The sea surface temperature effect on the length and size of skipjack tuna (Katsuwonus pelamis) catches in the Banda Sea, Indonesia

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Submission date: 13-Jun-2023 12:07PM (UTC+0800)
Submission ID: 2114983262
File name: 2020.1-18.pdf (771.16K)
Word count: 6633
Character count: 32847

The sea surface temperature effect on the length and size of skipjack tuna (*Katsuwonus pelamis*) catches in the Banda Sea, Indonesia

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Abstract. Determination of the fishing ground can be expected from the waters condition that is the habitat of a species. Water conditions are usually described with oceanographic parameters. One of the indicators to know the existence of a fish species is sea surface temperature (SST). Sea surface temperature is an important oceanographic parameter to determine the presence of *Katsuwonus pelamis* and facilitate in analyzing potential fishing areas. Sea surface temperature at the Banda Sea in November 2017, SST ranged from 29 to 29.5°C with a predominant temperature of 29.5°C. The sea surface temperature range in December 2017 was between 29 and 30°C, with a predominant temperature of 30°C. The SST range in January 2018 was 27-30°C, with dominancy of 29°C. The sea surface temperature range in February and March did not differed much from January, the SST ranged from 27.5 to 31°C with a dominant temperature of 28°C. The *K. pelamis* was caught at a temperature range of 29-30°C from November 2017 to March 2018 in the Banda Sea near Buru Island. Sea surface temperature does not affect the number and size of *K. pelamis* in the Banda Sea.

Key Words: *K. pelamis*, SST, distribution area, fishing ground, species habitat.

Introduction. Observation of sea surface temperature to detect the presence of skipjack tuna (*Katsuwonus pelamis*) is very appropriate because *K. pelamis* is a species whose swimming layer is found in the upper layer near the surface. Zainuddin et al (2015) reported that in Bone- Flores sea Bay the highest catch of *K. pelamis* was obtained in May, which was around 138 fish setting^{-1}. The catch corresponds to the SST conditions ranging between 29.75 and 30.25°C and the chlorophyll-A concentration between 0.125 and 0.213 mg m^{-3}.

Nakamura (1969) divides *K. pelamis* into six ecological levels, namely post larvae, prajuvenile, juvenile, adolescent, spawners, and spent fish. According to Waldrom (1962) the size of *K. pelamis* at first spawning/mature gonads in various world waters 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. Amiruddin (1993) said that in Indonesian waters is a real relationship between the abundance of *K. pelamis* and small pelagic fish and plankton.

Gunarso (1985) stated that the habits of *K. pelamis* is clustered while they actively seeking food. The number of *K. pelamis* in a group ranges from a few to thousands. Individuals in *K. pelamis* schooling have relatively the same size. Larger fish are in a deeper layer with small schooling, while small fish are in the surface layer with a large density (Irawan 1995). Large size of *K. pelamis* differs in their ability to adapt to small size tuna in overcoming environmental changes. By knowing the size of *K. pelamis*, it can see some of its characteristics in overcoming environmental changes. Remote sensing is the science and art of obtaining information about objects, regions or symptoms by analyzing data obtained using tools without direct contact with objects, regions or symptoms studied (Lillesand & Kiefer 1979).

According to Purbowaseso (1995), remote sensing is the science and art of obtaining information about objects and their environment from a distance without physical touch. Usually this technique produces several forms of imagery which are then processed and interpreted to produce useful data for applications in agriculture, fisheries, maritime affairs, archeology and other fields.

One effort to obtain information about the potential resources of coastal and marine areas in order to optimize coastal area management is the use of remote sensing technology and Geographic Information Systems (GIS). Information about objects found at a location on the earth's surface is taken using satellite sensors, then according to the purpose of the activities to be carried out, information about the object is processed, analyzed, interpreted and presented in the form of spatial information and spatial thematic maps using GIS.

Sea surface temperature. Ilahude & Birowo (1987) in Dahuri et al (2004) stated that SST near the South China Sea in the western season ranged from 26 to 28°C, while in Eastern Indonesia between 28 and 29°C. In the east season the SST in east Indonesia waters ranged from 28 to 26°C, while in west Indonesia waters ranged from 28 to 29°C. According to Weyl (1970) temperature is a physical quantity that states the amount of heat contained in an object.

