher proportion of males captured compared to females. This demonstrates a disparity observed in Digha Waters, India, where the female population exceeds that of males **(Uddin *et al*., 2015)**. The results of the chi-squared test indicated that the sex distribution of tiger prawn (*P. monodon*) in the annual distribution was balanced or not significantly different from a 1 : 1 ratio. However, there were variations in the distribution from month to month during the study, which was also observed in the waters of Sri Lanka **(De Croos *et al*., 2011)**. According to **Fisher (1930)**, **Bal and Rao (1990)** and **Romimohtarto and Juwana (2005)**, the conditions in the Arafura Sea after the moratorium suggest that prawn fishing has not been excessively high. These researchers argued that a sex ratio of 1 : 1 is indicative of low fishing pressure. However, deviations from this ideal ratio are often observed due to differences in behavior, growth, and mortality rates between male and female prawns.

According to **Motoh (1981)**, spawning occurs year-round in Philippine seas. Nevertheless, the findings of **Chodrijah and Faizah (2018)** in Tarakan Waters, North Kalimantan indicate that gonad maturity takes place in March, April, and September. Conversely, **Rajyalakshimi *et al*. (1984)** discovered that tiger prawn spawning occurs from October to April. Considering the gonad maturity stage observed in this study, it is advisable to avoid catching prawn in December and January, as the majority of the catch during this time consists of prawn in the phase I (growth period).

The average length of tiger prawn caught (Lc) in Arafura sea using a double rig trawl is 61,98 ± 7,87 mmCL. This is more than the average length of mature gonads (Lm), which is 60,03 ± 7,75 mmCL. **Chodrijah and Faizah (2018)** discovered a similar result in Tarakan Waters, Indonesia, where the length of Lc (40,69 mmCL) was larger than that of Lm (33,58 mmCL). According to **Pinheiro and Lins-Oliveira (2006)** and **Suman *et al*. (2019)**, if the length of the first time captured (Lc) is smaller than the length of the first time mature gonads (Lm), these conditions can negatively impact the resource's sustainability. The status of the tiger prawn fishing in the Arafura Sea after the 2015 – 2022 moratorium, as observed in this study, is highly favorable as it ensures the sustainability resources. Hence, it is imperative to uphold and control the administration (quantity of fishing equipment, timing, and fishing location), particularly during December and January, when the growth period's primary capture (phase I) typically occurs. Therefore, it is anticipated that the prawn resources would continue to be sustainable and that the utilization efforts will also be sustainable. **Olii *et al*. (2022)** stated that it is necessary to maintain favorable circumstances and an optimal environment for species. Additionally, **Purnawan *et al*. (2023)** emphasized the importance of stock monitoring as a crucial component of sustainable fisheries resource management.

CONCLUSION

The dimensions of the tiger prawn (*P. monodon*) captured in Arafura Sea following the 2015 – 2021 suspension varied from 30,2 to 99,8 mmCL, with weights ranging from 6 to 143 grams. The growth exhibited a negative allometry. The condition factor (K) varied between 0,14 and 3,29, with an average of 1,17±0,61. In balanced conditions, the sex ratio was 1,01 : 1, with a higher number of male compared to female. The yearly capture was primarily composed of sexually mature prawn (phase III, IV, V), whereas monthly data revealed that in December and January, it was predominantly composed of immature prawn (phase I). The mean length of captured tiger prawn (Lc) was 61,98 ± 7,87 mmCL, which was higher than the mean length that had reached sexual maturity (Lm) at 60.03 ± 7.75 mmCL. The state of tiger prawn fishing in the Arafura sea during the time of this study is highly favorable as it contributes to the preservation of the sustainable resources. Hence, it is imperative to uphold and govern the administration of prawn resources (including the quantity of fishing equipment, fishing season, and fishing location) in order to ensure their continued effectiveness and promote sustainable exploitation.

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REFERENCES

Adhawati, S. S.; Baso, A.; Malawa, A. and Adri Arief, A. (2017). Social study of cantrang (Danish trawl) fisheries post Moratorium at Makassar Straits and Bone Gulf, South Sulawesi Province, Indonesia. AACL Bioflux, 10(5), 1140–1149.

