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Relationship Between Length and Weight of Skipjack (*Katsuwonus pelamis*) Purse Seine Catching in the Maluku Sea, Indonesia

Name of the authors:

Erick Nugraha

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

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Corresponding author
Erick Nugraha

September, 2019

Relationship Between Length and Weight of Skipjack (*Katsuwonus pelamis*) Purse Seine Catching in the Maluku Sea, Indonesia

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Abstract. One important information that needs to be known in terms of fisheries resource management, for example in determining fish growth patterns and catch times so that only fish caught are decent-sized. These observations were made from 5 November 2018 to 5 May 2019 on. The area of fishing operations is in the Maluku Sea. Growth patterns during the observation of skipjack tuna are negative allometrics 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 the catch is the mackerel (*Decapterus macrosoma*) of 8,012 kg (8.44%), skipjack (*Katsuwonus pelamis*) amounting to 61,189 kg (64.48%), yellowfin (*Thunnus albacares*) by 24.345 kg (25.66%), sword fish (*Coryphaena hippurus*) by 50 kg (0.06%), tuna (*Euthunnus affinis*) by 1,289 kg (1, 36%).

Keywords: length and weight, catches, worth catching.

Introduction. In Indonesia, Skipjack (*Katsuwonus pelamis*) is one of the main capture fisheries commodities that have good development potential (van Duijn et al 2012). Arimoto (1999) stated that environmental friendly fishing technology is a fishing gear that has no negative impact on the environment, 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 (Vanichkul & Hongskul vide Merta, 2003).

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 things of growth to compare the conditions or the relative health conditions of certain fish populations or individuals. In accordance with growth, Nakamura (1969) divides skipjack (*Katsuwonus pelamis*) into six ecological levels, namely; Larvae and post larvae levels, Prajuvenil, Juvenil, Adolescent, Spawners, Spent fish.

Morphology of Skipjack (Katsuwonus pelamis)

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

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

Skipjack fish begin to spawn when about 40 cm long and each time they can produce 1,000,000-2,000,000 eggs. Skipjack tuna (*Katsuwonus 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 skipjack tuna (*Katsuwonus pelamis*) generally measure 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, 1999).

Relationship Length and Weight

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).

The difference in the value of *b* in fish is not only between different populations of the same species, but also between the same population in different years which may be associated with their nutritional conditions. This can occur due to the influence of ecological and biological factors. (Ricker, 1975).

Fish size is determined based on the length or weight. Older fish, generally longer and fatter. At the same age, female fish are usually heavier than male fish. When the eggs are ripe, the fish experience weight and volume increase. After laying the weight will return down. The growth rate of fish is also influenced by the availability of food in their environment (Poernomo, 2002).

Analysis of Growth Parameters

To predict the growth of skipjack (*Katsuwonus pelamis*), the fish frequency is determined first. Furthermore, the age group of fish is determined by the Tanaka (1960) vide Sparre & Venema (1999) 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 is obtained. Estimates of growth coefficient (K) and total length (L) values were obtained based on the Forl-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 skipjack (*Katsuwonus pelamis*), from the Bone Bay region by entering the values of the growth parameters into the growth model Von Bertalanffy (1934) vide Sparre & Venema (1999).

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, it is done by making a sigmoid curve 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. This research was conducted in November 2018 until May 2019 using purse seine vessels in the Maluku Sea Indonesian.
The equipment used during the study is as in table 1:

Table 1

Tools and materials

Tool Name	*Usage*
Portable GPS	to find out the position
Caliper	to measure the diameter of an object
Clock	for timepiece
Camera	As a documentation tool
Writing Tools	To record data needed
Meter / measuring board	To measure the length of fish caught
Digital scales	For weighing the catch of fish
Calculator	for doing calculations

Method of collecting data

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 literature from various types of reports. Fish length can be measured by measuring the total length (TL).

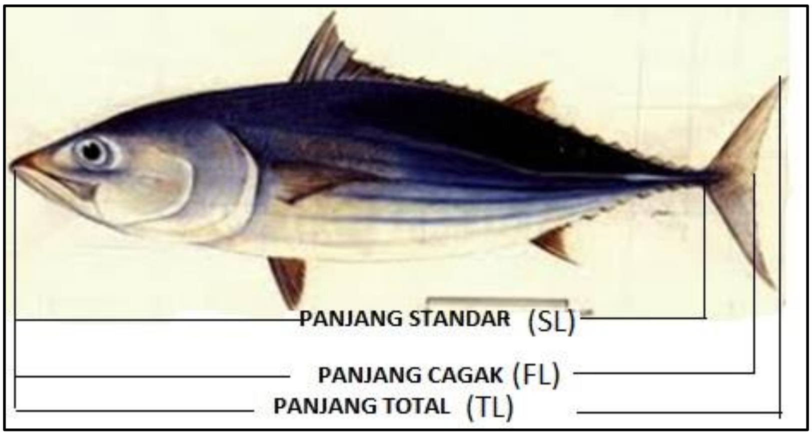


Figure 1. Measurement of the length of skipjack (*Katsuwonus pelamis*)
(source: WWF Indonesia, 2015)

In the weighing process is done by placing the Skipjack (*Katsuwonus pelamis*) with the position of the fish does not touch the ground and the body of the fish in a balanced scale by facing left and tail to right.

The length distribution is obtained by the class interval width, the middle value of the class, and the frequency in each group of length distributions of the long 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 the equation applies:

$$W=aL^b$$

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

If 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 is 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 (Sukima et al, 2016), with a hypothesis

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

H1: $\beta \neq 3$, the relationship between length and weight of fish is allometric

If 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 and Richter (2008) equation as follows:

$$\mathbf{Wr = W / Ws \times 100}$$

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.

$$\mathbf{Ws = {}_{a} L^{b}}$$

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

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

Where K is a condition factor, W is weight (gram), 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 by observing two fishing ground 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.

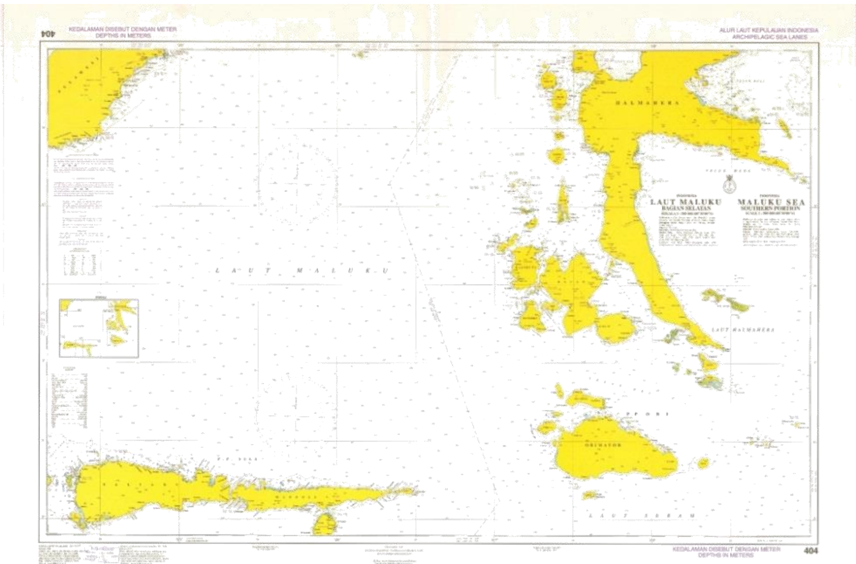


Figure 2. Fishing Ground

Sampling Fish Length and Weight

Sampling of fish caught with Purse seine will be measured in length and weight and randomly taken with a minimum of 30 per type of skipjack (*Katsuwonus pelamis*) from the catch of fishermen in each setting in waters FMA 715. The fish samples used can be seen in Figure 3.

Figure 3. Samples of skipjack fish

Length Measurement

The measured fish length is 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 are directly separated for weight measurement. An example of measuring the total length used can be seen in Figure 4.

Figure 4. Measurement of length

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 2.

Table 2

Catches in December 2018

Fish name	*Latin name Amount (kg)*	*Amount (kg)*
Scad	*Decapterus macrosoma*	3.220
Skipjack	*Katsuwonus pelamis*	12.202
Yellowfin	*Thunnus albacares*	4.342
	Total	19.764

Based on table 2 the number of types of catches obtained in December were 3,220 kg of overpass, 12,202 kg of skipjack (*Katsuwonus pelamis)*, and 4,342 kg of yellowfin tuna *(Thunnus albacares)*. So the total number of catches obtained during December 2018 is 19,764 kg. This catch is obtained with a total of five times the settings in one trip. The percentage of catches for December 2018 can be seen in figure 5.

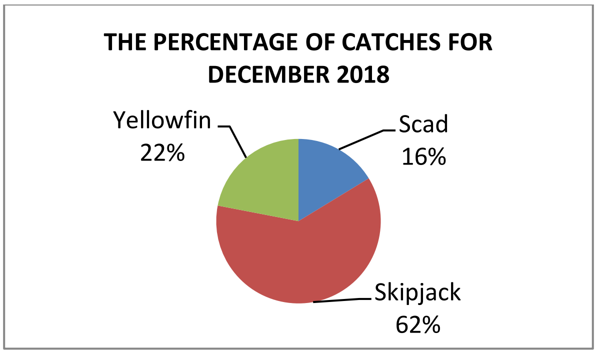


Figure 5. Diagram of percentage of catches in December 2018

Based on the picture 5 that the description of the catch diagram in December 2018 above shows the percentage of floating fish as much as 16.29%, skipjack (*Katsuwonus pelamis*) 61.74% of yellowfin (*Thunus albacares*) 21.97%. So it can be concluded that the most catch type in December 2018 is the type of tuna fish (Katsuwonus pelamis) with a percentage of 61.74% and the lowest catch is the type of flying fish (Decapterus macrosoma) 16.29%.