Nontji (1993) suggests that water temperature varies both vertically and horizontally. Horizontally the temperature varies according to latitude and vertically according to depth. Vertical variations in Indonesian waters in general can be divided into three layers, namely the mixed layer at the top, the thermocline layer in the middle and the cold layer at the bottom. The homogeneous layer ranges to a depth of 50-70 m, in this layer there is a mixture of water which causes the temperature of the layer to be homogeneous (around 28°C), the thermocline layer is a layer where the temperature decreases rapidly to depth, found in layers of 100-200 m (Figure 1). The cold layer usually shows lower temperatures than 5°C, at a depth of more than 200 m.

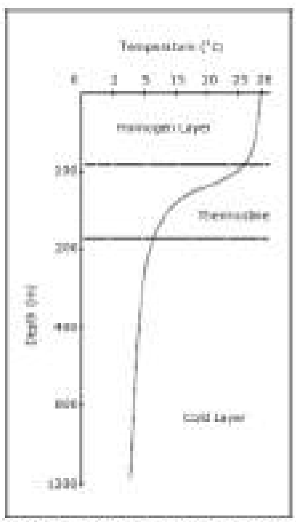

Figure 1. Changes in temperature at different sea depths (Nontji 1993).

Image sea surface temperature. Image of sea surface temperature (SST) can be generated from various thermal sensors carried by various remote sensing satellites such as NOAA-AVHRR, Landsat and MODIS (Moderate Resolution Imaging Spectroradiometer). Sea surface temperatures that can be monitored by satellites are oceanographic parameters that have a dominant influence on the existence of marine biological resources.

MODIS sensor characteristics. MODIS (Moderate Resolution Imaging Spectroradiometer) is one of the important instruments in the Terra satellite (EOS AM) (NASA 2007). The main purpose of Aqua and Terra is to understand the interrelated processes between the atmosphere, the sea and the land with changes in the weather system and climate patterns on earth.

However, because the MODIS sensors installed on both satellites can measure almost all land, sea and air parameters, their usefulness is very wide. Starting from plant index, soil moisture, aerosol levels in the air, sea surface temperature, and chlorophyll content of the sea. This data will increase understanding of the processes and global dynamics that occur in the land, oceans and lower layers of the atmosphere. MODIS plays an important role in the development of a global model of the earth system, which is able to predict global change quite carefully to help policymakers make important decisions regarding environmental protection.

Material and Method

Materials. The materials used in the present study are presented in Table 1.

Table 1

Tools and materials

No	*Material*	*Function*
1.	Purse seiner boat	Used to operate trawl rings
2.	Purse Seine Net	To operated fishing gear
3.	*Global positioning system* (GPS)	To find out the operating position of a fishing
4	Compass	As a signpost
5.	Watch	As a clue of time
6.	Digital Thermometer (TPM-10)	To measure temperature / temperature (sea surface temperature)
7.	Meter (*measure*)	To measure length of *K. pelamis*
8.	SeaDAS 7.5. Surfer 13.	To make a satellite imagery of the distribution of sea surface temperature
9.	Camera	As a documentation
10.	Stationery	As a recording
11.	Seawater	As an observation medium for data collection of sea surface temperature (SST) when operating trawl rings
12.	*K. pelamis*	As a sample data for length and size

Method of collecting data. The method used was survey method with a pattern, namely:

1. Interview with skipper, crew member, community leader and field technician.
2. Observation or observation of all series of fishing operations.
3. Documentation of all activities or supporting data for final practice activities.
4. Study on comparing data's from different literature sources.

The data taken in this final practice activity was divided into two types, namely as follows:

Table 2

Data collection methods

No	*Type of data*	*Source*
	Primary data	
1	- Position and timing of catching *K. pelamis*	Banda Sea
	- Amount of catches of *K. pelamis*	Banda Sea
	- Length and size of *K. pelamis*	Banda Sea
	- Sea surface temperature	Banda Sea
2	**Secondary Data**	
	- Image of sea surface temperature	http://oceancolor.gsfc.nasa.gov

Data analysis

Catch. The catch data which includes the composition of the catch weight and the size of the catch species were analyzed according to the space scale (latitude and longitude of catching area) and time scale (time catching period). The number of catches of *K. pelamis* grouped in daily and monthly periods was converted in the form of CPUE (kg/unit), then presented in graphical form. Furthermore, the distribution of the number of catches was grouped into three, namely many, medium and few.