Aguirre-Pabón, J.; Chasqui, L.; Muñoz, E. and Narváez-Barandica, J. (2023). Multiple origins define the genetic structure of tiger shrimp Penaeus monodon in the colombian Caribbean Sea. Heliyon, 9(7). https://doi.org/10.1016/j.heliyon.2023.e17727

Amani, A. A.; Arshad, A.; Yusoff, F. M. and Amin, S. M. N. (2015). Length-weight relationship and relative condition factor of Parapenaeopsis sculptilis (Heller, 1862) from the coastal waters of Perak, Peninsular Malaysia. Pertanika Journal of Tropical Agricultural Science, 38(2), 211–217.

Aprianti, E.; Simbolon, D.; Taurusman, A. A.; Wahju, R. I.; Yusfiandayani, R.; Mannojengi, A. and Astika, I. M. A. (2024). Spatial and Temporal Effect of Environmental Factors on the Length-Weight Relationship of the Bali Sardinella (Sardinella lemuru Bleeker, 1853) in Bali Strait Water. Egyptian Journal of Aquatic Biology and Fisheries, *28*(4), 41–54. https://doi.org/10.21608/ejabf.2024.365647

Arisandi, A. (2016). Inkonsisten Kebijakan. JKMP, 4(1), 1–18.

Bal, D. V., & Rao, K. V. (1990). Marine fisheries of India. 472.

Boutson, A.; Mahasawasde, C.; Mahasawasde, S.; Tunkijjanukij, S. and Arimoto, T. (2009). Use of escape vents to improve size and species selectivity of collapsible pot for blue swimming crab Portunus pelagicus in Thailand. Fisheries Science, 75(1), 25–33. https://doi.org/10.1007/s12562-008-0010-z

Chodrijah, U. and Faizah, R. (2018). Beberapa Aspek Biologi Udang Windu (P. monodon, Fabricus 1789) di Perairan Tarakan, Kalimantan Utara. Bawal. Research Center for Fisheries Management and Conservation.; 10(April), 49–55. https://doi.org/10.1.2018.49-55

De Croos, M. D. S. T.; Pálsson, S. and Thilakarathna, R. M. G. N. (2011). Sex ratios, sexual maturity, fecundity, and spawning seasonality of Metapenaeus dobsoni off the western coastal waters of Sri Lanka. Invertebrate Reproduction and Development, 55(2), 110–123. https://doi.org/10.1080/07924259.2010.548649

Effendie, H. Moch. I. (1997). Biologi perikanan. Yayasan Pustaka Nusatama.

Faye, A.; Sarr, A.; Diouf, M. and Thiaw, M. (2015). Contribution to the Study of the Size Structure , the Length-Weight Relationship , the Condition Factor and the Sex-ration of Shrimp Farfantepenaeus notialis (Pérez Farfante , 1967) in the Estuary of Sine-Saloum (Senegal). American Scientific Research Journal For Engineering Technology and Sciences, 14, 97–112.

Fisher, R. A. (1930). The genetical theory of natural selection (3rd ed.). Oxford University Press.

Gokce, G.; Aydin, I. and Metin, C. (2007). Length – weight relationships of 7 fish species from the North Aegean Sea , Turkey. International Journal of Natural and Engineering Sciences, 1, 51–52.

Gopalakrishnan, A.; Rajkumar, M.; Rahman, M. M.; Sun, J.; Antony, P. J.; Venmathi maran, B. A. and Trilles, J. P. (2014). Length-weight relationship and condition factor of wild, grow-out and "loose-shell affected" giant tiger shrimp, Penaeus monodon (Fabricius, 1798) (Decapoda: Penaeidae). Journal of Applied Ichthyology, 30(1), 251–253. https://doi.org/10.1111/jai.12269

Günther, A. and Beratan, I. N. L. (2013). POTENSI INVASIF IKAN ZEBRA CICHLID (Amatitlania nigrofasciata Günther , 1867) DI DANAU BERATAN , BALI DITINJAU DARI ASPEK. 5(2), 113–121.

Guo, H.; Ma, Zh.; JiaNg, Sh.; ZHaNg, D.; ZHaNg, N. and Li, Y. (2014). Length-weight relationship of oval pompano, Trachinotus ovatus (Linnaeus 1758) (Pisces: Carangidae) cultured in open sea floating sea cages in South China Sea. 61(1), 93–95.