Composition of Catches in January 2019

The types of catches obtained during capture operations in January 2019 can be seen in Table 3.

Table 3

Catches in January 2019

Fish name	*Latin name Amount (kg)*	*Amount (kg)*
Scad	*Decapterus macrosoma*	3.481
Skipjack	*Katsuwonus pelamis*	28.739
Yellowfin	*Thunus albacares*	4.001
Dolphin fish	*Choryphaena hippurus*	50
Mackarel	*Euythunnus affinis*	424
Total		36.695

Based on table 3 the number of catches obtained in January 2019 were 3,481 kg Scad (*Decapterus macrosoma)*, 28,739 kg skipjack (*Katsuwonus pelamis*), 4,001 yellowfin tuna (*Thunus albacares*), 50 kg of Dolphin fish (*Choryphaena hippurus)* and 424 kg of Mackarel (*Euythunnus affinis)*. So the total number of catches obtained during January 2019 is 36,695 kg. 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 6.

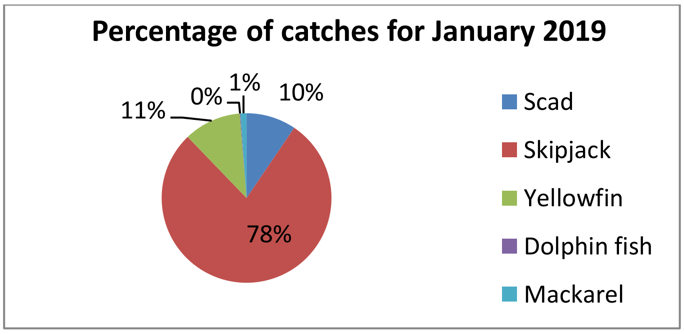


Figure 6. Diagram of percentage of catches in January 2019.

Based on Figure 6 that the description of the catch diagram in January 2019 above shows the percentage as much as 9.49% Scad (*Decapterus macrosoma)*, 78.32% skipjack (*Katsuwonus pelamis)*, 10.90% yellowfin tuna (*Thunus albacares*), 0.14%, Dolphin fish (*Choryphaena hippurus)* and 1,15% Mackarel *(Euythunnus affinis*). So it can be concluded that the most types of catches in January 2019 are skipjack (*Katsuwonus* *pelamis)* species with a percentage of 78.32% and the lowest catch is the type of Dolphin fish (*Choryphaena hippurus)* as much as 0.14%.

Composition of Catches in February 2019

The types of catches obtained during fishing operations in February 2019 can be seen in Table 4.

Table 4

Catches in February 2019

Fish name	*Latin name Amount (kg)*	*Amount (kg)*
Scad	*Decapterus macrosoma*	1.311
Skipjack	*Katsuwonus pelamis*	8.023
Yellowfin	*Thunnus albacares*	6.525
Mackarel	*Euythunnus affinis*	515
Total		16.374

Based on table 4 the number of catches obtained in February 2019 were 1,311 kg of Scad (*Decapterus macrosoma)*, 8,023 kg of skipjack (*Katsuwonus pelamis)*, 6,525 kg of yellowfin tuna (*Thunus albacares*) and 515 kg of Mackarel *(Euythunnus affinis*). So the total number of catches obtained during February 2019 is 16,374 kg. This catch is obtained with a total of nine times the settings in one trip. The catch percentage process for February 2019 can be seen in Figure 7.

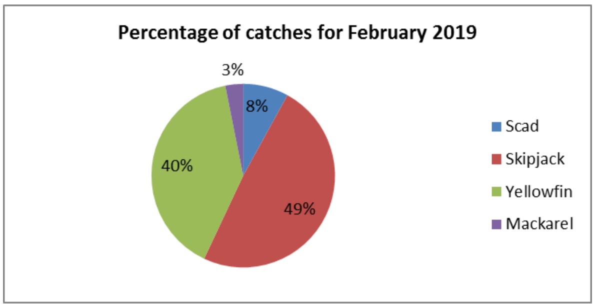


Figure 7. Diagram of percentage of catches in February 2019

Based on Figure 7 that the description of the catch diagram in February 2019 above shows the percentage of fly fish as much as 8.00%, redfin tuna 39.85%, skipjack 48.99% and 3.16% tuna. So it can be concluded that the most types of catches in February 2019 are tuna species with a percentage of 48.99% and the lowest catch is tuna species as much as 3.16%.

Composition of Catches in March 2019

The types of catches obtained during capture operations in March 2019 can be seen in Table 5.

Table 5

Catches in March 2019

Fish name	*Latin name Amount (kg)*	*Amount (kg)*
Mackerel	*Euythunnus affinis*	350
Skipjack	*Katsuwonus pelamis*	12.225
Yellowfin	Thunnus albacares	9.488
Total		22.063

Based on table 5 the number of types of catches obtained in March 2019 are 350 kg of Mackarel *(Euythunnus affinis*), 12,225 kg of skipjack (*Katsuwonus pelamis)*, and 9,488 kg of yellowfin tuna (*Thunus albacares*). So the total number of catches obtained during March 2019 is 22,063 kg. This catch is obtained by a total of four times the settings in one trip. The percentage of catches in March 2019 can be seen in Figure 8.

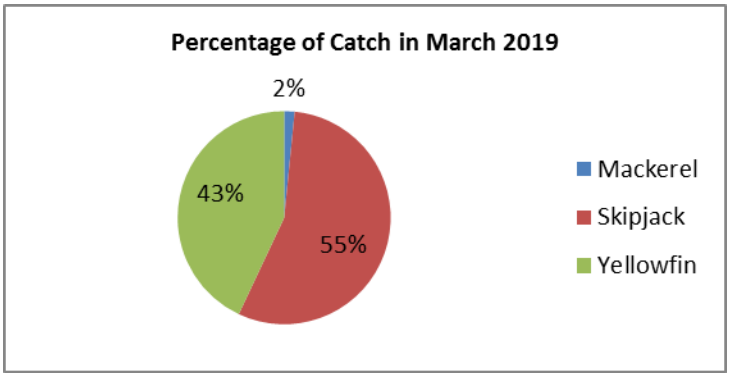


Figure 8. Diagram of percentage of catches in March 2019

Based on Figure 8, the catch diagram description in March 2019 above shows the percentage of skipjack (*Katsuwonus pelamis)* as much as 55%, Mackarel *(Euythunnus affinis*) 1.57% and yellowfin tuna (*Thunus albacares*) 43.02%. So it can be concluded that the type of the most catches in March 2019 is the type of skipjack (*Katsuwonus pelamis)* with a percentage of 55.41% and the lowest catch is the type of Mackarel *(Euythunnus affinis*) as much as 3%.

Composition of Catches for Four Months

The composition of the catches obtained during four months, namely from December 2018 to March 2019. In December 2019 the catches were 19,764 kg with the number of settings five times a setting in one trip, whereas in January 2019 the catches were 36,695 kg with a total of nine times the settings in one trip. And in February 2019 the catches were 16,374 kg with a total of nine times the settings in one trip, then the catches obtained in March 2019 were 22,063 kg with a total of four times the settings in one trip.

So it can be concluded from the above statement that the catches obtained during the four months namely, from December 2018 to March 2019 were 94.896 kg 27 times setting in 4 trips. The catch for four months can be seen in Table 6.

Table 6

Catches for four months

Month	*Settings*	*Trip*	*Catches (kg)*	*Average (kg)*
December	5	1	19.764	3.953
January	9	1	36.695	4.077
February	9	1	16.374	1.674
March	4	1	22.063	3.677
Total	27	4	94.896	3.163

Percentage of catches for four months can be seen in Figure 9.

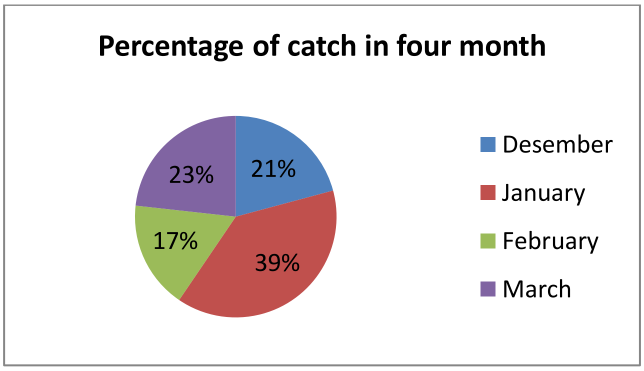


Figure 9. Chart of catch for four months

Based on Figure 9, the catch diagram description for the four months above namely in December 2018 was 20.83%, January 2019 was 38.67%, February 2019 was 17.25%, and March 2019 was 23.25%. So it can be concluded that the most catches in January 2019 with a percentage of 38.67% and the lowest catches found in February 2019 with a percentage of 17.25 Types of catches in four months can be seen in Table 7.

Table 7

Types of fish caught for four months

Fish name	*Latin name*	*Amount (kg)*	*Percent (%)*
Scad	*Decapterus macrosoma*	8.012	8,44
Skipjack	*Katsuwonus pelamis*	61.189	64,48
Yellow fin	*Thunnus albacares*	24.356	25,66
Mackerel	*Euythunnus affinis*	1,289	1,36
Dolphin Fish	*Choryphaena hippurus*	50	0,06
	Total	94.896	100

Adapun persentase jenis ikan hasil tangkapan selama empat bulan dapat dilihat pada gambar 10.

