Relationship between length and weight of skipjack tuna (Katsuwonus pelamis) purse seine catching in the Maluku Sea, Indonesia

by Cek Turnitin

Relationship between length and weight of skipjack tuna (*Katsuwonus pelamis*) purse seine catching in the Maluku Sea, Indonesia

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Abstract. An important information that needs to be known in terms of fisheries resource management, is determining fish growth patterns and catch period, so fisherman catching only feasible fish category. The observations were made from 5 November 2018 to 5 May 2019. The area of fishing operations was in the Maluku Sea. Growth patterns during the observation of skipjack tuna (*Katsuwonus pelamis*) were negative allometric and fish that have been feasible to catch during practice as many as 124 fish from a total sample of 664 fish. The catches obtained during the observation were 94,896 kg in 27 times the settings that have been carried out for four trips with the composition of catch: *Decapterus macrosoma* of 8,012 kg (8.44%), *K. pelamis* amounting 61,189 kg (64.48%), *Thunnus albacares* 24,345 kg (25.66%), *Xiphias gladius* 50 kg (0.06%), *Euthynnus affinis* 1,289 kg (1.36%).

Key Words: length-weight relationship, catches, feasible catching, *K. pelamis*, fisheries resource management.

Introduction. Skipjack tuna (*Katsuwonus pelamis*) is targeted by various types of fishing gear in coastal countries (Novianto et al 2019). In Indonesia, *K. pelamis* is one of the main capture fisheries commodities that have good development potential (van Duijn et al 2012). The largest producer country is Japan with a total catch of 28%, followed by Indonesia 25%, Maldives 21% and other countries 26% (IPNLF 2016). Species caught using pole and line are skipjack tuna *Katsuwonus pelamis*, yellowfin tuna *Thunnus albacares*, bigeye tuna *Thunnus obesus* and albacore *Thunnus alalunga* (Nainggolan et al 2017).

Arimoto (1999) stated that environmental friendly fishing technology is a fishing gear that has no negative impact on the environment, did not damage the water bottom (benthic disturbance), has less possible lost and low contribution on pollution. The length-weight relationship of fish is one of the important information that needs to be known in terms of fisheries resource management, for example in determining fishing gear selectivity and fishing time so that only fish that are caught are of a decent size (Merta 1993).

Richter (2007) further stated that the measurement of fish length and weight aims to find out the specific weight and length variation of fish individually or groups of individuals as a guide to obesity, health, and physiological conditions including gonadal development. Length-weight relationship analysis can also estimate the condition factor or often called the index of plumpness, which is one of the important aspects of growth to compare the conditions or the relative health conditions of certain fish populations or individuals. In accordance with growth, Nakamura (1969) divides *K. pelamis* into six ecological levels, namely: larvae and post larvae levels, prajuvenil, juvenil, adolescent, spawners, spent fish.

Morphology of K. pelamis. *K. pelamis* is a medium-sized fish from the *Scombridae* family. It is the only species of the genus *Katsuwonus*. The largest fish body length can reach 1 m with a weight of more than 18 kg. *K. pelamis* which are caught are about 50 cm length.

The size of *K. pelamis* in various waters of the world when they first spawn/mature gonads is different. In its development, *K. pelamis* will reach adulthood at the fourth stage. At this stage, *K. pelamis* can reach a length of 39.1 cm for males and 40.7 for females.

K. pelamis begin to spawn at about 40 cm long and each time they can produce 1,000,000-2,000,000 eggs. *K. pelamis* spawn throughout the year in equatorial waters or between spring and early fall for subtropical regions. The spawning period will get shorter and farther away from the equator. FAO (1983) suggests that *K. pelamis* generally measures 40-80 cm with a maximum size of 100 cm.

Fish growth. Growth is an increase in size, both in length and weight. Growth is influenced by genetic, hormonal and environmental factors (nutrients) (Fujaya 2002).

Length-weight relationship. The relationship between length and weight of fish are allometric negative, allometric positive and isometric. Isometric growth is where the increase in fish length is balanced by weight gain, whereas allometric growth is the length increase faster or slower than the weight gain (Effendi 1997).

According of Nugraha (2010), *K. pelamis* in the Banda Sea have long been exploited and have shown signs of overfishing, this is marked by a decrease in fish catch and size, changes in catch composition, and a tendency to increase the proportion of some small-sized fish.

Analysis of growth parameters. To predict the growth of *K. pelamis*, the fish frequency is determined first. Furthermore, the age group of fish is determined by the Sparre & Venema (1998) method. The results of Cohort grouping on long frequency data obtained the average length of each age group. The average length value is then plotted against age so that the shape of the growth curve was obtained. Estimates of growth coefficient (K) and total length (L) values is obtained based on the Ford-Walford method (Sparre & Venema 1999). After knowing the values of K, L and t0, it can be determined the growth model and longevity relationship of *K. pelamis*, from the Bone Bay region by entering the values of the growth parameters into the growth model of Sparre & Venema (1998).

