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ANALYSIS OF STOCK AND UTILIZATION RATE OF LONGTAIL TUNA (*Thunnus tonggol*) IN THE JAVA SEA

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ABSTRACT

Longtail is one of the most important economic species in Indonesia to purse seine and mini purse seine catch. This research activity aims to determine population parameter i.e. growth, mortality, and determine the management strategies for longtail tuna. The collecting of length and weight data was conducted at Pekalongan fishing port from October to December 2019. The sampling method used was a systematic random sampling method, with the collected data being the length and weight of the longtail tuna. The long weight r relationship was negative allometric and the b value was 2.7776. The asymptotic length rate ($L\infty$) was 55 cm FL, growth rate (K) was 0,88/year and zero age (t_0) was 0,1536 year. Natural mortality (M) is 1.41/year, fishing mortality (F) is 1.38/year, total mortality (Z) is 2.79/year. The level of exploitation (E) of 0.49 (underexploited), so that utilization can be increased.

Keywords: longtail tuna; growth rate; exploitation rate; Java Sea

INTRODUCTION

The longtail tuna (*Thunnus tonggol*) is one of the oceanodromous pelagic fish, its population being in the clear neritic waters (Carpenter and Niem, 2001 *in* Wagiyo and Febrianto, 2015). According to Yesaki (1991) *in* Hidayat & Noegroho (2018), longtail tuna have economic value in Indonesian fisheries. The spread of this species is unique compared to other species belonging to the genus Thunnus which are commonly found in the deep sea. Longtail tuna are only found in shallow waters near land or islands. This species exists in tropical and subtropical waters in the Indo Pacific region between 47 ° N to 33 ° S (Froese & Pauly, 2009 *in* Hidayat & Noegroho, 2018).

The use of longtail tuna resources is feared to have an impact on the growth of the fish (Kusumaningrum *et al.*, 2014). Effendie (2002) *in* Mahmud *et al.*, (2019) states that growth is influenced by internal (heredity, sex, age, and disease) and external factors (the amount of food available and water quality). Compared to other tuna, the growth of longtail tuna is slower and lives longer, making it vulnerable to overfishing (Griffiths, 2010).

This study aims to analyze the stock and utilization rate of longtail tuna in purse seine in the Java Sea

RESEARCH METHODS

The research method used was a survey method. Nasution (2004) suggested survey research aimed at gathering information about a large population, by performing direct calculations, namely primary data calculations.

Method of Collecting Data

Data collected in the form of primary and secondary data. Primary data were obtained by taking samples of longtail tuna and morphometric measurements in the form of fish length and weight. Whereas secondary data is obtained based on literature or references in previous studies which are then used as a comparison.

Sampling Method

The sampling method used a systematic random sampling method. Sampling is done once a month for 3 months, from October to December 2019 at the Pekalongan Archipelago Fisheries Port (PPN), Central Java, Indonesia.

Ship sample

Longtail tuna sampling using a boat with a mini purse seine fishing gear. Selection of fishing gear such as longtail tuna (*Thunnus tonggol*) located in the Java Sea is the catch of the main mini purse seine. Determination of the sample vessel following the procedure Sadhotomo and Potier (1991) *in* Saputra, (2009), if the ship that landed less than 5 pieces, chosen one ship, the ship's number one. If more than 5 ships arrive, 2 ships will be selected as sample vessels. The first ship is the shipping number 1 and the second sample ship is the ship whose catch is different from ship number 1, and so multiples of 5.

Fish Sample

Fish samples A fish sample is taken 10% from the catch obtained by the sample ship (Saputra, 2009 *in* Septiana, 2019).