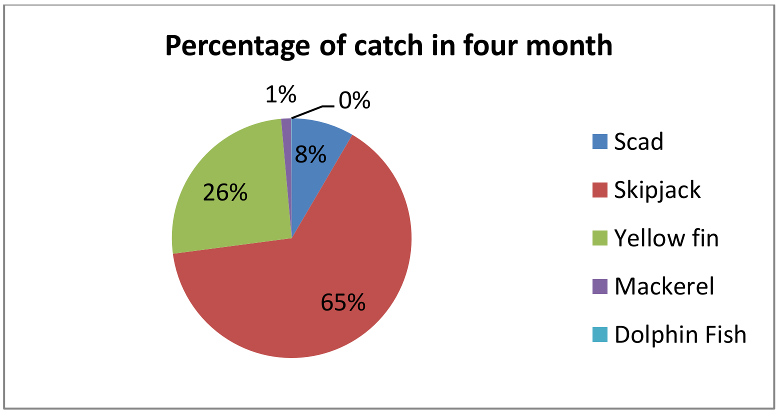


Figure 10. Types of catches for four months

Based on Figure 10, it can be seen that catches for four months on Purse seine catches with Scad (*Decapterus macrosoma*) of 8.012 kg (8.44%), skipjack (*Katsuwonus pelamis*) at 61.189 kg (64.48%), yellowfin (*Thunnus albacares*) by 24.356 kg (25.66%), Dolphin fish (*Coryphaena hippurus*) by 50 kg (0.06%), and Mackarel (*Euythunnus affinis*) by 1.289 kg (1.36%).

Length and Weight Measurement of Skipjack (Katsuwonus pelamis)

Skipjack (*Katsuwonus pelamis*) is often referred to as skipjack (*Katsuwonus pelamis*) which is obtained when finished fishing in the FMA 715 region during December 2018-March 2019 with purse seine, following the Skipjack (*Katsuwonus pelamis*) can be seen in Figure 11.

Figure 11. Skipjack (*Katsuwonus pelamis*)

The measurement results of the skipjack fish sampled have a maximum length of 77 cm and a maximum weight of 7.595 grams, while the Skipjack (*Katsuwonus pelamis*) in the subsequent measurements were measured to have a minimum length of 22 cm and a minimum weight of 175 grams, and the average length of the Skipjack (*Katsuwonus pelamis*) during observation was 34.09 cm and an average weight of 796.03 grams. From the sample which only measured length and weight was 664 individuals due to very limited opportunities in the observation location. The measurement results can be seen in Table 8.

Table 8

The results of length and weight measurements of Skipjack (*Katsuwonus pelamis*)

Research time	*Number of samples*	*Length measurement (cm)*			*Weight measurement (grams)*		
		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

In Table 8 it is known that the highest length of Skipjack (*Katsuwonus pelamis*) obtained in January 2019 was 77 cm and the highest weight obtained in January 2019 was 7,595 grams and the lowest length of Skipjack (*Katsuwonus pelamis*) obtained in December 2018 was 22 cm and the lowest weight was obtained in December 2018 by 175 grams.

Based on observations of Skipjack (*Katsuwonus pelamis*) catches caught with purse seine in December 2018-March 2019 obtained samples of Skipjack (*Katsuwonus pelamis*) as many as 664 fishes, while processing the length of the Skipjack (*Katsuwonus pelamis*). The results of the calculation of the length and weight of Skipjack (*Katsuwonus pelamis*) during observation can be seen in Table 9.

Table 9

The length and weight of skipjack fish during observation

Bulan	*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

Note: n: number of samples, a: intercept, b: slope, r: correlation

Table 9 shows that Skipjack (*Katsuwonus pelamis*) from December 2018-March 2019 experienced a negative allometric growth pattern because the value of b showed less than 3, which means that the growth of its length is faster than the growth of its weight. The value of r indicates close to 1, it can be interpreted that there is a close relationship between the growth of length and growth of Skipjack (*Katsuwonus pelamis*) weight.

Length and Weight relationship of Skipjack (Katsuwonus pelamis) in December 2018

In table 8 it is known that the Skipjack (*Katsuwonus pelamis*) sampled in December 2018 as many as 150 fishes have a value of = 0.018907 and b = 2.97 with r = 0.9890, so that the length and weight of the Skipjack (*Katsuwonus pelamis*) obtained in December 2018 is W = 0.018907L2.97 and a graph of the relationship between the length of Skipjack (*Katsuwonus pelamis*) in December 2018 can be seen in Figure 12.

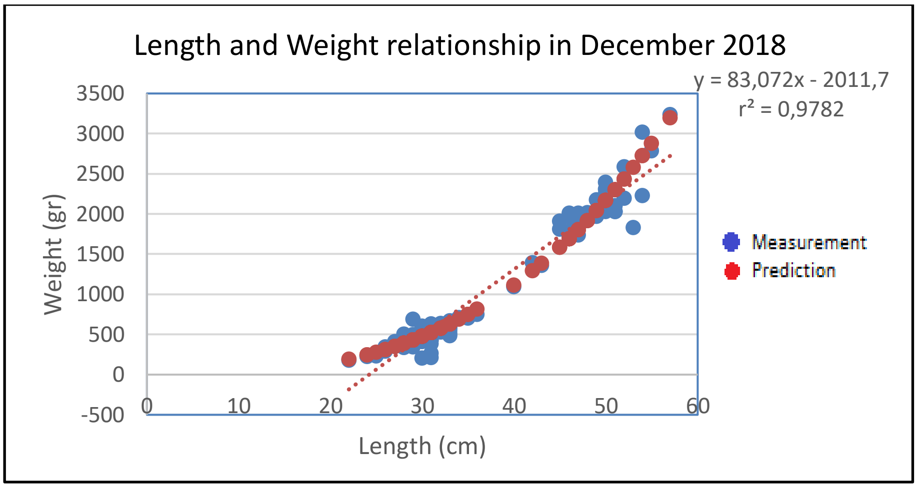


Figure 12. Length and weight relationship of skipjack fish in December 2018

Based on the value of b obtained from the equation W = 0.018907 L2.97 that the value of b = 2.97 where b <3 so it is suspected that the growth pattern of Skipjack (*Katsuwonus pelamis*) in December is negative allometric, this indicates that the weight is increasing faster than its length, r calculation = 0.98 which means that the value of r is close to 1 (one). This shows that there is a close relationship between length and weight.

Length and weight relationship of Skipjack (Katsuwonus pelamis) in January 2019

In table 11 it is known that the Skipjack (*Katsuwonus pelamis*) sampled in January 2019 as many as 240 tails have a value of a = 0.034649 and b = 2.79 with r = 0.94, so that the length and weight of the Skipjack (*Katsuwonus pelamis*) in January 2019 is W = 0.034649L2.79 and the graph of the relationship between the length of Skipjack (*Katsuwonus pelamis*) weights in January 2019 can be seen in Figure 13.

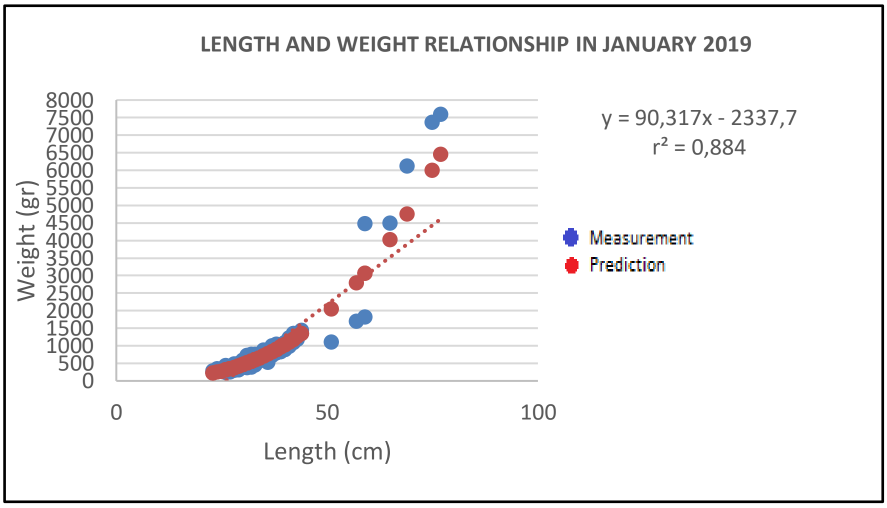


Figure 13. Length and Weight relationship of Skipjack (*Katsuwonus pelamis*) in January 2019

Based on the value of b obtained from the equation W = 0.034649L2.79 that the value of b = 2.79 where b <3 so it is suspected that the growth pattern of Skipjack (*Katsuwonus pelamis*) in January is negative allometric, this indicates that the weight is increasing longer than the length, calculation r = 0.9402 which 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 Skipjack (Katsuwonus pelamis) in February 2019

In Table 11 it is known that the Skipjack (*Katsuwonus pelamis*) that were sampled in February 2019 totaling 210 fishes have a value of = 0.027348 and b = 2.86 with r = 0.96, so that the length and weight of Skipjack (*Katsuwonus pelamis*) in February 2019 is W = 0.027348L2.86 and the graph of the relationship between the length of Skipjack (*Katsuwonus pelamis*) in February 2019 can be seen in Figure 14.