Capable size. The size of a fish worth catching is the size of the fish at the length of the first gonad ripening (length at first maturity = Lm). To get the Lm value, a sigmoid curve is made between the middle value of the class and the cumulative frequency (%) of skipjack (*Katsuwonus pelamis*). The intersection between F50 and sigmoid curves is the value of Lm.

Material and Method. The present research was conducted from November 2018 until May 2019 using purse seine vessels in the Indonesian Maluku Sea. The equipment used during the study were: portable GPS, caliper, watch, camera, writing tools, meter/measuring board, digital scales, calculator.

Data collecting method. Data collection was carried out by means of observation by following all the activities of purse seine fishing. Data collection was also carried out by interviewing respondents using the help of questionnaires, documentation of various activities on board and the study of various literatures from various types of reports. Fish length can be measured by measuring the total length (TL).

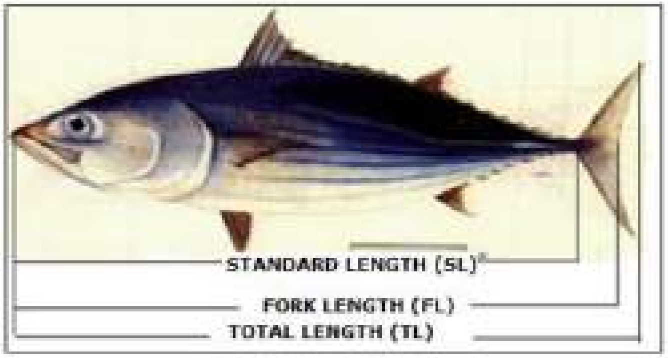

Figure 1. Measurement of the length of *Katsuwonus pelamis* (Source: WWF Indonesia, 2015).

In the weighing process fish were placed in a balanced scale by head on the left and tail to the right.

The length distribution was obtained by the class interval width, the middle value of the class, and the frequency in each group of length distributions of the length frequency that have been determined in the same class interval and then plotted in a graph.

Length and weight relationship. The relationship between length and weight is described in two isometric and allometric forms. For these two patterns we used the following equation:

$$W=aL^b$$

Where W is the weight of the fish and L is the length of the fish, while a is the coefficient value and b is an exponent that indicates isometric growth when the value of b = 3

Linearized through logarithmic transformation, the equation is obtained:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

To get parameters a and b, simple linear regression analysis was used with Log W as 'y' and Log L as 'x'.

To test a significant value of b not equal to 3, a t-test with a significant level was performed (Sukimin et al 2016), with a hypothesis:

H0: β = 3, the relationship between length and weight is isometric which means length and weight are balanced.

H1: β ≠ 3, the relationship between length and weight of fish is allometric.

If β it is less than 3 then it is negative allometric means that the length of the fish is more dominant than the weight of the fish while if more than 3 then it is positive allometric means the weight of the fish is more dominant than the length of the fish.

Condition factor. The relative weight (Wr) and the coefficient (K) of the condition factor are used to evaluate the condition factor of each individual, the relative weight (Wr) is determined based on the Rypel & Richter (2008) equation as follows:

$$Wr = W / Ws \times 100$$

Where Wr is the relative weight, W is the weight of each fish, and Ws is the standard weight predicted from the same sample because it is calculated from the combined length-weight regression through the distance between species.

$$Ws = a L^b$$

Fulton condition coefficient (K) is determined based on Okgerman (2005) with the following formula:

$$K = WL^{-3} \times 100$$

Where K is a condition factor, W is weight (g), L is length (cm) and -3 is the coefficient of length to ensure that the value of K tends to be 1.

Fishing ground. In conducting the research two fishing grounds were observed in Fisheries Management Area (FMA) 715 namely the North Maluku Sea and the South Maluku Sea. The southern Maluku Sea between 01º11'52''S and 124º37'23''E to 01º23'47''S and 124º37 '10''E and 01º10'02''S and 125º34'33''E to 01º27'30 ''S and 126º31'55''E which is about 200 NM from a fishing ground in the northern Maluku Sea between 01º56'52''N and 126º07'15''E to 01˚56'04''N and 127˚05 '42''E to 01º38'56''N and 126º06'34''E to 01º37'17''N and 127º05'39''E which is about 100 NM from the fishing base can be seen in Figure 2.

Figure 2. Fishing ground.

Sampling fish length and weight. Fish sampling caught with purse seine was measured in length and weight which were randomly taken. Mminimum of 30 individuals per catch in each setting from FMA 715 waters were considered.

Length measurement. The measured fish length was the total length, which is the length of the fish from the tip of the front mouth to the tip of the tail, and the fish that have been measured were directly separated for weight measurement. An example of measuring the total length used can be seen in Figure 3.

Figure 3. Measurement of length (original).

Measurement of fish length and weighing aims to determine fish growth patterns and the effect of environmental changes on fish growth.

Results. The types of catches obtained during capture operations in December 2018 can be seen in Table 1.

Table 1

Catches in December 2018

Common name	*Scientific name*	*Amount (kg)*
Shortfin scad	*Decapterus macrosoma*	3,220
Skipjack tuna	*Katsuwonus pelamis*	12,202
Yellowfin tuna	*Thunnus albacares*	4,342
Total		19,764

This catch was obtained with a total of five times the settings in one trip. The percentage of catches for December 2018 can be seen in Figure 4.