Data Analysis Method

Length - Weight Relationship

The length-weight relationship follows cubic law, that the weight of fish as a cube of its length is following the equation of Bal and Rao (1984), namely:

$$W = a.L^b \quad (1)$$

$$Log\ W = Log\ a + b\ Log\ L \quad (2)$$

Where W =fish weight (gram); L =fork lenght (cm); a = intercept (the intersection between the regression line and the y-axis); b = regression coefficient (slope angle of the line)

Length-weight relationship, calculated by the linear regression formula as follows:

$$\boldsymbol{Y = a + bx} \quad (3)$$

Where : Y= Log W (weight of fish in gr); x = Log L (fish length in cm)

To find out the nature of growth, a t-test of the value of b based on the criterion by Bal & Rao (1984):

a) If b = 3, growth is *isometric*, i.e. the length increase is equal to the growth in weight,
b) If b> 3, then the growth pattern is positive *allometric*, i.e. the weight gain is faster than the length increase,
c) If b <3, then the growth pattern is negative *allometri*c, that is, the length increase is faster than the weight gain.

To find out if the value of b is obtained greater, equal or smaller than 3, a t-test is performed at a 95% confidence interval, and the t- table value is significantly 5% (n-2) (Steel and Torrie, 1993):

$$t_{count} = \left|\frac{3-b}{Sb}\right| \quad (4)$$

Where : Sb = Standard deviation; H_0 : b = 3 (isometric); H_1 : b ≠ 3 (allometric); If t_{count} is smaller than t_{table} then H_0 is accepted and H_1 is rejected.; If t_{count} is greater than t_{table} then H_1 is accepted and H_0 is rejected.

The Condition Factor *(K)*

The condition factor (K) indicates the good condition of fish, in terms of physical capacity for survival and reproduction. The condition factor is calculated using a metric system based on the length of the sample fish weights. If the weight gain is balanced with the length increase, the fish growth is isometric so the equation for calculating the condition factor becomes (Effendie, 2002):

$$K = \frac{10^5 W}{L^3} \quad (5)$$

If growth is allometric i.e. length increases and weight gain is not balanced, then the equation becomes (Effendie, 2002):

$$K = \frac{W}{aL^b} \quad (6)$$

Where : K = condition factor; W= bodyweight of fish (gr); L = fish length (cm)

Estimation of Fish Growth Parameters

Calculation of the growth equation uses the non-parametric Scoring of the VBGF Fit method Using ELEFAN I (electro length-frequency analysis) contained in the FISAT II program package, by inputting long interval data. L∞ can be predicted using the Pauly formula (1984):

$$L_\infty = \frac{L_{maks}}{0{,}95} \quad (7)$$

Where : Lmax = highest sample length obtained

Determination of the value of to according t_o value (Saputra and Subiyanto, 2008) uses Pauly's empirical formula by using a multiple regression relationship between the theoretical age at zero fish length (t_o) and infinity length (L∞) and K, as follows:

$$Log - t_o = -0{,}3952 - 0{,}2752\ Log\ L_\infty - 1{,}038\ Log\ K \quad (8)$$

Where :L∞ = asymptotic length (cm); K = k growth coefficient Von Bertalanffy

Growth parameters are estimated using the von Bertalanffy model (Pauly, 1984) with the following formula:

$$L_t = L_\infty\ (1 - e^{-K(t-t0)}) \quad (9)$$

Where : L_t = fish length at age t (cm); L∞ = asymptotic length (cm); t_o = the theoretical age of fish at length 0; K = growth coefficient Von Bertalanffy

First Time Size Caught (Lc50%)

The first measure taken is obtained by finding the mean value of the fish caught. The method of determining the size of the fish is first carried out in the following way:

1. Create a length class of longtail tuna and calculate the frequency of each long class
2. Count the number of each class length
3. Calculate the cumulative percentage of each class length
4. The Lc50% value is obtained by plotting the cumulative percentage of longtail tuna released with carapace length.

Mortality

Z value calculation (*total mortality*) is obtained by using the catch curve method which is converted to length, in the FISAT II program package. Formula for calculating the value of Z by Wetherall *et al*. (1987) *in* Saputra and Subiyanto (2008) are as follows:

$$Z = K\ [(L_\infty - \hat{I}) / (\hat{I} - I')] \quad (10)$$

Where : Z = total mortality; K = growth curve index Von Bertalanffy; L∞ = length of infinity; Î = average length of fish at a certain age; I = the smallest fish in the sample