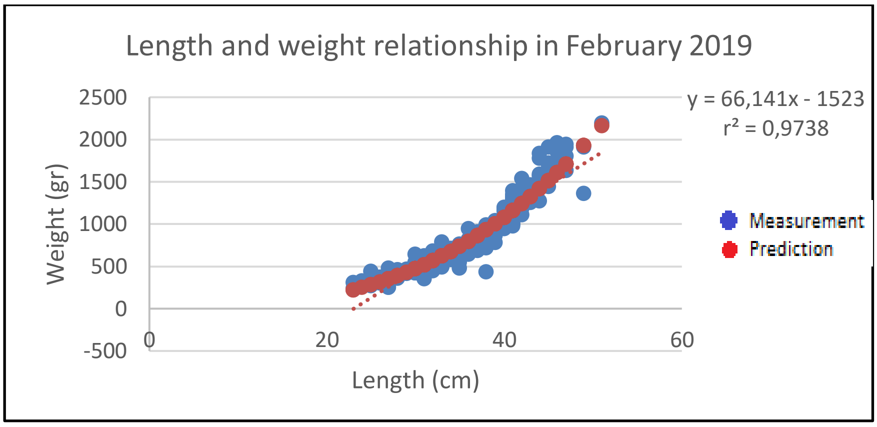


Figure 14. Length and weight relationship of skipjack (*Katsuwonus pelamis*) in February 2019

Based on the value of b obtained from the equation W = 0.027348L2.86 that the value of b = 2.86 where b <3 so that it is suspected that the growth pattern of Skipjack (*Katsuwonus pelamis*) in February is negative allometric, this indicates that the weight is increasing longer than the length, calculation r = 0.96 which 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 Skipjack (Katsuwonus pelamis) in March 2019

In table 11 it is known that the Skipjack (*Katsuwonus pelamis*) sampled in March 2019 as many as 64 tails have a value of = 0.955329 and b = 1.92 with r = 0.99, so that the length and weight of Skipjack (*Katsuwonus pelamis*) obtained in March 2019 is W = 0.955329L1.92 and the graph of the relationship between the length of Skipjack (*Katsuwonus pelamis*) in March can be seen in Figure 15.

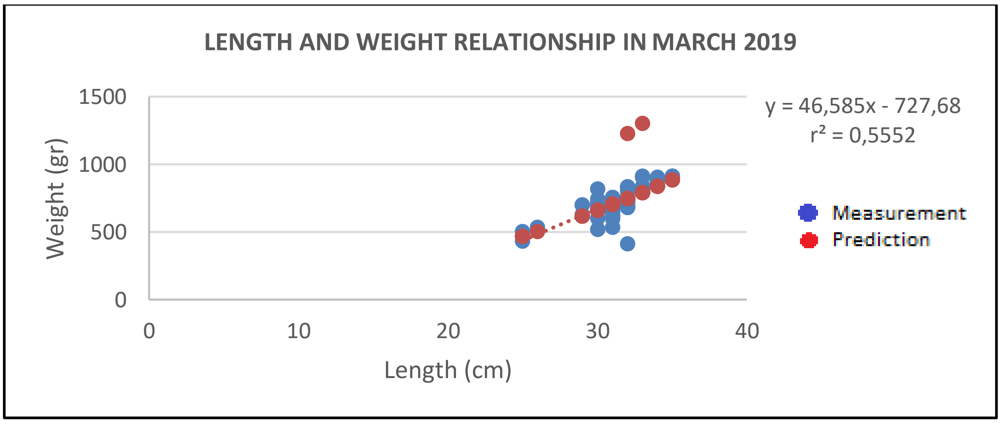


Figure 15. Relationship between the length of skipjack fish in March 2019

Based on the value of b obtained from the equation W = 0.955329L1.92 that the value of b = 1.92 where b <3 so it is suspected that the growth pattern of skipjack tuna in March is negative allometric, this indicates that the growth of its weight is slower than its length, calculation of r = 0.99 which 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 Skipjack (Katsuwonus pelamis) During Observation

So from 664 tuna fish that were sampled during the observation obtained a value = 0.036211 and b = 2.79 with r = 0.9494, so that the length and weight of the Skipjack (*Katsuwonus pelamis*) W = 0.036211L2.79 and the graph of the length relationship of fish weights Skipjack (*Katsuwonus pelamis*) during observations can be seen in Figure 16.

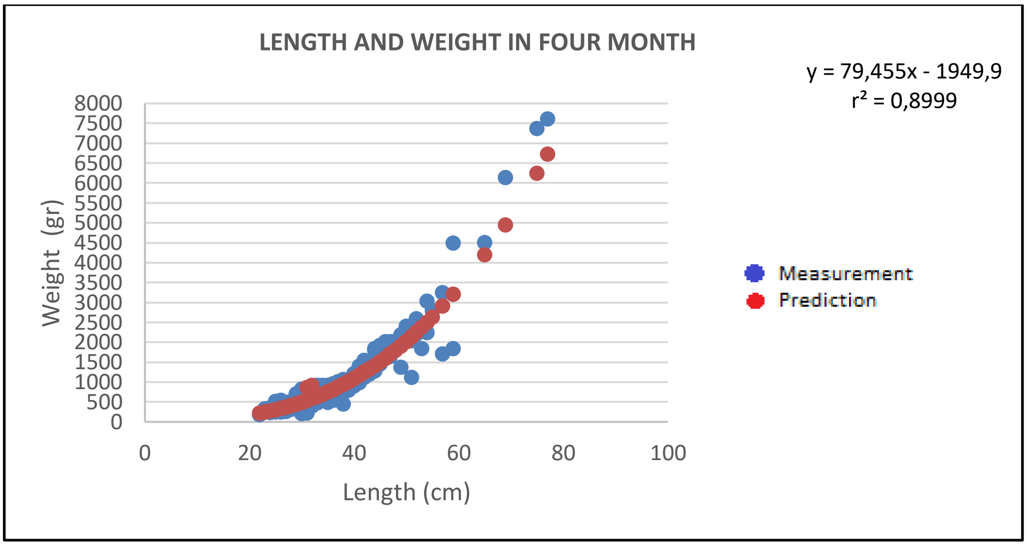
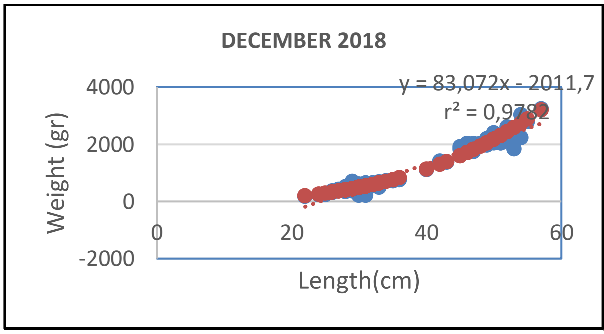
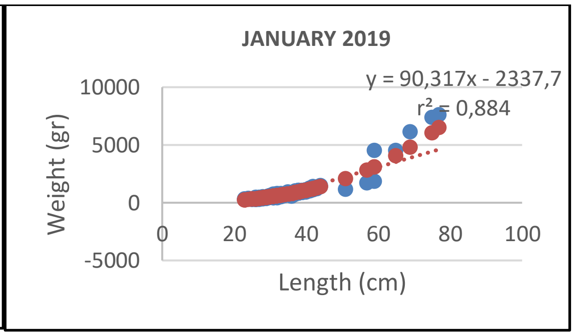
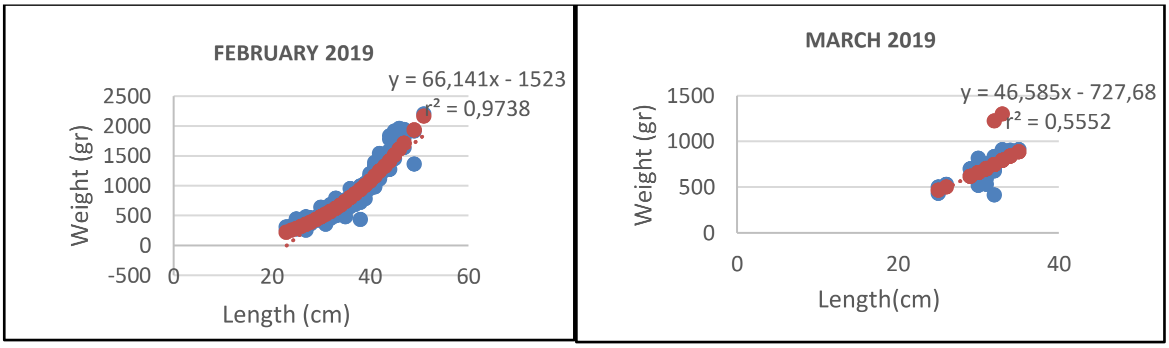


Figure 16. Length and weights relationship between Skipjack (*Katsuwonus pelamis*) during Observation

Based on the value of b obtained from the equation W = 0.036211L2.79 that the value of b = 2.79 where b<3 so it is suspected that the growth pattern of Skipjack (*Katsuwonus pelamis*) during the observation is negative allometric. Indicating that the growth of the weight increases longer than the length, the calculation of r = 0.95 which means that the value of r is close to 1. This shows that there is a close relationship between the length and weight. The graph of the relationship between the length of skipjack tuna in December 2018-March 2019 can be seen in Figure 17.







Note : • Measurement, • Prediction

Figure 17. Graphic of the length relationship of Skipjack (*Katsuwonus pelamis*) from December 2018 to March 2019

Figure 17 shows the relationship of Skipjack (*Katsuwonus pelamis*) where overall growth is on a different exponential line. And in Table 11 during the observation there is 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 fish in the Maluku Sea is a negative allometric growth which indicates that long growth is faster than fish weight.