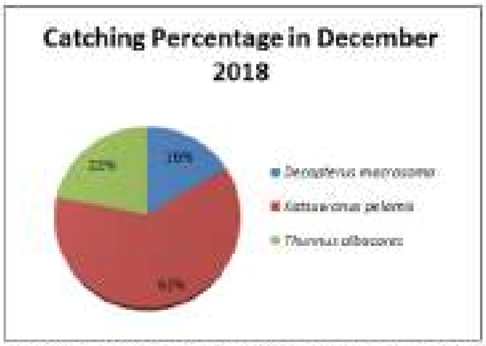

Figure 4. Diagram of percentage of catches in December 2018.

Composition of catches in January 2019. The types of catches obtained during capture operations in January 2019 can be seen in Table 2.

Table 2

Catches in January 2019

Common name	*Scientific name*	*Amount (kg)*
Shortfin scad	*Decapterus macrosoma*	3,481
Skipjack tuna	*Katsuwonus pelamis*	28,739
Yellowfin tuna	*Thunus albacares*	4,001
Common dolphinfish	*Coryphaena hippurus*	50
Mackarel	*Euthynnus affinis*	424
Total		36,695

This catch is obtained with a total of nine times the settings in one trip. The percentage of catches for January 2019 can be seen in Figure 5.

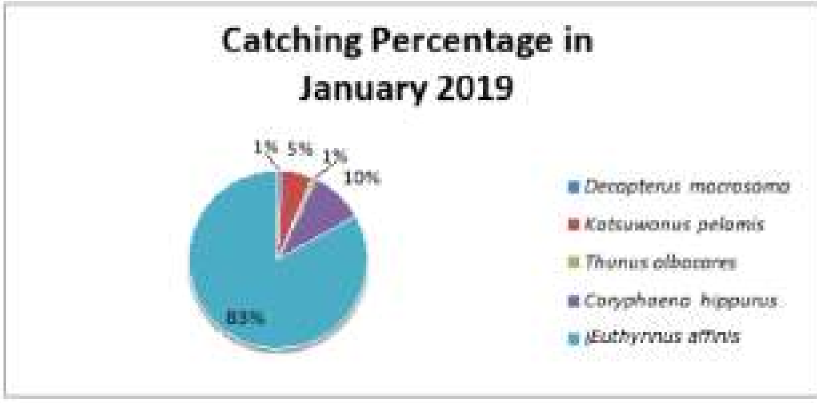

Figure 5. Diagram of percentage of catches in January 2019.

So it can be concluded that the biggest catch in January 2019 was constituted of *K. pelamis* with a percentage of 78.32% and the lowest catch by *C. hippurus* (0.14%).

Composition of catches in February 2019. The dstribution of catches obtained during fishing operations in February 2019 can be seen in Table 3.

Table 3

Catches in February 2019

Common name	*Scientific name*	*Amount (kg)*
Shortfin scad	*Decapterus macrosoma*	1,311
Skipjack tuna	*Katsuwonus pelamis*	8,023
Yellowfin tuna	*Thunnus albacares*	6,525
Mackerel	*Euthynnus affinis*	515
Total		16,374

This catch was obtained with a total of nine times settings in one trip. The catch percentage process for February 2019 can be seen in Figure 6.

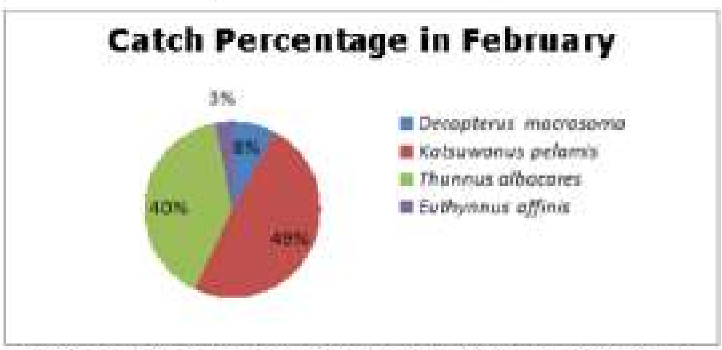

Figure 6. Diagram of percentage of catches in February 2019.

So it can be concluded that the highest catches in February 2019 was of *T. albacares* representing 40% and the lowest catch was represented by E. affinis with 3%.

Composition of catches in March 2019. The types of catches obtained during capture operations in March 2019 can be seen in Table 4.

Table 4

Catches in March 2019

Common name	*Scientific name*	*Amount (kg)*
Mackerel tuna	*Euthynnus affinis*	350
Skipjack tuna	*Katsuwonus pelamis*	12,225
Yellowfin tuna	Thunnus albacares	9,488
Total		22,063

This catch was obtained by a total of four time settings in one trip. The percentage of catches in March 2019 can be seen in Figure 7.