M (natural mortality) is calculated based on Pauly's empirical formula (1984) by entering the parameters K per year, L_∞ (cm), and T (average annual water surface temperature in degrees Celsius). Pauly's empirical formula is as follows:

$$Log\ M = -0{,}0066 - 0{,}279\ Log\ L_\infty + 0{,}6543\ Log\ K + 0{,}4634\ Log\ T \quad (11)$$

Where: M = k natural mortality coefficient: L∞ = infinity bridge (cm); K = k growth coefficient Von Bertalanffy; T= average temperature of the waters

Capture mortality (F) can be calculated by subtracting total mortality (Z) from natural mortality (M), by the formula below:

$$Z = F + M, \text{ becomes: } F = Z - M \quad (12)$$

Where: Z = coefficient of total mortality; F =capture; mortality coefficient; M = natural mortality coefficient

Exploitation

The rate of exploitation is determined by comparing the capture mortality (F) to total mortality (Z) (Gulland, 1971 *in* Pauly, 1984):

$$E = \frac{F}{F+M} = \frac{F}{Z} \quad (13)$$

Where: E = exploitation; F= capture mortality coefficient; M = natural mortality coefficient; Z = coefficient of total mortality

Catch mortality rate (F) or optimum exploitation rate according to Gulland (1971) *in* Pauly (1984) are :

$$F_{optimum} = M \text{ dan } E_{optimum} = 0{,}5 \quad (14)$$

Where : F_{opt} = optimum capture mortality coefficient; M = natural mortality coefficient; E_{opt}= optimum exploitation

The exploitation rate (E) of the fish population is said to have reached overfishing if it has exceeded the optimum catch level limit value. Optimum capture (E_{opt}= 0.5) if the population is in a balanced state, ie the amount of rejuvenation in the population is equal to death and migration

RESULT AND DISCUSSION

Result

Length Frequency Distribution

The number of longtail tuna observed from October to December 2019 was 541 fish. The frequency distribution can be seen in Table 1 and Figure 1.

Table 1. The Distribution Of The Length Frequency Of Longtail Tuna In October - December 2019

Hose class (cm)	20/10/19	17/11/19	15/12/19	Total
35-37	0	0	0	0
37-39	0	1	8	9
39-41	0	4	22	26
41-43	1	24	13	38
43-45	2	13	36	51
45-47	3	4	24	31
47-49	36	22	18	76
49-51	68	122	34	224
51-53	9	41	14	64
53-55	1	10	10	21
55-57	0	0	1	1
Total sample				541

Based on the Bhattacarya method, a bar diagram is obtained which illustrates the number of existing long frequency distributions. (Figure 1)

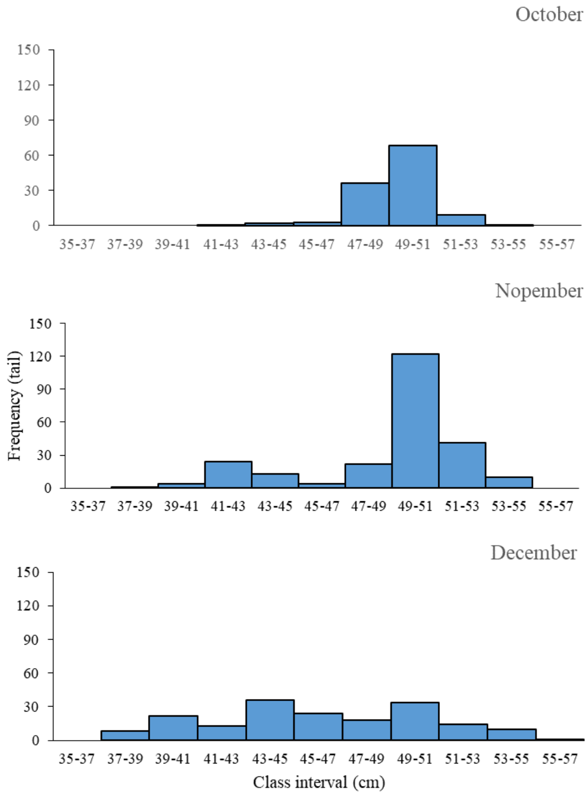

Figure 1. Length Frequency Of Longtail Tuna (*Thunnus tongol*) Period From October To December 2019 in PPN Pekalongan

Relationship Length- Weight

The results of the analysis of the relationship length-weight longtail tuna pointing k an equation $W = 0{,}0417L^{2.7776}$ with a correlation value (r^2) was 94 % (Figure 2). After the t-test was done with a 95% confidence level (α = 0.05), it was found that the growth pattern was negatively *allometric*, so that the length increase was faster than the weight gain.