Decent Frequency of Catching Skipjack (Katsuwonus pelamis) in December 2018

According to Nugraha and Rahmat (2008) in their research stated that the first Skipjack (*Katsuwonus pelamis*) gonad cooked at a size of 40.0-40.6 cm, so that conclusions can be drawn then the skipjack tuna that should be caught should be above 40.6 cm. The Skipjack (*Katsuwonus pelamis*) diagram is worth capturing and not yet capture in December 2018 can be seen in figure 18.

Figure 18. Frequency of catching skipjack tuna in December 2018

In December 2018 during the observation there were 150 Skipjack (*Katsuwonus pelamis*) as samples in 5 settings. In the class length of 39.6-43.9 cm, there are three Skipjack (*Katsuwonus pelamis*) caught, two of them are already feasible to catch, so that in December 2018 there were 34 Skipjack (*Katsuwonus pelamis*) and 116 Skipjack (*Katsuwonus pelamis*) fish that were not yet feasible to catch. The highest frequency of tuna fish in the class 26.4-30.7 cm was 56 heads and the lowest in the class 35.2-39.5 was one tail.

Frequency of Catching Skipjack (*Katsuwonus pelamis*) in January

The frequency of Skipjack (*Katsuwonus pelamis*) caught in January 2019 can be seen in Figure 19.

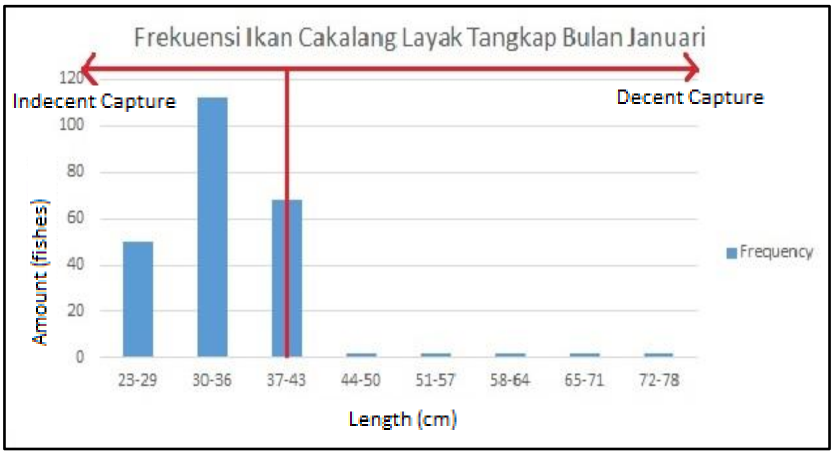


Figure 19. Frequency of skipjack tuna worth catching in January 2019

In January 2019 during the observation there were 240 Skipjack (*Katsuwonus pelamis*) as samples in nine settings. In class length 37.0-43.0 cm, there are 68 Skipjack (*Katsuwonus pelamis*) caught, 20 of them are already feasible to catch so that in January 2019 there are 30 Skipjack (*Katsuwonus pelamis*) and 210 Skipjack (*Katsuwonus pelamis*) that are not yet feasible to catch. The highest frequency of Skipjack (*Katsuwonus pelamis*) in the class 30.0-36.0 cm was 112 fishes and the lowest was in the class 44.0-50 to class 72.0-78.0 each as many as two fishes.

Frequency of Catching Skipjack (Katsuwonus pelamis) in February 2019

The frequency of skipjack fish caught in February 2019 can be seen in figure 20.

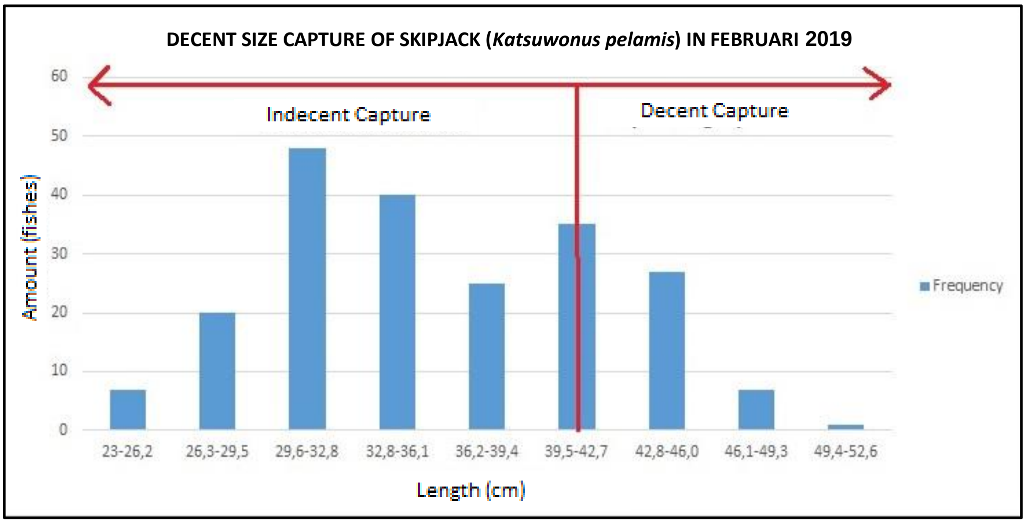


Figure 20. Frequency of Skipjack (*Katsuwonus pelamis*) worth catching in February 2019

In February 2019 during the observation there were 210 tuna fish as samples in nine settings. In class length 39,5-42.7 cm, there are 35 skipjack (*Katsuwonus pelamis*) caught, 25 of which are worth catching, so that in February 2019 there are 60 skipjack (*Katsuwonus pelamis*) and 150 skipjack (*Katsuwonus pelamis*) that are not yet feasible to catch. The highest frequency of skipjack (*Katsuwonus pelamis*) in the class 29.6-32.8 cm was 48 fishes and the lowest in the 49.4-52.6 class was one fish.

Frequency of Catching Skipjack (Katsuwonus pelamis) in March

The frequency of skipjack (*Katsuwonus pelamis*) caught in March 2019 can be seen in Figure 21.

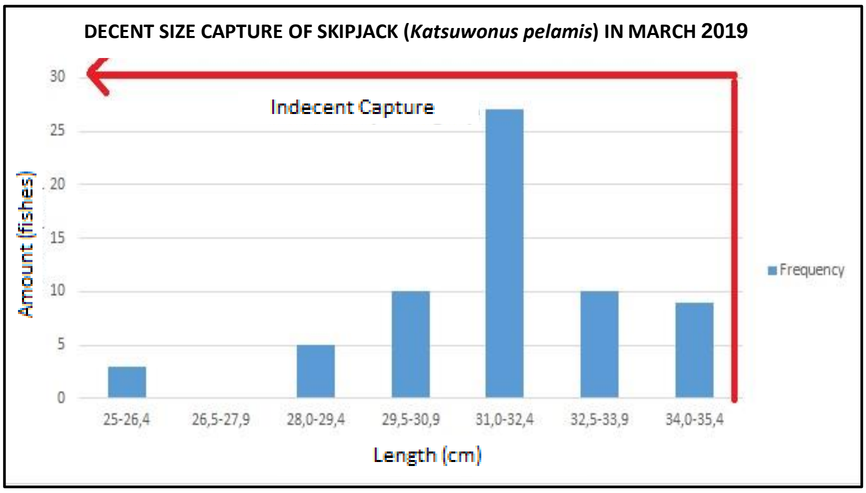


Figure 21. Frequency of skipjack (*Katsuwonus pelamis*) worth catching in March 2019

In March 2019 during the observation there were 64 skipjack (*Katsuwonus pelamis*) as samples in four settings. In March 2019 there was no skipjack (*Katsuwonus pelamis*) that was feasible to catch because this month the longest length of the skipjack (*Katsuwonus pelamis*) was 35 cm while the skipjack (*Katsuwonus pelamis*) was above 40.6 cm. The highest frequency of skipjack (*Katsuwonus pelamis*) in class 31.0-35.4 cm is 27 fish and the lowest in class 26.5-27.9 is zero fish. So that in March 2019 skipjack (*Katsuwonus pelamis*) in the Maluku Sea are still classified as immature gonad fish, so they are not feasible to be caught.

Frequency of Catching Skipjack Fish During Observation

The frequency of skipjack (*Katsuwonus pelamis*) caught during observation can be seen in Figure 22.

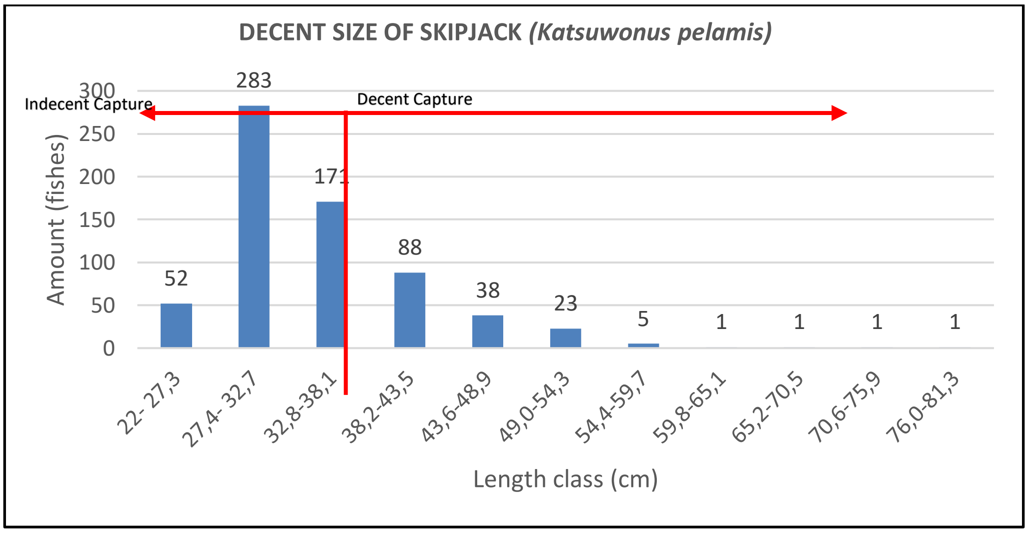


Figure 22. The long frequency distribution of skipjack (*Katsuwonus pelamis*).