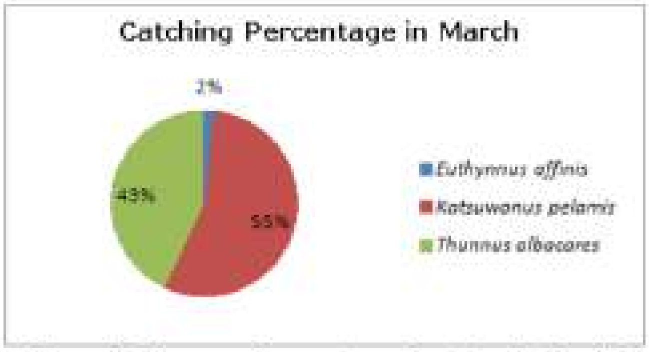

Figure 7. Diagram of percentage of catches in March 2019.

So it can be concluded that catches in March 2019 was dominated by *K. pelamis* with 43% and the lowest catch was represented by *E. affinis* (2%).

Composition of catches for four months. The catches composition in four months on purse seine were *Decapterus macrosoma* 8,012 kg (8.44%), *K. pelamis* 61,189 kg (64.48%), *Thunnus albacares* 24,356 kg (25.66%), *C. hippurus* 50 kg (0.06%), and *Euthynnus affinis* 1,289 kg (1.36%) (Table 5).

Table 5

Types of fish caught for four months

Common name	*Scientific name*	*Amount (kg)*	*Percent (%)*
Scad	*Decapterus macrosoma*	8,012	8.44
Skipjack tuna	*Katsuwonus pelamis*	61,189	64.48
Yellow fin	*Thunnus albacares*	24,356	25.66
Mackerel tuna	*Euthynnus affinis*	1,289	1.36
Common dolphinfish	*Coryphaena hippurus*	50	0.06
	Total	94,896	100

The percentage of fish species broken down for the four months can be seen in Figure 8.

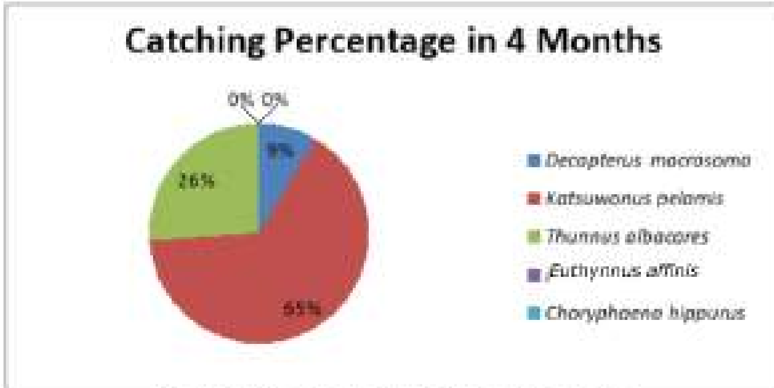

Figure 8. Types of catches for four months.

Length and weight measurement of K. pelamis. A *K. pelamis* sample captured during December 2018 - March 2019 by purse seine can be seen in Figure 9.

Figure 9. *Katsuwonus pelamis* (original).

The measurement results of the *K. pelamis* sampled had a maximum length of 77 cm and a maximum weight of 7,595 g, while the *K. pelamis* in the subsequent measurements were measured to have a minimum length of 22 cm and a minimum weight of 175 g, and the average length of the *K. pelamis* during observation was 34.09 cm and an average weight of 796.03 grams. Sample for length and weight measurements consisted of 664 individuals due to very limited opportunities in the observation location. The detailed measurement results can be seen in Table 6.

Table 6

The results of length and weight measurements *Katsuwonus pelamis*

Research time	*Samples (n)*	*Length (cm)*			*Weight (g)*		
		Max	*Min*	*Avarage*	*Max*	*Min*	*Avarage*
December	150	57	22	34.45	3.235	175	847.17
January	240	77	23	34.46	7.595	240	784.36
February	210	51	23	36.01	2.195	240	862.80
March	64	35	25	31.44	910	410	725.77
During observation	664	55	23.25	34.09	3.483	266.3	796.03

n - number of sampled individuals.

Based on observations of *K. pelamis* catches caught with purse seine in December 2018 - March 2019 we recorded 664 individuals, while processing the length of captutred specimens. The detailed results concerning the length and weight of *K. pelamis* during observation can be seen in Table 7.

Table 7

Length and weight of *Katsuwonus pelamis* during observation

Month	*n*	*a*	*b*	*r*	*T count*	*T table*	*Growth pattern*
December	150	0.018907	2.97	0.9890	49,468	1.65	Allometric negative
January	240	0.034649	2.79	0.9402	57,461	1.65	Allometric negative
February	210	0.027348	2.86	0.9601	49,519	1.65	Allometric negative
March	64	0.955329	1.92	0.9986	9,054	1.66	Allometric negative
During observation	664	0.036211	2.79	0.9486	77,862	1.64	Allometric negative

n - number of samples, a - intercept, b - slope, r - correlation.