First Time Size Caught (Lc50%)

Based on the analysis using logistic curves, it is known that the size of the first time caught (Lc50%) is 47.5 cm (Figure 4), with a fish length mode ranging from 49-51 cmFL.

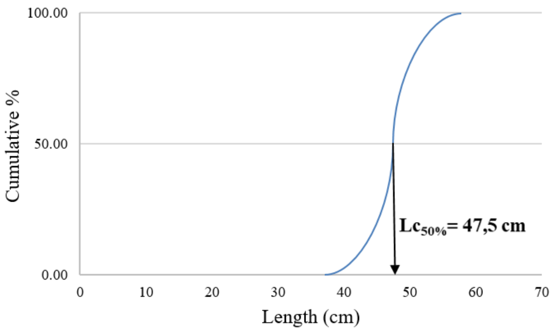

Figure 2. Size of the First Caught (Lc50%) Longtail Tuna (*Thunnus tonggol*)

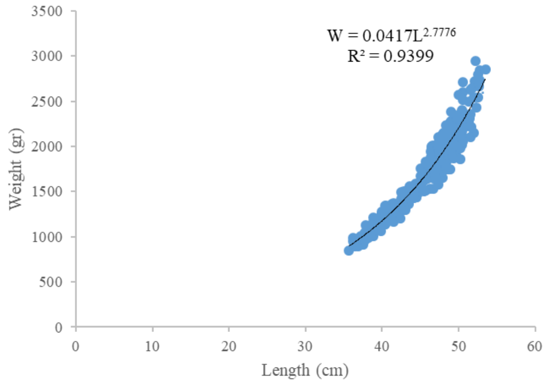

Figure 3. Relationship Between Fork Length And Weight Of Longtail Tuna In The Java Sea.

Growth Parameters

Analysis with the FISAT II program obtained asymptotic length (L∞) = 55 cmFL and the growth coefficient (K) = 0.88/year. The theoretical age estimate when the length of the fish is zero (t_0) is 0.154 per year. The values of the growth parameters are used as a basis to get the Von Bertalanffy equation of longtail tuna, which is Lt = 55 (1-$e^{-0.88 * (t + 0.154)}$). From this equation can be made the relationship curve between age and fish length (Figure 5). The smallest longtail tuna (FL) length during the study was 35.7 cm, the longest was 53.5 cm. the growth rate (Ø) of longtail tuna in the Java Sea waters was obtained around 3.43.

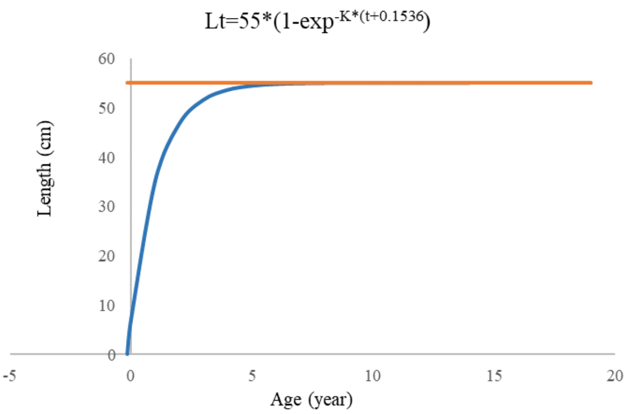

Figure 4. Long relationships and longevity

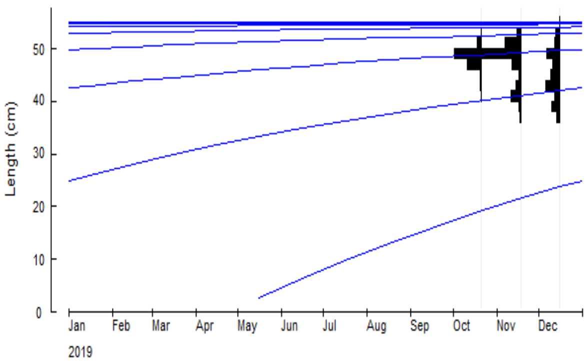

Figure 5. Von Bertalanffy Growth Curve Based Right On The Length-Frequency Data Of Longtail Tuna