During the observation there were 664 tuna as samples for four months in the Maluku Sea from 664 samples of skipjack (*Katsuwonus pelamis*) caught, skipjack (*Katsuwonus pelamis*) declared of size 40.7 and above with 124 fish worth capturing out of 124 samples. So that if presented, the size is feasible to catch and not yet capture can be seen in Figure 23.

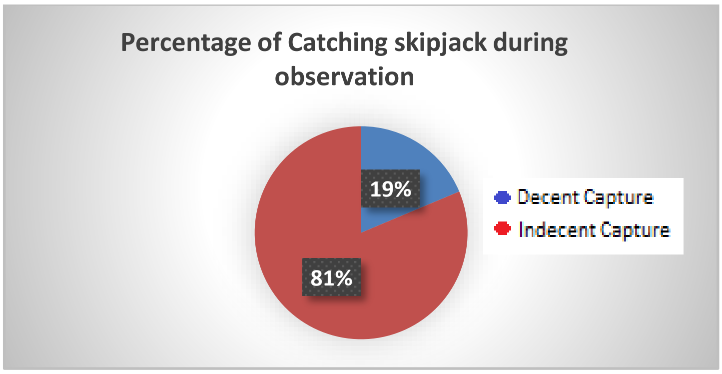


Figure 23. Percentage of skipjack (*Katsuwonus pelamis*) catching.

From the picture 23 the percentage of skipjack (*Katsuwonus pelamis*) that are already feasible to catch is 19%, this is due to several factors such as the size of the mesh size of the net, the location of the fishing ground where there are still fish that are not worthy of catching, and the fishing season so that there are a lot of skipjack (*Katsuwonus pelamis*) those under 40.6 cm were caught.

Conclusion. From observations following the capture in the waters of the Maluku Sea, there were several types of fish caught, including Scad (Decapterus macrosoma) of 8,012 kg (8.44%), skipjack (*Katsuwonus pelamis*) at 61,189 kg (64.48%), yellowfin (*Thunnus albacares*) by 24,356 kg (25.66%), dolphin fish (*Coryphaena hippurus*) by 50 kg (0.06%), and mackerel (*Euythunnus affinis*) by 1,289 kg (1.36%) with the number of catches 94,896 kg as many as 27 times the settings in 4 trips.

Based on observations known skipjack (*Katsuwonus pelamis*) with a number of 664 fishes and the results of regression analysis of the relationship of the length of the skipjack (*Katsuwonus pelamis*) obtained a value of b = 2.79, the growth pattern of allometric fish is negative, and the number of fish worth catching is 124 heads or about 19% of the total sample of 664 individuals.

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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 only catching 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 to 61,189 kg (64.48%), *Thunnus albacares*) by 24.345 kg (25.66%), *Xiphias gladius* by 50 kg (0.06%), *Euthynnus affinis* by 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%, Maldive 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).

~~Fish size is determined based on the length or weight. Older fish are generally longer and fatter. At the same age, female fish are usually heavier than male fish. When the eggs are ripe, the fish experience weight and volume increase. After laying the weight will be reduced. The growth rate of fish is also influenced by the availability of food in their environment (Poernomo 2002).~~

According of Nugraha B et al. (2010) that *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 Forl-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).

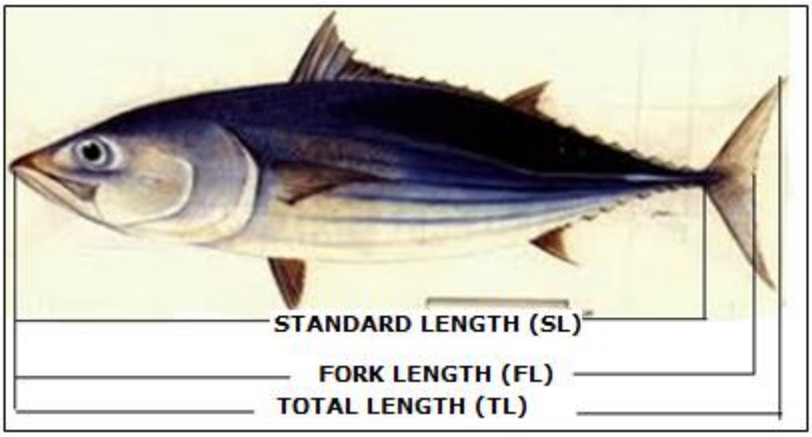

Figure 1. Measurement of the length of *Katsuwonus pelamis* (Source: WWF Indonesia, 2015).

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 (Sukima 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.

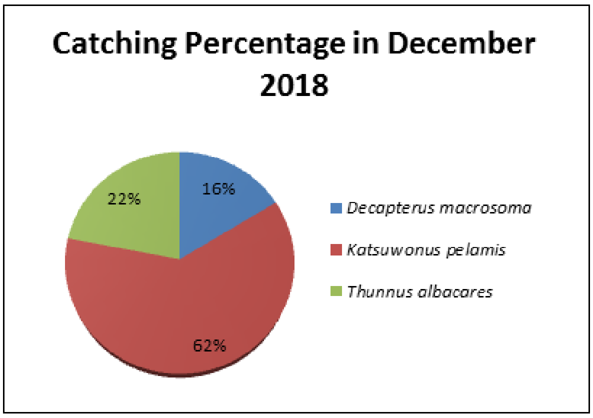

Figure 4. Diagram of percentage of catches in December 2018.

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

Fish name	*Latin 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.

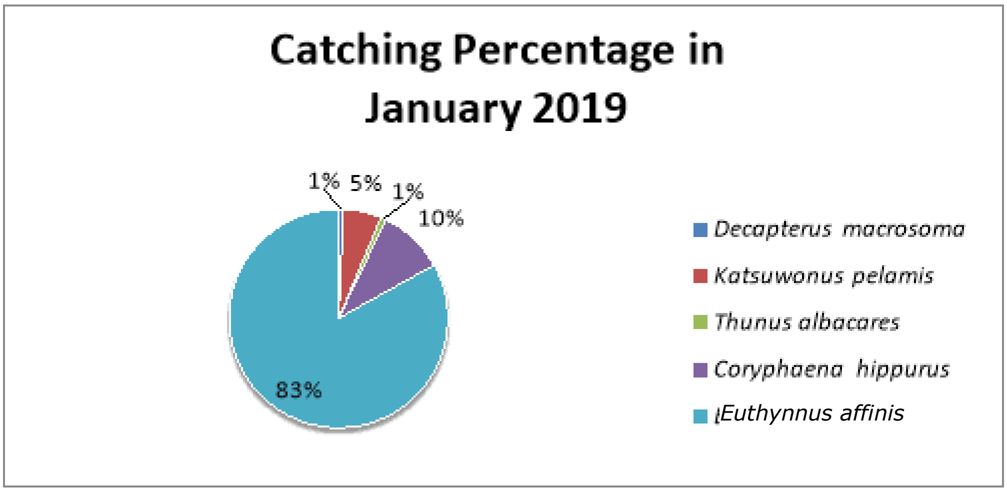

Figure 5. Diagram of percentage of catches in January 2019.

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

Fish name	*Latin 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.

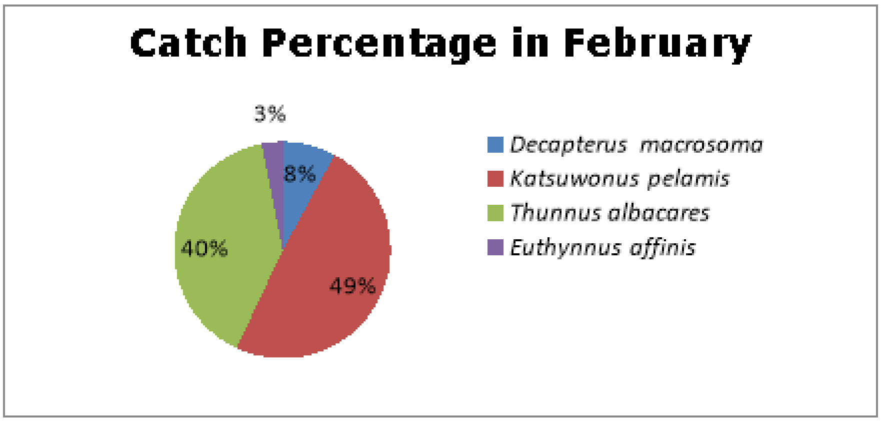

Figure 6. Diagram of percentage of catches in February 2019.

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

Fish name	*Latin 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.

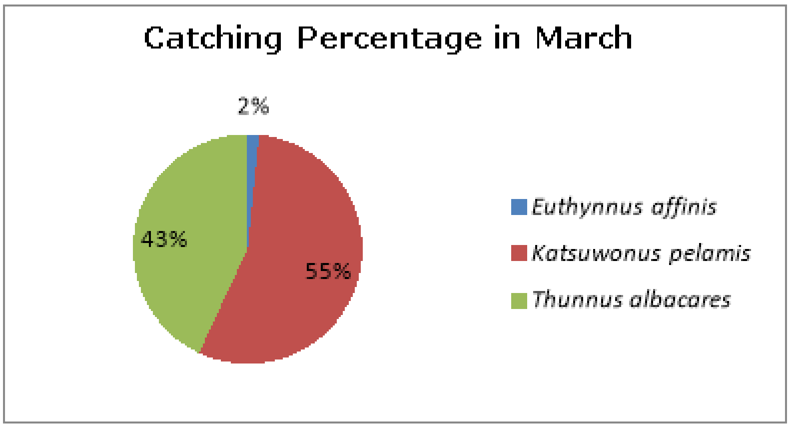

Figure 7. Diagram of percentage of catches in March 2019.