Sea surface temperature (SST). Hutagalung (1988) suggested that temperature is a physical quantity which states the amount of heat flow contained in an object. Sea surface temperature data is known by conducting a digital analysis of Aqua MODIS level 2 satellite images obtained by downloading sea surface temperature images from the internet (http://oceancolor.gsfc.nasa.gov) which have the*.bz2 file extension then displayed in the form of PNG (Portable Network Graphics). The concentration of sea surface temperature in the fishing area during fishing operation trips can be calculated using the SeaDAS 7.5 software which is operated with the Windows10 program. The steps of image processing and SST are as follows:

1. Import data
   The first step is to import satellite data that has been extracted. MODIS is displayed in the form of SSH products because the one being processed is SST.
2. Cropping
   Recording by satellite sensors includes the recording area that matches the sweep of the sensor, therefore it is necessary to limit the area to the image so that the image only contains the research area in the Banda Sea, because fishermen are only allowed to catch fish on Marine Protected Area (MPA) 714.
3. Classification
   Classification is done to distinguish land, clouds and sea. The sea that is meant here is the value of sea surface temperature. Giving color (color lut) serves to facilitate visual observation. In the SST image there is a color bar that has an interval of 4°C and every 1°C has a different color so it can be seen clearly the difference in concentration of sea surface temperature in each fishing area. The lowest temperature on the color bar is -2°C and the highest is 35°C.
4. Calculating sea surface temperature
   Calculation of SST can be done by using the cursor position function at the point of fishing area. Cursor position displays the SST value, the time of data recording (sensor) and the position of the capture area.

The image of sea surface temperature that has been made in the map of the distribution of sea surface temperature was analyzed visually and interpreted by looking at the distribution pattern of sea surface temperature. Data on sea surface temperature can be used as an indication of the existence of *K. pelamis*. Sea surface temperature distribution is presented in the form of images, then analyzed by the SeaDAS program to obtain the sea surface temperature range, dominant SST, SST averaged in each setting position which is then presented in table form.

Relationship of fish catching with SST. The relationship between catch and sea surface temperature at the same time and position was analyzed by presenting scatter diagrams. The two variables are also presented in the form of mathematical equations, namely simple regression equations (Wallpole 1995) as follows:

$$Y = a + bx$$

Where: Y: Tuna catch (kg)
x: Sea surface temperature (°C)
a: Intercept
b: Regression coefficient for sea surface temperature

To determine the degree of relationship between the catch variable and the SST variable, a correlation analysis was performed. The higher the correlation value, the relationship between the two coefficients is getting tighter. Correlation analysis was performed using Microsoft Excel and SPSS (Statistical Package For Social Science) software ver. 25.0. The degree of relationship is expressed by a correlation coefficient (r) which is the root of the coefficient of determination (R^2).

$$R^2 = \frac{\sum (Y_i - \bar{Y})^2 - \sum (Y_i - \hat{Y})^2}{\sum (Y_i - \bar{Y})^2}$$

Where: $\hat{Y}$: variable Y
: value of Y from the regression equation
$\dot{Y}$: coefficient of determination

While the range of the correlation coefficient values is: $-1 \leq r \leq +1$

A close correlation if: $r \geq 0.7$ and $r \leq -0.6$, and the correlation is not tight if: $-0.6 < r < 0.7$ The total catch, length size of *K. pelamis*, and profile of sea surface temperature are then used to predict potential fishing areas. The three indicators are given a weighting score with a scoring technique with the following conditions:

1. If on a fishing ground obtained catches that are included in the high category (>10,001 kg $trip^{-1}$) are given a weight of 5, medium catches (5,001-10,000 kg $trip^{-1}$) are given a weight of 3 and a low catch (≤5,000 kg $trip^{-1}$) given weight 1.
2. If the *K. pelamis* caught in a fishing ground falls into a large size category (≥40 cm pcs) given a weight of 3, while the small size (<40 cm/pcs) is given a weight 1. This grouping of large/small fish refers to Matsumoto's opinion (1984).
3. If the SST is dominated by the optimum SST for fishing, then the fishing ground can be categorized as a good fishing ground and given a weight of 3 and if it is not dominated by the optimum SST it is given a weight of 1.