Mortality and Exploitation

Total mortality (Z) of longtail tuna in the waters of the Java Sea obtained 2.79 per year. The average temperature in the waters of the Java Sea in 2019 is 29 ° C, so if it is included in Pauly's empirical equation (1980), the natural mortality (M) is 1.41. Capture mortality (F) obtained from F = Z-M is 1.38/year so that the exploitation rate (E) is obtained 0.49 per year. Figure 6 shows the estimated total mortality rate (Z), natural mortality (M), capture mortality (F), and exploitation (E) in the Java Sea.

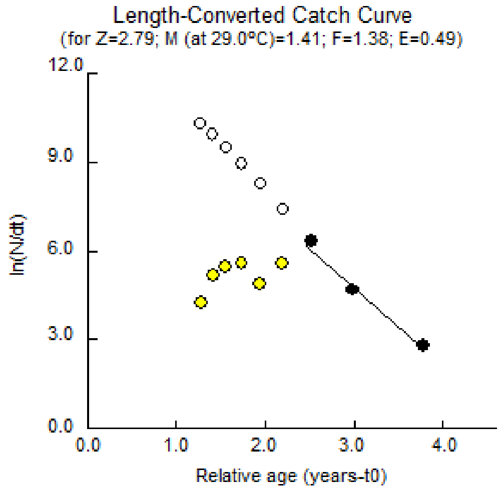

Figure 6. Mortality Rate and Exploitation Rate of Longtail Tuna

Discussion

Java Sea, the equation W = $0.0417L^{2.77776}$ with b = 2.7776 is produced. After the t-test, it was concluded that the growth pattern is negative allometric (b <3), indicating that the length increase is faster than the weight gain. This result is the same as several studies in various locations (Table 2) that can be used as a comparison. According to Biswas (1993) *in* Restianingsih & Hidayat (2018), the difference in values of a and b depend on gender, maturity stage, eating intensity, and others. According to Gulland (1983); Sparre & Vanema (1999) that variations in the value of b are also caused by various factors such as temperature, salinity, food (quantity, quality, and size), sex, gonad maturity stage, and habitat preservation.

The catch of longtail tuna in the Java Sea using a mini purse seine tagging tool obtained a maximum length of 53.5 cmFL. These results are smaller than the catch of gill nets in Taiwan waters which is 79.6 cmFL (Chiang *et al.*, 2011), Japanese waters that are 72 cmFL (Itoh *et al.*, 1999), Java Sea waters which is 81 cmFL (Restianingsih & Hidayat, 2018), the waters of the Persian Gulf are 125 cmFL (Kaymaram *et al.*, 2011), greater than the catch of Langsa waters which is 51 cmFL (Wagiyo & Febriyanti, 2015). The maximum length of longtail tuna in the Java Sea in this study is lower than Restianingsih and Hidayat research (2018) because, in previous studies, fish samples were taken based on 2 fishing gear namely purse seine and mini purse seine while this study only used mini purse seine fishing gear. This was confirmed by Griffiths *et al.* (2010), longtail tuna in tropical waters generally have a smaller maximum length compared to fish in subtropical waters. Furthermore, it is stated that differences in fishing gear and fishing location affect the distribution of the size of the fish caught.