Table 7 shows that *K. pelamis* from December 2018 to March 2019 experienced a negative allometric growth pattern because the value of b was less than 3, which means that the length growth is higher than weight growth. The r value close to 1, can be interpreted that there is a close relationship between the length growth and weight growth of *K. pelamis*.

Length and weight relationship of K. pelamis in December 2018. In Table 7 it is showed that the *K. pelamis* sampled in December 2018 consisted of 150 individuals had a value of a = 0.018907 and b = 2.97 with r = 0.9890, so that the length and weight of *K. pelamis* obtained in December 2018 was $W = 0.018907L^{2.97}$. A graphical representation of the relationship between the length and weight of *K. pelamis* in December 2018 can be seen in Figure 10.

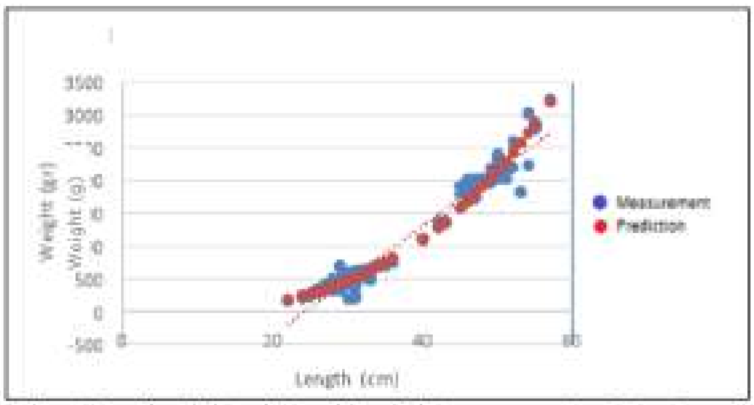

Figure 10. Length and weight relationship of *Katsuwonus pelamis* in December 2018.

Based on the value of b obtained from the equation $W = 0.018907L^{2.97}$ were b = 2.97 where b<3 so it is suspected that the growth pattern of *K. pelamis* in December was negative allometric, this indicates that the weight increased faster than length, r calculation = 0.98 means that the value of r is close to 1. This shows that there is a close relationship between length and weight.

Length and weight relationship of K. pelamis in January 2019. In Table 7 it is shown that in January 2019, 240 *K. pelamis* individuals were sampled with value of a = 0.034649 and b = 2.79 with r = 0.94, so that the length and weight of the *K. pelamis* in January 2019was $W = 0.034649L^{2.79}$. A graphical representation of the relationship between the length and weight of *K. pelamis* in January 2019 can be seen in Figure 11.

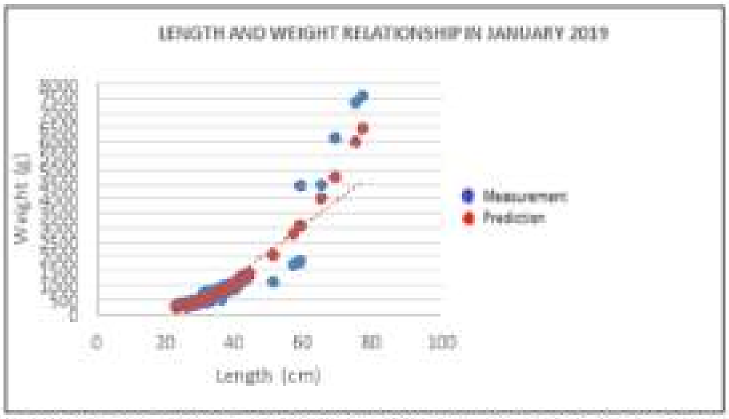

Figure 11. Length and weight relationship of *Katsuwonus pelamis* in January 2019.

Based on the value of b obtained from the equation $W = 0.034649L^{2.79}$ were b = 2.79 where b<3, it is suspected that the growth pattern of *K. pelamis* in January was negative allometric, this indicates that the weight increased higher than the length, calculation of r = 0.9402 means that the value of r is close to 1. This shows there is a close relationship between length and weight.

Length and weight relationship of K. pelamis in February 2019. In Table 7 it is shown that in February 2019, 210 *K. pelamis* individuals were sampled with a = 0.027348 and b = 2.86 with r = 0.96, so that the length and weight of *K. pelamis* in February 2019 was $W = 0.027348L^{2.86}$. The graphical representation of the length and weight relationship of *K. pelamis* in February 2019 can be seen in Figure 12.

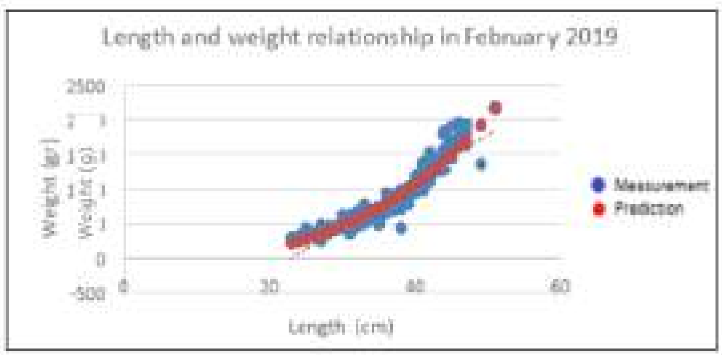

Figure 12. Length and weight relationship of *Katsuwonus pelamis* in February 2019.