After obtaining the weight values for each indicator on a particular fishing ground, then the weights are added together. In this case, the three indicators are assumed to have the same effect on the assessment of a fishing ground. The final step in determining this fishing ground is by grouping the combined weight values which are the sum of the three indicators into three, namely:

1. If the combined weight value is in the highest range, then the fishing ground is categorized as a potential fishing ground.
2. If the combined weight value is in the middle range, then the fishing ground is categorized as medium fishing ground.
3. If the combined weight value is in the lowest range, then the fishing ground is categorized as a potential fishing ground.

Result and Discussion. The amount of *K. pelamis* caught in November 2017 to March 2018 tend to fluctuate. The catches in November 2017 and January 2018 were lower than in December 2017, February 2018 and March 2018. In January 2018 the catch amount was 372 kg with CPUE of 124 kg $unit^{-1}$. In December 2017 the highest number of catches was 11,200 kg with CPUE of 5,600 kg $unit^{-1}$. Whereas in February 2018 the total catch was 9,200 kg with CPUE of 2,300 kg $unit^{-1}$ and in March 2018 the number of catches was 5,300 kg with CPUE of 1,766.66 kg $unit^{-1}$ (Figure 2).

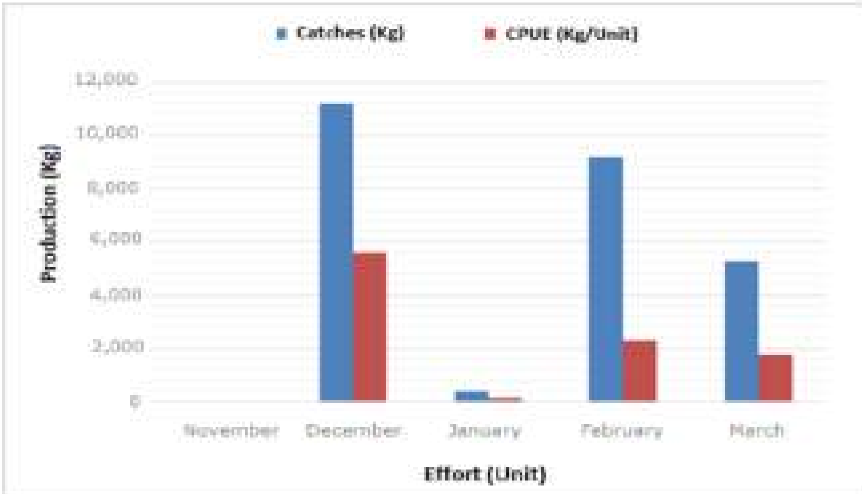

Figure 2. Amount of catch and CPUE in November, December, January, February, March 2018.

Daily catches tended to fluctuate during the period of November 2017 - March 2018 (Figure 3). The most catches occurred on February 10, 2018 as many as 6,000 kg, while the lowest catches occurred in November and January because there was no *K. pelamis* catch at all.

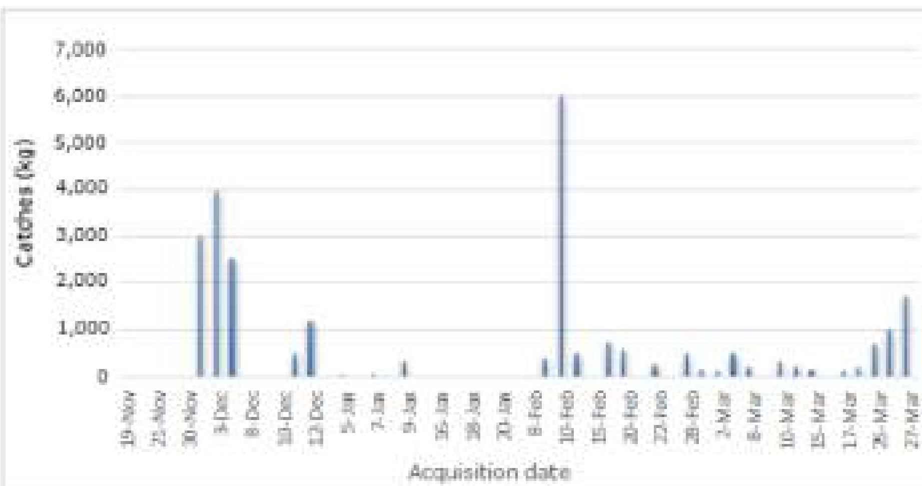

Figure 3. Daily catches in November, December, January, February, March 2018.