Hasan, M. R.; Hossain, M. Y. and Mamun, A. Al. (2020). Length-weight relationships of 12 indigenous fishes and 3 shellfishes from mangrove and floodplain ecosystems in Southwestern Bangladesh. Egyptian Journal of Aquatic Biology and Fisheries, 24(5), 69–76. https://doi.org/10.21608/ejabf.2020.103532

Hhademzadeh, O. and Haghi, M. (2017). Length-weight relationship and condition factor of white leg shrimp Litopenaeus vannamei (Boone , 1931) in culture systems of Choebdeh , West-South of Iran. International Journal of Fisheries and Aquatic Studies, 5(January 2017), 298–301.

Hikmayani, Y. and Rahadian, R. (2015). Effectivity of Ex-Foreign Ships Moratorium and Transhipment Policy on Captured Fisheries Business Performance. Jurnal Kebijakan Sosek KKP, 2, 101–112.

Jamal, M. (2015). Trammel Net Selectivity for Penaeid Shrimps in Takalar Regency Waters, South Sulawesi Province. Jurnal Ilmu Kelautan Dan Perikanan), 25(2), 96–105.

Khademzadeh, O. and Haghi, M. (2021). Length-weight relationship and condition factor of white leg shrimp Length-weight relationship and condition factor of white leg shrimp Litopenaeus vannamei (Boone , 1931) in culture systems of Choebdeh , West-South of Iran. 5(January 2017), 298–301.

King, M. (2013). Fisheries biology, assessment and management: Second edition. Fisheries Biology, Assessment and Management: Second Edition, 1–382. https://doi.org/10.1002/9781118688038

Komi, G. W. and Francis, A. (2017). Length-Weight Relationship, Condition Factor and Aspects of Growth Parameters of the Black Tiger Shrimp (Penaeus monodon) in the Andoni River System, Niger Delta, Nigeria. Global Journal of Science Frontier Research (D), 17(2), 8–18.

Kumari, M. S.; Sucharita, M. S.; Prasad, D. B. and Sekhar, P. D. (2015). Length-weight relationship and condition factor of Penaeus monodon Fabricius, 1798 in northern Odisha, India. Int. J Sci. Res, 4(4), 1300–1304.

Li, Y.; Zhou, F.; Ma, Z.; Huang, J.; Jiang, S.; Yang, Q.; Li, T. and Qin, J. G. (2016). Length–weight relationship and condition factor of giant tiger shrimp, Penaeus monodon (Fabricius, 1798) from four breeding families. SpringerPlus, 5(1). https://doi.org/10.1186/s40064-016-2979-6

Luthfia, S. S. (2023). (Analyzing National Fisheries Governance through Government Regulation No. 11 of 2023 on Measured Fish Capture to Realize the Blue Economy). 12(11), 483–501.

Machmudi, M. I. (2020). Potensi Perikanan Udang di Laut Arafura Capai Rp10 Triliun. Media Indonesia. https://mediaindonesia.com/ekonomi/343828/potensi-perikanan-udang-di-laut-arafura-capai-rp10-triliun

Mane, S.; Sundaram, S.; Hule, A.; Sawant, M. and VD, D. (2019). Length weight relationship of commercially important penaeid prawns of Maharashtra , India. International Research Journal of Science and Engineering, 7(June), 35–40.

Mohale, H. P.; Jawahar, P.; Jayakumar, N.; Oli, G. A.; Ravikumar, T.; Bhosle, R. V.; Ananda, S. N.; Kadam, R. V. and Sonwal, M. C. (2024). Length-weight Relationship and Condition Factors of Seven Penaeus Shrimp Species along the Southeast Coast of Tamil Nadu (Southern India). Indian Journal of Animal Research, Of, 1–3. https://doi.org/10.18805/ijar.b-5218

Motoh, H. (1981). Studies on the fisheries biology of the giant tiger prawn , Penaeus monodon in the Philippines. SEAFDEC, Philippines, 7, 1–128.

Nasution, Z.; Amri, K.; Arifin, T.; Pranowo, W. S.; Haryadi, J.; Wibowo, S.; Zulham, A.; Mbay, L. N.; Syamdidi, Nugraha, R. B. A.; Sumiono, B. and Erlania, E. (2016). Potensi Sumber Daya Kelautan dan Perikanan WPPNRI 718. Amafrad Press.