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

Fish name	*Latin 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.

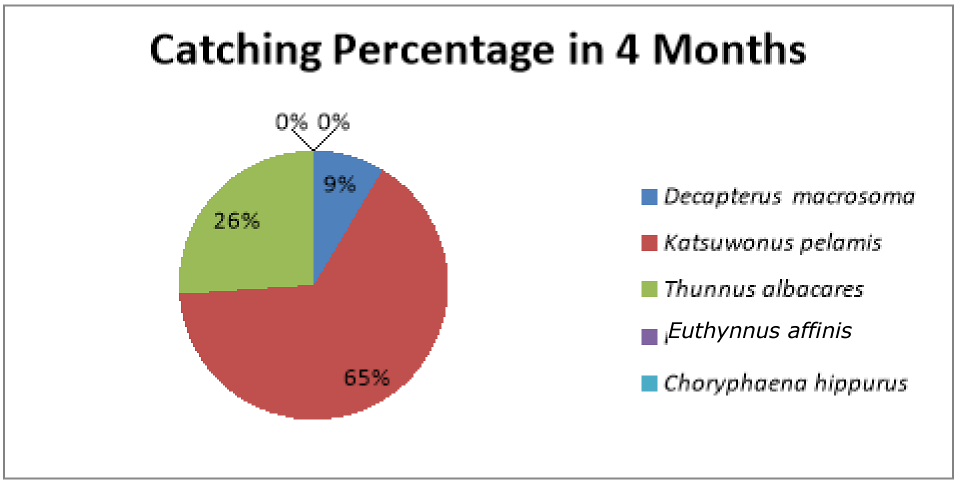

Figure 8. Types of catches for four months.

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.

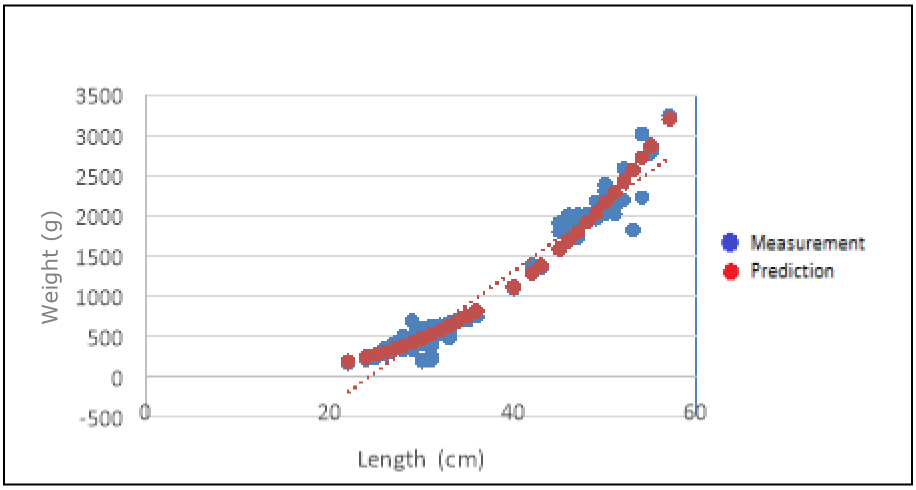

Figure 10. Length and weight relationship of *Katsuwonus pelamis* in December 2018.

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.

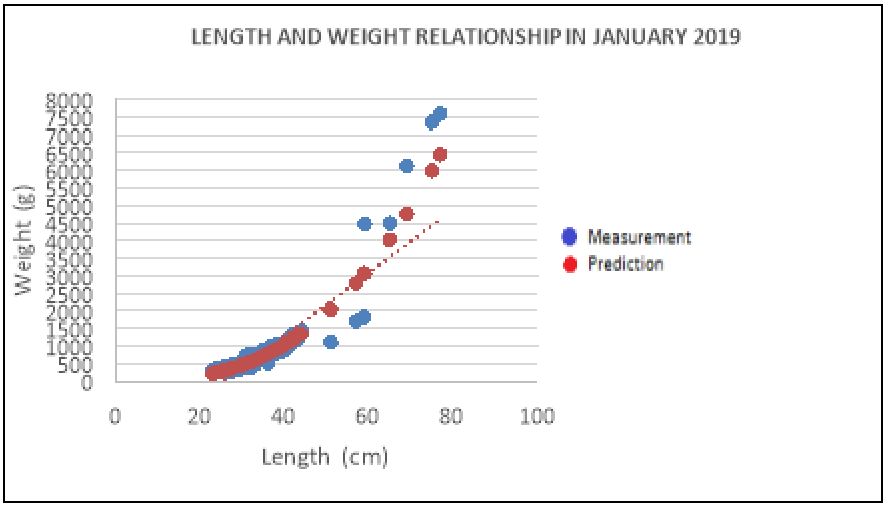

Figure 11. Length and weight relationship of *Katsuwonus pelamis* in January 2019.

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.

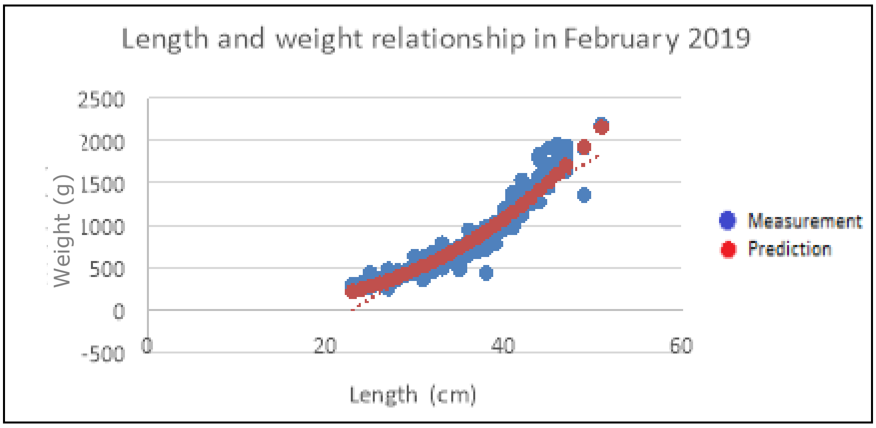

Figure 12. Length and weight relationship of *Katsuwonus pelamis* in February 2019.

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.

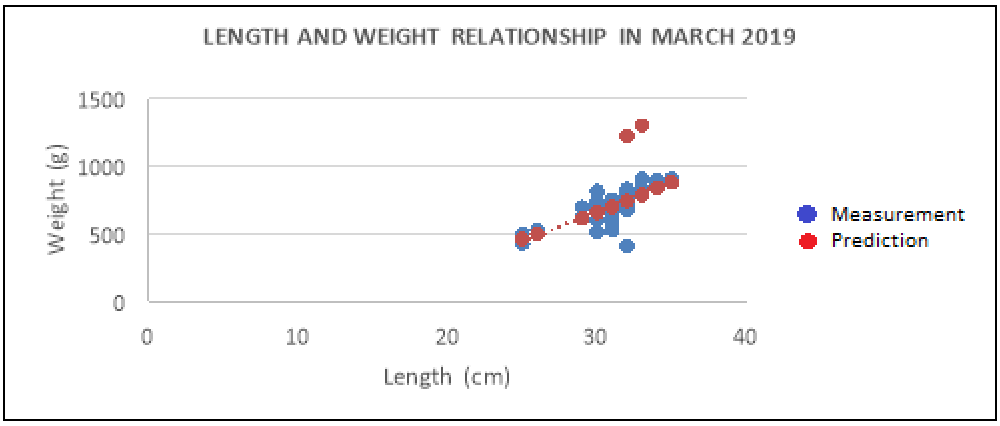

Figure 13. Relationship between length and weigth of *Katsuwonus pelamis* in March 2019.

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.

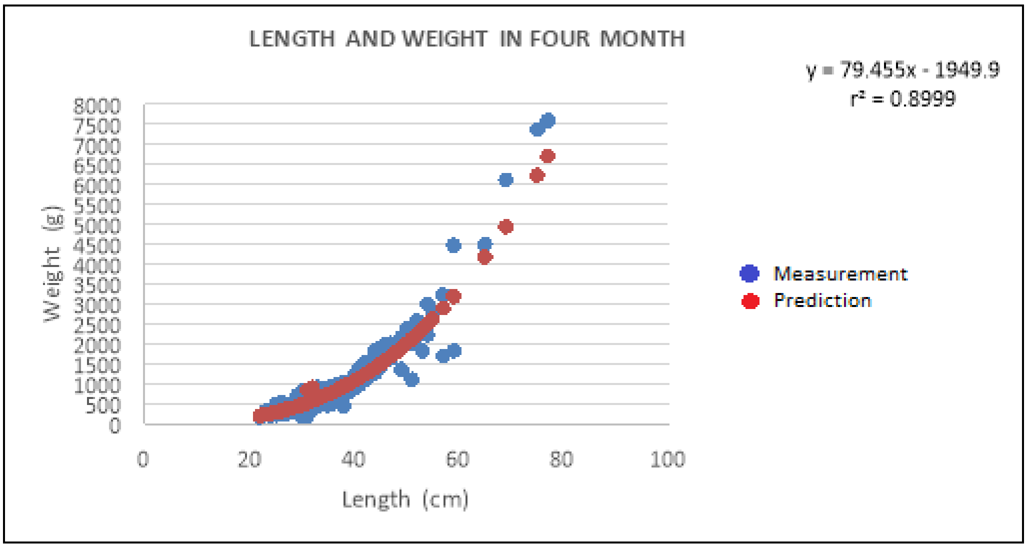

Figure 14. Length-weight relationship of *Katsuwonus pelamis* during observation.