The number of *K. pelamis* sampled to determine the composition of the length of *K. pelamis* in November, December, January, February, March was 810 individuals by measuring 30 samples each after catching. From 810 *K. pelamis* samples, resulted 91% small and 9% large individuals (Figure 4). According to fisherman at Kendari Ocean Fisheries Port, *K. pelamis* which are 40 cm or bigger in size, are included in the large category while fish that are below 40 cm are included in the small size category.

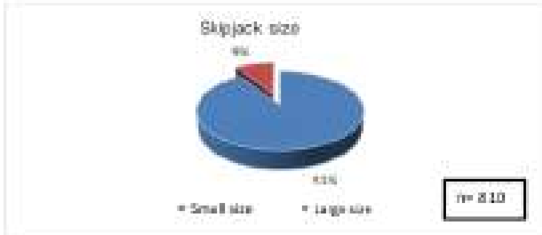

Figure 4. *Katsuwonus pelamis* size in November 2017 - March 2018.

In November 2017 there were no *K. pelamis* because the ship carried out fishing operations close to the Kendari Ocean Fishing Port which was at position 4°01'40S - 122°59'09E, while in December 2017 it was dominated by small-sized *K. pelamis* which was almost 99% while the remaining 1% was large individuals. In January 2018 the size of *K. pelamis* that dominates was the small size that reached 94% while the large sized individuals was only 6%. In February 2018 a similar pattern was found in the previous month, namely small-sized *K. pelamis* which dominated as much as 90% and the remaining 10% were large. Whereas in March was the same as in December, January, February, the size of *K. pelamis* was dominated by small size as much as 87% and the remaining 13% was represented by large individuals (Figure 5).

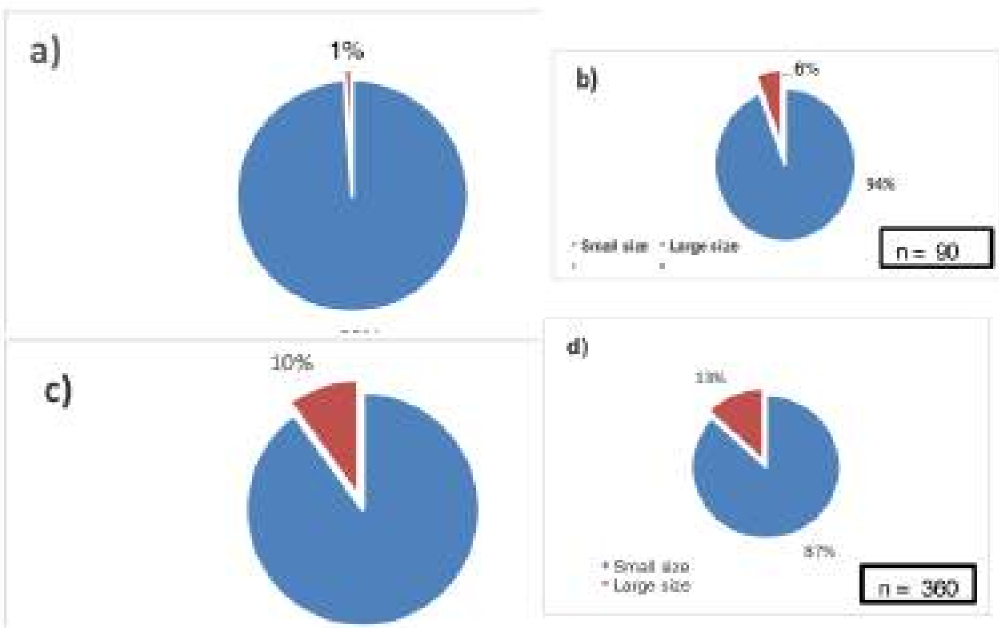

Figure 5. Monthly size of *Katsuwonus pelamis* in (a) December 2017 (b) January 2018, (c) February 2018, and (d) March 2018.