Based on the value of b obtained from the equation $W = 0.027348L^{2.86}$ where b = 2.86 where b<3 so that it is suspected that the growth pattern of *K. pelamis* in February was negative allometric, this indicates that the weight increased higher than the length; r = 0.96 means that the value of r is close to 1. This shows the existence of a close relationship between length and weight.

Length and weight relationship of K. pelamis in March 2019. In Table 7 it can be seen that in March 2019, 64 *K. pelamis* individuals were sampled with a = 0.955329 and b = 1.92 with r = 0.99, so that the length and weight of *K. pelamis* obtained in March 2019was $W = 0.955329L^{1.92}$. A graphical representation of the relationship between the length and weight of *K. pelamis* in March can be seen in Figure 13.

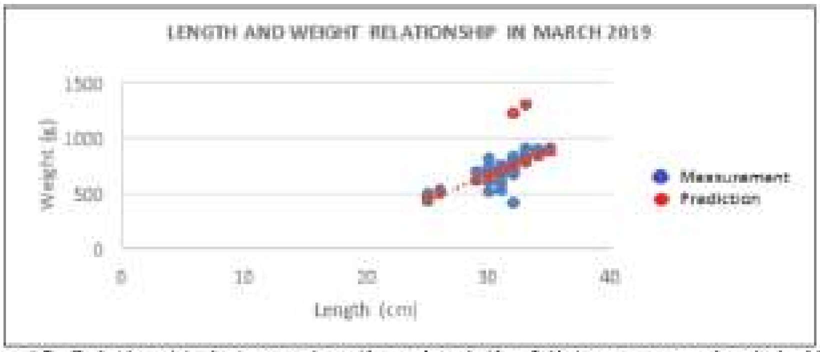

Figure 13. Relationship between length and weigth of *Katsuwonus pelamis* in March 2019.

Based on the value of b obtained from the equation $W = 0.955329L^{1.92}$, where b = 1.92 where b<3, it is suspected that the growth pattern of *K. pelamis* in March was negative allometric, this indicates that the growth of its weight is slower than its length increase; r = 0.99 means the value of r is close to 1. This shows there is a close relationship between length and weight.

Length and weight relationship of K. pelamis during observation. So from 664 tuna fish that were sampled during the observation we obtained a value of 0.036211 and b = 2.79 with r = 0.9494, so that the length and weight of *K. pelamis* revealed $W = 0.036211L^{2.79}$. The graphical representation of the length-weight relationship of *K. pelamis* during observations can be seen in Figure 14.

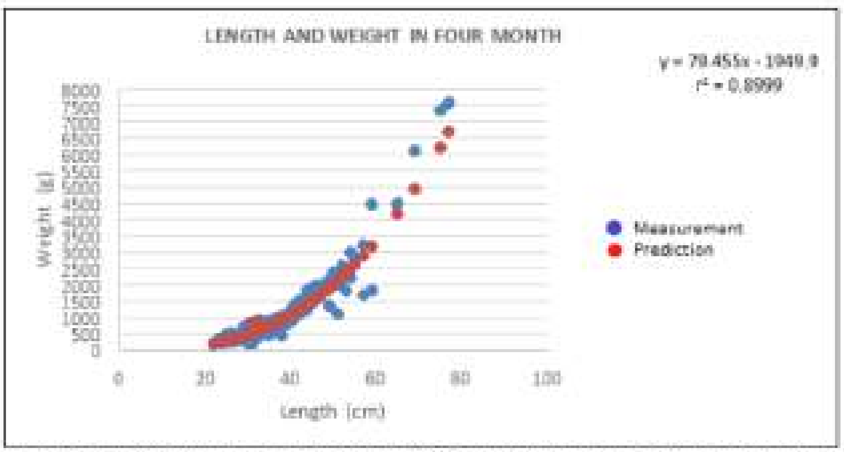

Figure 14. Length-weight relationship of *Katsuwonus pelamis* during observation.

Based on the value of b obtained from the equation $W = 0.036211L^{2.79}$ where b = 2.79 and b<3, it is suspected that the growth pattern of *K. pelamis* during the observation is negative allometric. Indicating that the growth of the weight increases higher than the length, the calculation of r = 0.95 means that the value of r is close to 1. This shows that there is a close relationship between the length and weight. The graphical represention of the relationship between the length and weight of *K. pelamis* from December 2018 to March 2019 can be seen in Figure 15.

During the observation there was a value of b = 2.79 but if it is calculated monthly will get a value of b that varies. But from December 2018 to March 2019 the results show that the growth of *K. pelamis* in the Maluku Sea was negative allometric which indicates that lenght growth is faster than fish weight increase.

Feasible catching frequency of K. pelamis in December 2018. According to Nugraha & Rahmat (2008) the first maturation of *K. pelamis* occurring at a size of 40.0-40.6 cm, so that in conclusion *K. pelamis* that should be caught should be above 40.6 cm. The *K. pelamis* diagram concerning feasible and infeasible to catch in December 2018 can be seen in Figure 15.