Nie, Z. L.; Wei, J.; Ma, Z. H.; Zhang, L.; Song, W.; Wang, W. M. and Zhang, J. (2014). Morphological variations of Schizothoracinae species in the Muzhati River. Journal of Applied Ichthyology, 30(2), 359–365. https://doi.org/10.1111/jai.12376

Nurlaili, N.; Muhartono, R. and Hikmayani, Y. (2016). Dampak Kebijakan Moratorium Terhadap Sektor Usaha Perikanan Tangkap Di Kota Bitung. Jurnal Kebijakan Sosial Ekonomi Kelautan Dan Perikanan, 6(2), 145. https://doi.org/10.15578/jksekp.v6i2.3327

Oketoki, T. O.; Ansa, E. J.; Oguntade, O. R.; Ukenye, E. A. and Omidiji, O. (2024). Length-weight relationship and condition factor of invasive Penaeus monodon along the south coastline of Nigeria. Nigerian Journal of Fisheries, 13(1–2), 1043–1050.

Olii, A. H.; Wonneberger, E. and Pasisingi, N. (2022). Growth Performance of Layang (Scad) Fish (Decapterus russelli, Ruppell 1830) Caught from Tomini Bay, Indonesia. Ilmu Kelautan: Indonesian Journal of Marine Sciences, 27(2), 181–188. https://doi.org/10.14710/ik.ijms.27.2.181-188

Pinheiro, A. P. and Lins-Oliveira, J. E. (2006). Reproductive Biology of Panulirus echinatus (Crustacea: Palinuridae) from São Pedro and São Paulo Archipelago, Brazil. Nauplius, 14(2), 89–97.

Piratheepa, S.; Edrisinghe, U. and Chitravadivelu, K. (2013). Investigation on length-weight relationship of Penaeus monodon (Fabricius, 1798) in Kakkaithevu coastal waters in the northern part of Sri Lanka. Tropical Agricultural Research, 25(1), 133. https://doi.org/10.4038/tar.v25i1.8037

Purnawan, S.; Karina, S.; Kang, M. and Manik, H. M. (2023). Fish Stock Status Assessment in Alue Naga Waters Using A 200 Khz Single Beam Echosounder. Ilmu Kelautan: Indonesian Journal of Marine Sciences, 28(1), 57–68. https://doi.org/10.14710/ik.ijms.28.1.57-68

Purwanto, P. (2010). Thebiological optimal level of theArafura shrimp fishery. Ind. Fish, 16(2), 79–89.

Purwanto, P. (2017). Model Optimisasi Dengan Sasaran Beragam Untuk Pengelolaan Perikanan Udang Di Laut Arafura. Jurnal Kebijakan Perikanan Indonesia, 3(1), 61. https://doi.org/10.15578/jkpi.3.1.2011.61-79

Ragheb, E. (2023). Length-weight relationship and well-being factors of 33 fish species caught by gillnets from the Egyptian Mediterranean waters off Alexandria. Egyptian Journal of Aquatic Research, *49*(3), 361–367. https://doi.org/10.1016/j.ejar.2023.01.001

Rajyalakshimi, T.; Pillai, S. M. and Ravichandran, P. (1984). The biology of Penaeus monodon in the capture fisheries of Orissa coast in the context of occurrence of natural brood stock. First International Confurence. Culture of Penaeid Prawn and Shrimp, 4–7.

Ranjan Das, R.; Saravana, A.; Ambilkanandham, K.; Saranya, C.; Arumugam, S. and Panigrahi, A. (2021). Poultry Fisheries & Wildlife Sciences Length Weight Relationship and Condition Factor (K) of Penaeus indicus (H. milne Edwards) Based on Developmental Stages, Grow Out Stages, Brood Stock Stages and Sex. The Pharma Innovation Journal, 10(9), 85–89.

Romimohtarto, K. and Juwana, S. (2005). Biologi laut : ilmu pengetahuan tentang biota laut (2nd ed.). Djambatan.

Russell, B. C. and Houston, W. (1989). Offshore fishes of the Arafura Sea. Beagle: Records of the Museums and Art Galleries of the Northern Territory, The, 6, 69-84. Beagle: Records of the Museums and Art Galleries of the Northern Territory, 6, 69-84.