Sea surface temperature. Distribution of sea surface temperatures is presented in the Banda Sea at positions around 03°09'18S - 124°45'07E and 04°01'40S - 122°59'09E in the form of imagery showing the distribution of sea surface temperature clearly different colors (pallet) at each different temperature range. From the overall imagery of sea surface temperature produced that the sea surface temperature in November 2017 to March 2018 varied from the lowest temperature of 28°C to the highest of 31°C (Figure 6).

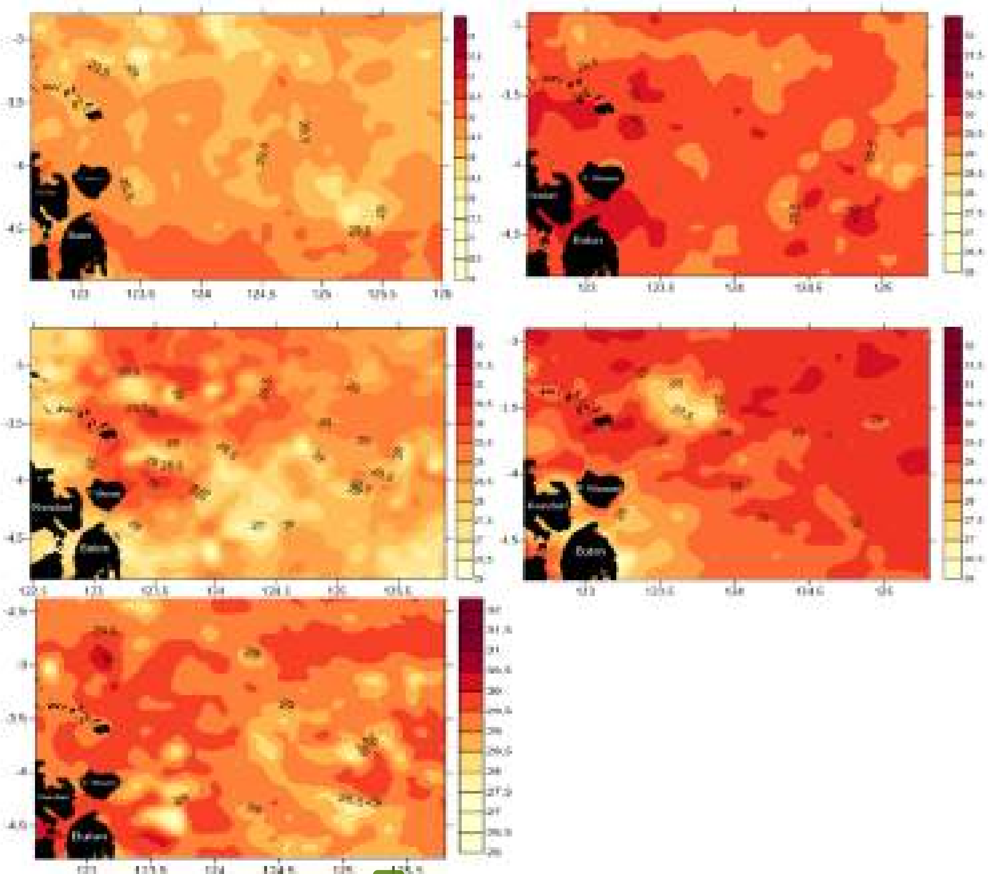

Figure 6. SST satellite imagery. a) November 2017 b) December 2017 c) January 2018 d) February 2018 and e) March 2018.

The imagery of sea surface temperature in November 2017 (Figure 6a) shows that the SST in the Banda Sea ranged from 29 to 29.5°C, with a dominant temperature of 29.5°C near the island of Saponda. Satellite images in December 2017 (Figure 6b) show that the SST in the Banda Sea was not much different from November ranging from 29 to 30°C, with a dominant temperature of 30°C. In January 2018 (Figure 6c) the imagery of sea surface temperature was lower than the previous month which ranged from 27 to 30°C, with a dominant temperature of 29°C. In February and March (Figure 6d and 6e) the imagery of sea surface temperature was not much different from January, which was around 27.5-31°C with a dominant value of 28°C. Waters were dominated by high and stable temperatures in November 2017, December 2017, January 2018 and the low temperatures were more common, namely on January 24, January 25, February 7, February 8, February 9, February 10, February 15, February 16, February 20, February 21, February 22, March 1, March 2, March 7, March 26, March 27, 2018 (Figure 7).