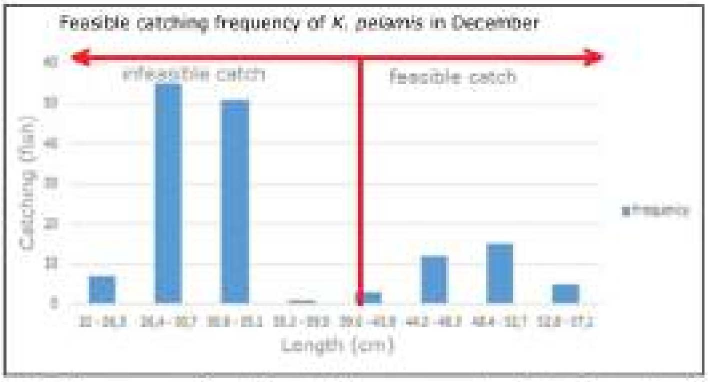

Figure 15. Frequency of catching *Katsuwonus pelamis* in December 2018.

In December 2018 during the observation there were 150 *K. pelamis* individuals as samples in 5 settings. In the class length of 39.6-43.9 cm, there were three individuals caught, two of them were already feasible to catch, so that in December 2018 there were 34 fishes of *K. pelamis* which were feasible to catch and 116 fishes were infeasible to catch. The highest frequency of *K. pelamis* in the class of 26.4-30.7 cm was represented by 56 individuals and the lowest frequency was recorded for the class of 35.2-39.5 cm with one individual.

K. pelamis catching frequency in January. The frequency of caught *K. pelamis* in January 2019 can be seen in Figure 16.

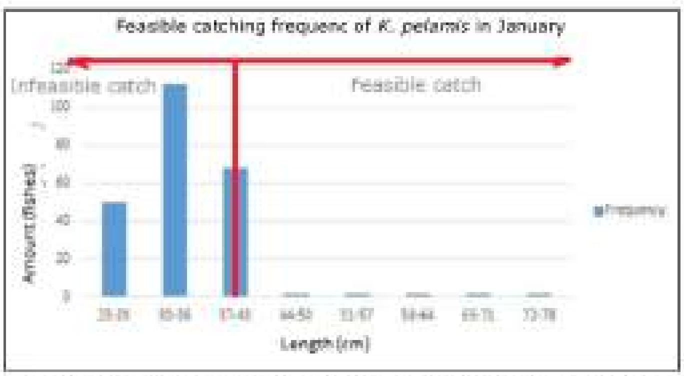

Figure 16. Frequency of *Katsuwonus pelamis* worth catching in January 2019.

In January 2019 during the observation there were 240 *K. pelamis* as samples in nine settings. In class length 37.0-43.0 cm, was represented by 68 individuals, 20 of them were already feasible to catch so that in January 2019 there were 30 feasible and 210 not feasible *K. pelamis*. The highest frequency of *K. pelamis* was the class of 30.0-36.0 cm counting 112 individuals and the lowest frwquency was recorded for the class 44.0-50 cm and class 72.0-78.0 cm each class counting two individuals.

***K. pelamis* catching frequency in February 2019**. The frequency of *K. pelamis* caught in February 2019 can be seen in Figure 17.

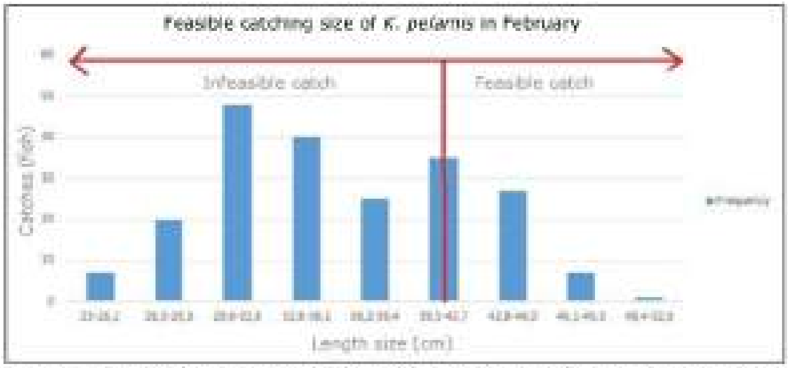

Figure 17. Frequency of *Katsuwonus pelamis* worth catching in February 2019.

In February 2019 during the observation there were 210 *K. pelamis* as samples in nine settings. In class length 39.5-42.7 cm, there were 35 individuals caught, of which 25 were at the feasible catching size, so that in February 2019 there were 60 feasible and 150 not feasible *K. pelamis*. The highest frequency of *K. pelamis* was in the class of 29.6-32.8 cm with 48 fish and the lowest frequency was represented by the class of 49.4-52.6 cm with one fish.

***K. pelamis* catching frequency in March 2019**. The frequency of caught *K. pelamis* in March 2019 can be seen in Figure 18.