Table 2. The Parameters a & b in The Length-Weight Relationship Of Longtail Tuna Of Some Waters In The World

Reference	Study area	Length parameter	a	b
James *et al.* (1993)	India	TL	0,000083	2,71
Khorshidian & Carrara (1993)	Iran	FL	0,0015	2,43
Griffiths *et al.* (2010)	Australia	FL	0,00005	2,83
Darvishi *et al.* (2003)	Iran	FL	0,00004	2,7
Kaymaram *et al*. (2011)	Persian Gulf	FL	0,00002	2,83
Abdussamad *et al*. (2012)	India	FL	0,0148	3
Wagiyo & Febrianti (2015)	Langsa Waters	FL	0,0495	2,71
Restianingsih & Hidayat (2018)	Java Sea	FL	0,015	3,02
Mahmud *et al.* (2019)	Bali Strait	TL	0,00001	2,89
Penelitian ini	Java Sea	FL	0,0417	2,77

Note: TL: total length; FL: fork length

The mini purse seine is 35 cmFL. This value is greater than the fish caught in the Java Sea of previous research by 11.5 cmFL (Restianingsih & Hidayat, 2018), Langsa waters by 29 cmFL (Wagiyo & Febrianti, 2015), Australia by 15 cmFL, (Griffiths *et al*., 2010) and South Indian waters of 23 cmFL (Abdussamad *et al*., 2012). The difference in the length of the size in this study and previous studies is due to differences in fishing gear and the location of capture, differences in fishing gear cause differences in methods or capture. This is reinforced by Widodo (1988) that the difference in the value of growth parameters is more influenced by the composition of the sample fish and the method or method of capture used. If young fish are caught more then the growth coefficient will be high and vice versa, if old fish are caught a lot, then the growth coefficient will be low.

The asymptotic length (L∞) of longtail tuna based on research in the Java Sea of 55 cmFL was reached at the age of more than 15 years. The growth velocity index (Ø) value of 3.43 indicates that the growth of longtail tuna in tropical waters has rapid growth (Mahmud *et al*., 2019). The growth rate (K) in this study was 0.88/year, higher than previous studies in the Java Sea of 0.4/year (Restianingsih & Hidayat, 2018), the Persian Gulf by 0.35/year (Kaymaram *et al*. , 2011). And lower than Langsa waters by 1.5/year (Wagiyo & Febrianti, 2015), Australian waters by 0.233/year (Griffiths *et al*, 2010). The analysis showed that the asymptotic length (L∞) was 55 cmFL. This value is lower than that of longtail tuna in the Java Sea (Restianingsih & Hidayat, 2018) of 85 cmFL of the Malacca Strait (Wagiyo & Febrianti, 2015) which is 55, 65 cmFL, East Indian coast waters which are 123.5 cmFL (Abdussamad *et al*., 2012) and in the Persian Gulf at 133.79 cmFL (Kaymaram *et al*., 2011). The size of the first caught (Lc50%) longtail tuna in the Java Sea by 47.5 cmFL, this value is lower than the research of longtail tuna in the South China Sea by 47.8 cmFL (Hidayat & Noegroho, 2018). Differences in environmental characteristics, fishing gear specifications, number of fish samples, and length distribution obtained are thought to be the main factors in the difference in maximum length and growth rate. According to Pauly (1980) in Sparre & Venema (1999) that the K value is a parameter that determines how quickly the fish reach its asymptotic length.

If the value of K <1 of this fish has slow growth. A slow growth rate greatly affects the pattern of utilization. To achieve sustainable use patterns, young fish must be allowed to grow to maturity before being caught. The first size of caught (Lc50%) longtail tuna was 47.5 cm FL, while the size of the first time mature gonads (Lm50%) longtail tuna according to Hidayat & Noegroho (2018) amounted to 41.1 cmFL. This Lc value is greater than the Lm value. From these results, it is known that most of the longtail tuna caught were past the size of the first mature gonad (Lc> Lm). This shows that mini purse seine fishing gear that operates in the Java Sea is environmentally friendly to gray tuna because it has caught adult fish so recruitment can occur. This mini purse seine net can be maintained even if there are additional efforts or capture units, this type of fishing gear should be recommended. L∞, K, and t0 values from several study sites can be seen in Table 3.