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.

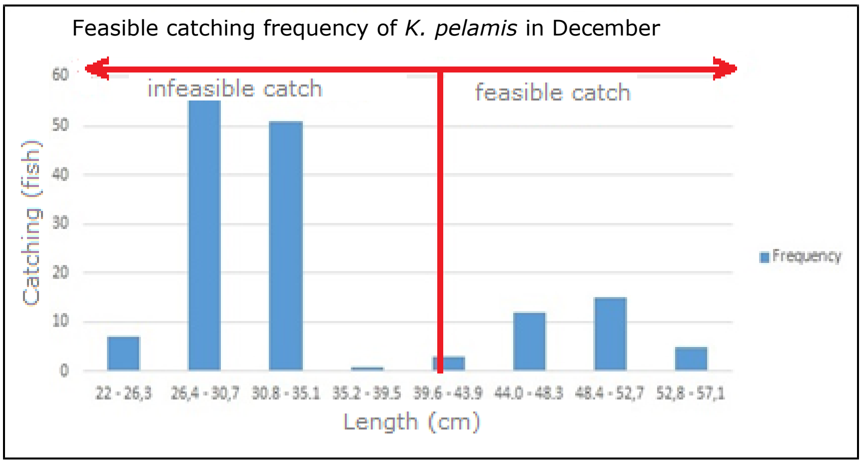

Figure 15. Frequency of catching *Katsuwonus pelamis* in December 2018.

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.

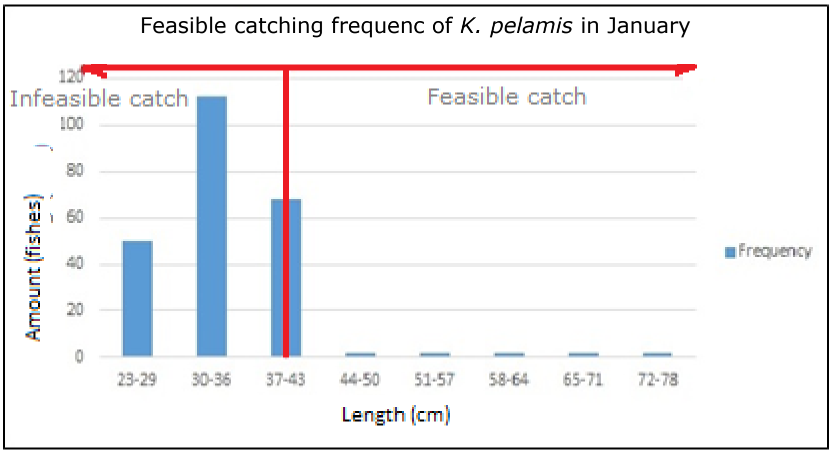

Figure 16. Frequency of *Katsuwonus pelamis* worth catching in January 2019.

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.

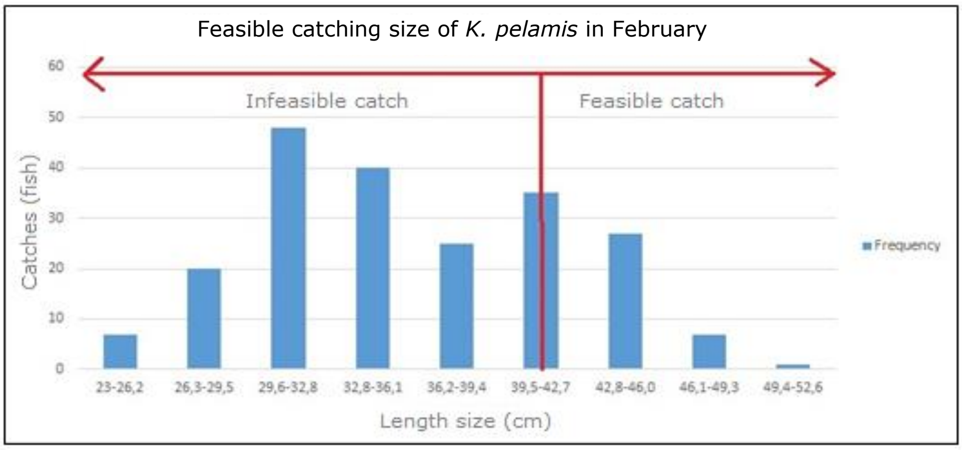

Figure 17. Frequency of *Katsuwonus pelamis* worth catching in February 2019.

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.

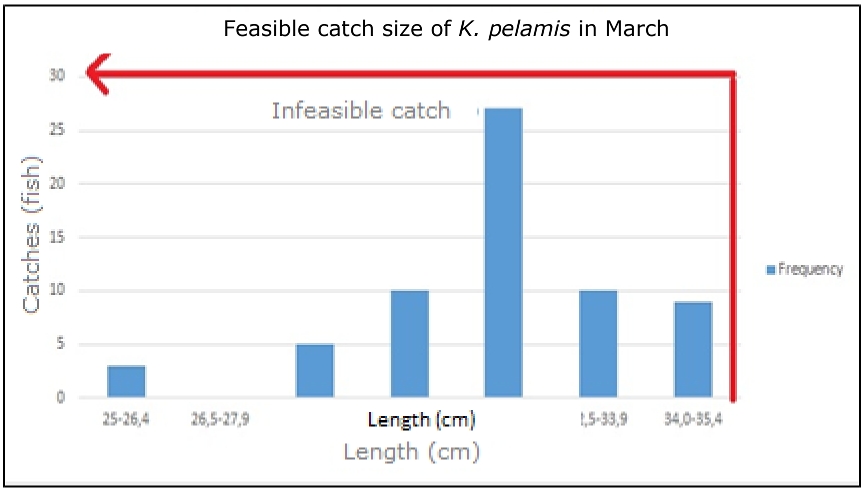

Figure 18. Frequency of *Katsuwonus pelamis* feasible catch in March 2019.

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.

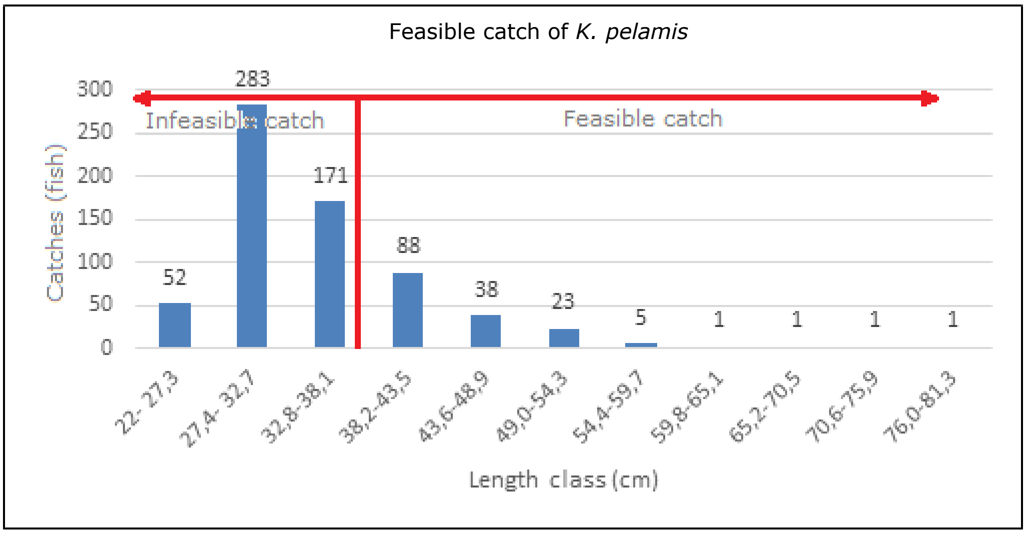

Figure 19. The length frequency distribution of *Katsuwonus pelamis*.

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.

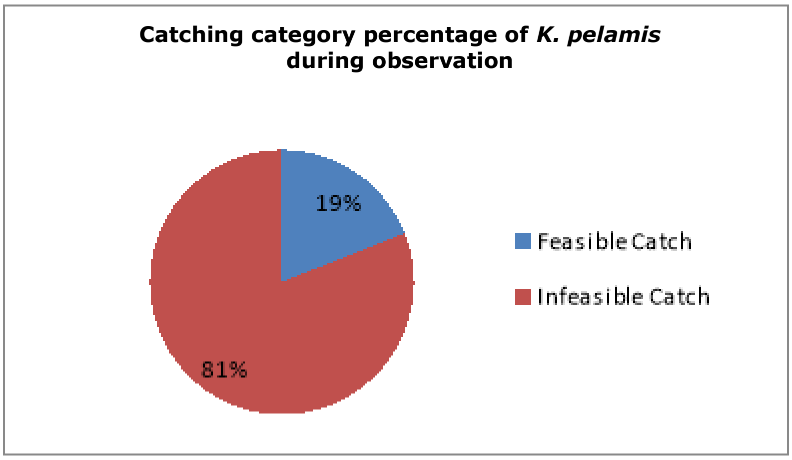

Figure 20. Percentage of *Katsuwonus pelamis* catching.

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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