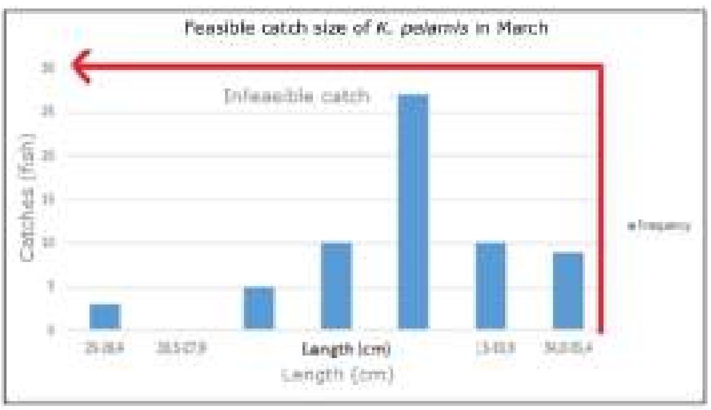

Figure 18. Frequency of *Katsuwonus pelamis* feasible catch in March 2019.

In March 2019 during the observation there were 64 *K. pelamis* as samples in four settings. Also there was no *K. pelamis* that was feasible to catch because this month the maximum length of the *K. pelamis* was 35 cm while the minimum feasible length is 40.6 cm. All the catch was categorized in the class of 31.0-35.4 cm with all 27 specimens caught. So that in March 2019 *K. pelamis* in the Maluku Sea was still classified as immature, so they were infeasible to catch.

Frequency of K. pelamis catching during observation. The frequency of *K. pelamis* caught during observation can be seen in Figure 19.

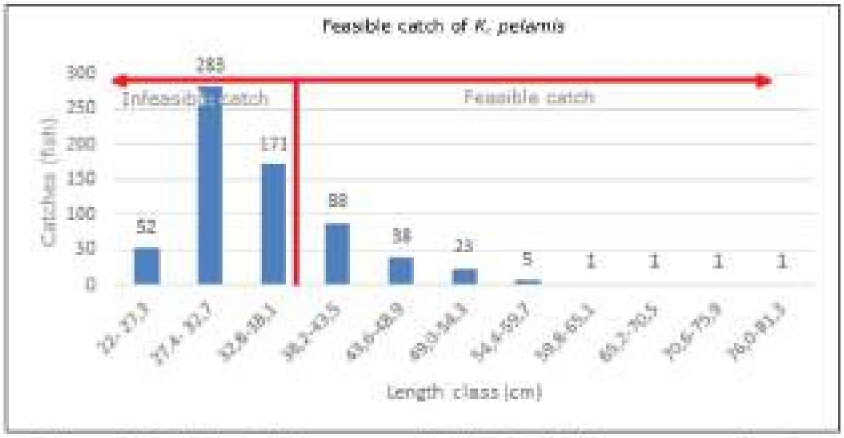

Figure 19. The length frequency distribution of *Katsuwonus pelamis*.

During the observation there were 664 *K. pelamis* samples in four months in the Maluku Sea from out of which 124 specimens were of 40.7 cm and above, and was declared feasible for catch. A graphical representation of the feasible and infeasible catch can be seen in Figure 20.

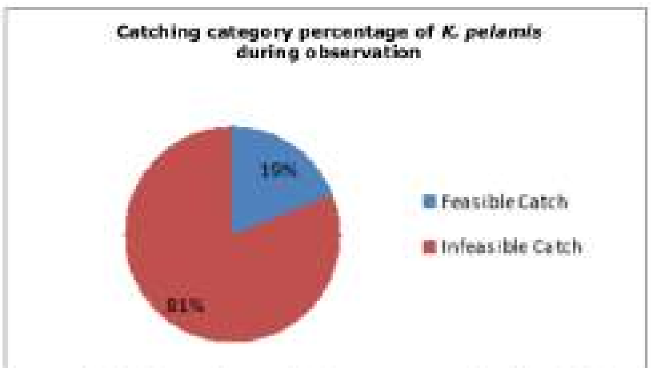

Figure 20. Percentage of *Katsuwonus pelamis* catching.

Figure 20 shows that the percentage of *K. pelamis* which was already feasible to catch was 19%, this is due to several factors such as the size of the net, the location of the fishing ground where there are still fish that are infeasible to catch, and the fishing season so that there were high number of *K. pelamis* under 40.6 cm among those captured.

Conclusions. From observations following the capture in the waters of the Maluku Sea, there were several types of fish caught, including *D. macrosoma* of 8,012 kg (8.44%), *K. pelamis* 61,189 kg (64.48%), *T. albacares* 24,356 kg (25.66%), *C. hippurus* 50 kg (0.06%), and *E. affinis* 1,289 kg (1.36%) with a total catch of 94,896 kg, harvested through 27 times settings in 4 trips.

Based on observations there were 664 samples of *K. pelamis* and the results of regression analysis of the relationship of the length and weight of the *K. pelamis* resulted value of b = 2.79; the growth pattern of fish was negative allometric, and the number of fish worth catchingwas 124 individuals or about 19% of the total sample (664 individuals).

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