Saputra, S. W.; Djuwito, D. and Rutiyaningsih, A. (2013). Beberapa Aspek Biologi Udang Jerbung (Penaeus merguiensis). Journal of Management of Aquatic Resources, 2(3), 47–55. https://doi.org/10.14710/marj.v2i3.4181

Sari, Y. D. (2018). Dampak Kebijakan Moratorium Perizinan Kapal Asing Terhadap Sumberdaya Perikanan Demersal di WPP 718. 32, 1–13.

Sari, Y. D.; Triyanti, R.; Zamroni, A.; Huda, H. M.; Wijaya, R. A.; Suryawati, S. H. and Nababan, B. O. (2021). Strategy to re-utilization shrimp resources in the Arafura Sea. IOP Conference Series: Earth and Environmental Science, 860(1), 1–8. https://doi.org/10.1088/1755-1315/860/1/012058

Senen, B.; Tinggi, S.; Hatta-Sjahrir, P. and Sulistiono, S. (2011). Aspek biologi ikan layang deles (Decapterus macrosoma) di perairan Banda Neira, Maluku, Indonesia

Community development View project. January 2011. https://www.researchgate.net/publication/320324710

Siagian, J.; Arthana, I. W.; Pebriani, D. A. A. and Saraswati, S. A. (2020). The Composition, Size Distribution and Growth Patterns of Penaeus monodon and Penaeus merguiensis at the Estuary of Tukad Aya, Jembrana Bali. Advances in Tropical Biodiversity and Environmental Sciences, 4(1), 15. https://doi.org/10.24843/atbes.2020.v04.i01.p04

Siar, S. V.; Suuronen, P. and Gregory, R. (2017). Socio-economics of trawl fisheries in Southeast Asia and Papua New Guinea. In FAO Fisheries and Aquaculture Proceedings No. 50 (Issue October 2015). https://www.fao.org/responsible-fishing/resources/detail/es/c/1379048/

Solanki, H. G.; Ujjania, N. C.; Gopal, C. and Pillai, S. M. (2020). Length-weight relationship, condition factor and length-frequency analysis of tiger shrimp (Penaeus monodon fabricius, 1798). International Journal of Fauna and Biological Studies, 7(4), 191–195. www.faunajournal.com

Sparre, P. and Venemma, S. C. (1992). Introduction to tropical fish stockassesment. Part I. Manual. FAO Fish. Tech. Pap.; 306(1).

Steel, R. G. D. and Torrie, J. H. (1989). Principles and procedures of statistics biometric approach (T. by B. Sumantri.; Ed.). Gramedia Pustaka Utama.

Sulaiman, A.; Hendiarti, N.; Syamsudin, F.; Frederik, M. C. G.; Djajadihardja, Y. S. and Andiastuti, R. (2005). Riset dan Teknologi Pemantauan Dinamika Laut Indonesia. Badan Riset Kelautan dan Perikanan.

Suman, A.; Kembaren, D. D.; Ramadhani, A.; Pane, P. and Taufik, D. M. (2020). Status Stok Udang Jerbung (Penaeus merguiensis) di Perairan Bengkalis dan Sekitarnya Serta Kemungkinan Pengelolaannya Secara Berkelanjutan . Jurnal Kebijakan Perikanan Indonesia, 12(1). https://doi.org/10.15578/jkpi.12.1.2020.11-22

Suman, A.; Lestari, P.; Ramadhani, A. and Pane, P. (2019). Population Parameters of Endeavour Shrimp (Metapenaeus ensis de Haan) di Perairan Binuangeun dan Adjacent, Jawa Barat. 25(June), 19–26. https://doi.org/http://dx.doi.org/10.15578/ifrj.25.1.2019.19-26

Suman, A.; Satria, F.; Nugraha, B.; Priatna, A.; Amri, K. and Mahiswara, M. (2018). Status Sumberdaya Ikan Tahun 2016 di Wilayah Pengelolaan Perikanan Negara Republik Indonesia (WPPNRI) Serta Alternatif Pengelolaannya. Jurnal Kebijakan Perikanan Indonesia, 10(2), 107. https://doi.org/10.15578/JKPI.10.2.2018.107-128

Sumiono, B. (2011). Distribusi, komposisi jenis Udang, kepadatan stok dan status pemanfaatan Arafura, penaeid di Laut.