Based on the results of the study found the natural mortality value (M) of longtail tuna is 1.41/year. This value is higher than previous studies in the Java Sea of 0.61/year (Restianingsih & Hidayat, 2018) and natural mortality in Langsa waters of 1.04/year. According to Ernaningsih *et al.* (2019) that natural mortality values that continue to increase can be caused by inappropriate water environment, lack of food, predation, illness, and death due to age.Capture mortality value (F) is 1.38/year. This result is the same as research in the Persian Gulf at 1.38/year (Kaymaram *et al*., 2013), higher than previous studies in the Java Sea at 1.01/year (Restianingsih & Hidayat, 2018), and lower when compared with fish caught in the Langsa waters of 2.07 (Wagiyo & Febrianti, 2015), East Indian waters of 2.94/year (Abdussamad *et al.*, 2012). According to Suman & Boer (2015) *in* Restianingsih & Hidayat (2018), it is explained that the rate of death due to capture (F) varies according to the diversity of capture effort each year. F value indicates how much and increasing the pressure of fishing (fishing pressure) on fish stocks in water. According to Restianingsih & Hidayat (2018) not only because of differences in fishing pressure, but differences in the value of natural mortality and fishing mortality are also influenced by the number of fish samples and the size range obtained.

Based on the study it was found that the utilization rate (E) of longtail tuna in the Java Sea was 0.49. This value is smaller than previous studies in the Java Sea by 0.59 (Restianingsih & Hidayat, 2018), Langsa waters by 0.51 (Wagiyo & Febrianti, 2015) and in East Indian waters by 0.774 (Abdussamad *et al*., 2012). The exploitation rate (E) indicates that the utilization rate of longtail tuna is still under-exploited (E = 0.50). According to Pauly *et al*. (1984) states that the value of rational and sustainable exploitation rates in a watershed at E <0.50 or the highest at E = 0.50. So that utilization activities can be increased until they reach the optimum limit (Pauly, 1987 in Yuliana, 2017). Increased utilization must be balanced with management strategies for tuna fishing. Efforts such as setting the net, and setting the minimum fish length size that can be taken. Besides, the regulation of fishing gear that can be used, the minimum length of fish that can be caught, including the prohibition of fishing when the spawning season (Yuliana *et al.*, 2016).

Table 3. Estimation Growth Parameter Of Longtail Tuna In Several Locations

Reference	Study area	L∞	K	t_0
Wilson (1981a)	Papua New Guinea	122,9	0,41	-0,032
Wilson (1981b)	Papua	131,8	0,395	-0,035
Silas *et al.* (1985)	India	93	0,49	-0,240
Supongpan &Saikliang (1987)	Thailand	58,2	1,44	-0,27
Prabhakar & Dudley (1989)	Omani Waters	133,6	0,228	
Yesaki (1989)	Thailand	108	0,55	
Itoh *et al.* (1999)	Japan	55	1,7	-0,089
Griffiths *et al.* (2010)	Australia	135,4	0,233	-0,02
Kaymaram *et al*. (2011)	Persian Gulf	133,79	0,35	
Abdussamad *et al*. (2012)	India	123,5	0,51	-0,0319
Wagiyo & Febrianti (2015)	Malacca Strait	55,65	1,5	
Restianingsih & Hidayat (2018)	Java Sea	85	0,4	-0,046
Mahmud *et al*., (2019)	Bali Strait	86,1	0,12	-0,24
This Research	Java Sea	55	0,88	-0,154

CONCLUSION

The length-weight relationship of negative allometric longtail tuna is negative with b = 2.7776. The asymptotic length (L∞) of longtail tuna based on research in the Java Sea is 55 cm FL, the growth velocity index (Ø) is 3.43, the growth rate (K) is 0.88/year and the size first changes ($LC_{50\%}$)of longtail tuna in the Java Sea at 47.5 cmFL.

The total mortality value (Z) of longtail tuna in the Java Sea is 2.79/year, the natural mortality (M) value of longtail tuna is 1.41/year Captured mortality (F) is obtained from F = Z-M is 1.38 per year. This shows the natural mortality value in longtail tuna in the Java Sea is greater than the mortality.Utilization level (E) of longtail tuna in the Java Sea is 0.49 (less exploited), which means there is a need to increase utilization.

Management strategies for longtail tuna in the Java Sea can be done with arrangements such as nets and setting the minimum fish length that can be taken. Besides, it can also regulate fishing gear that can be used, the minimum length of fish that can be caught, including the prohibition of catching fish compilation spawning season.

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