Sumiono, B. (2012). Status Sumberdaya Perikanan Penaeid dan Alternatif Pengelolaannya di Indonesia. J. Kebijak. Perikan. Ind, 4(1), 27–34. https://doi.org/http://dx.doi.org/10.15578/jkpi.4.1.2012.27-34

Sururi, M.; Mustasim, M.; Hoek, F. and Anasri, A. (2017). Laju Eksploitasi Sumberdaya Ikan Layang (Decapterus macrosoma) yang didaratkan di Pangkalan Pendaratan Ikan (PPI) Kota Sorong-Papua Barat. Jurnal AIraha, 6(1), 001–009.

Tirtadanu, Amri, K.; Makmun, A.; Priatna, A.; Pane, A. R. P.; Wagiyo, K. and Yusuf, H. N. (2022). Shrimps distribution and their relationship to the environmental variables in Arafura Sea. IOP Conference Series: Earth and Environmental Science, 1119(1). https://doi.org/10.1088/1755-1315/1119/1/012003

Tirtadanu. and Chodirjah, U. (2020). Karakteristik Biologi Dan Tingkat Pemanfaatan Biological Characteristics and Exploitation Status of Giant Tiger Prawn in Sebatik Waters , Kalimantan Utara. 25(September 2019), 203–214.

Uddin, N.; Ghosh, S. and Maity, J. (2015). Reproductive biology , maturation size and sex ratio of black tiger shrimp (Penaeus monodon Fabricius, 1798) from fishing grounds of Digha coast, West Bengal, India. International Journal Aquatic Biology, 3(6), 372–378.

Udoinyang, C. E. (2016). Length-weight relationship and condition factor of seven shrimp species in the artisanal shrimp fishery of Iko river estuary, southeastern Nigeria Udoinyang EP, Amali O, Iheukwumere CC, Ukpatu JE. International Journal of Fisheries and Aquatic Studies IJFAS, 109(42), 109–114. www.fisheriesjournal.com

Ukpatu, J. E. (2021). Biometric structure and welfare of tiger shrimp (Penaeus monodon (FABRICIUS , 1798) in Okoro River Estuary, south eastern Nigeria. AKSU Journal of Agriculture and Food Sciences, 5(1), 25–33.

Ulath, M. A.; Handayani, Razak, A. D.; Sururi, M.; Gunaisah, E.; Sudirman, Sepri, Suruwaky, A.; Muhfizar, Mustasim, & Simau, S. (2018). Analysis on Trammel Net and Pa Monofilament Shrimp Net Towards Shrimp Fishing in Kaimana Bay, Indonesia. Russian Journal of Agricultural and Socio-Economic Sciences, 85(1), 288–295. https://doi.org/10.18551/rjoas.2018-12.36

Umamah, M.; Wisudo, S. H. and Wahyu, R. I. (2017). Pengelolaan Sumberdaya Udang Yang Berkelanjutan di Laut Aru dan Arafura. I(3), 245–255. http://jurnal.ipb.ac.id/index.php/pspalbacore/article/viewFile/19020/13280

Wakida-Kusunoki, A. T.; De Anda-Fuentes, D. and López-Téllez, N. A. (2016). Presence of giant tiger shrimp Penaeus monodon (Fabricius, 1798) in eastern Peninsula of Yucatan coast, Mexico. Latin American Journal of Aquatic Research, 44(1), 155–158. https://doi.org/10.3856/vol44-issue1-fulltext-16

Walpole, R. E. (1993). Pengantar statistika. PT Gramedia Pustaka Utama.

Weatherley, A. H.; Gill, H. S. and Casselman, J. M. (1987). The biology of fish growth.

Wijopriono, W.; Wiadnyana, N. N.; Dharmadi, D. and Suman, A. (2019). Implementasi Penutupan Area Dan Musim Penangkapan Untuk Pengelolaan Perikanan Udang Di Laut Arafura. Jurnal Kebijakan Perikanan Indonesia, 11(1), 11. https://doi.org/10.15578/jkpi.11.1.2019.11-21