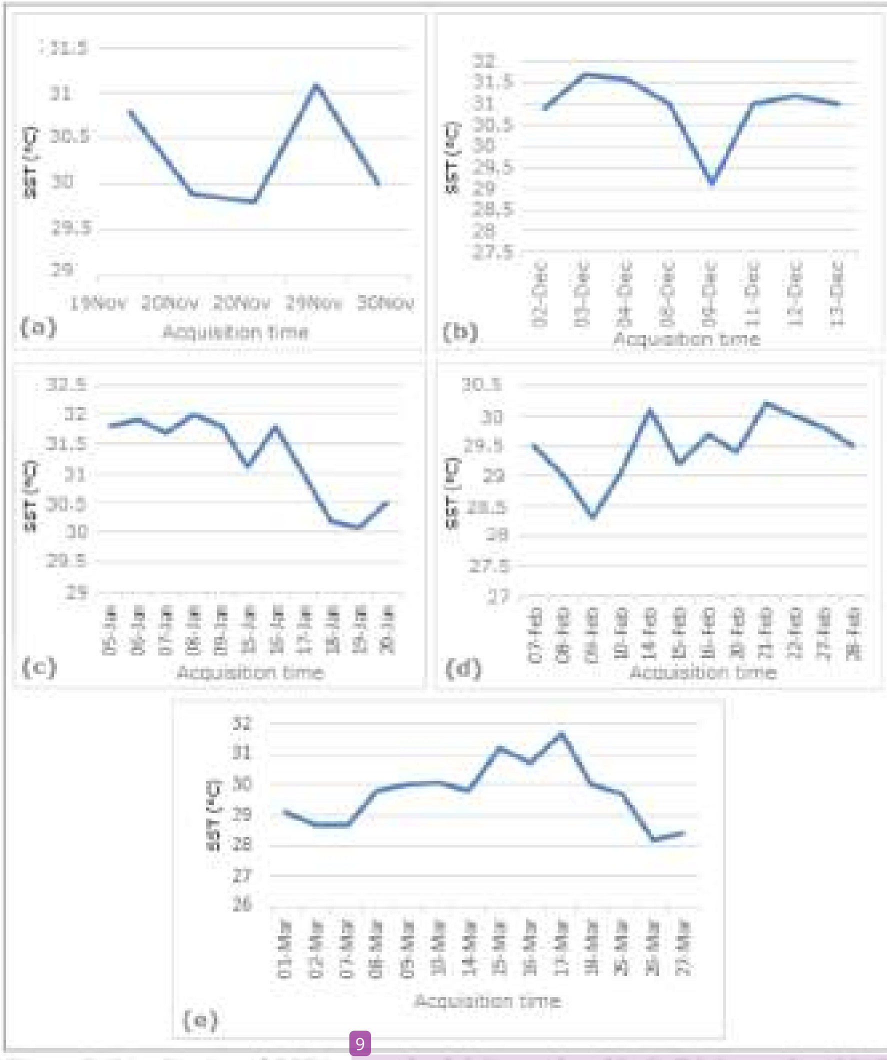

Figure 7. Distribution of SST in months (a) November 2017, (b) December 2017, (c) January 2018, (d) February 2018, (e) March 2018.

Relationship between sea surface temperature and K. pelamis catches. Sea surface temperature can be used as an indicator to determine the existence of a species of fish in waters. Each fish species has a tolerance of certain temperature range which are favored for its survival so that it influences the presence and spread of fish in the waters.

To see the relationship between sea surface temperature and the presence of *K. pelamis*, the in-situ capture data was overlayed against ex-situ sea surface temperature data at the position of the area at the same time using SPSS 25. Data normality test used the Kolmogorov-Smirnov test. The relationship of sea surface temperature to the catch of *K. pelamis* was calculated using simple linear regression. Simple linear regression equation was used as an estimator of the regression model to describe the surface temperature of the *K. pelamis* catch. Based on Figure 8, it can be seen that the highest catch of *K. pelamis* was in SST ranging from 28 to 31°C.

Based on the calculation we obtained the regression equation y = 2.8498x + 767.99 with a determination coefficient of 4.4% (Figure 8). This shows that the model used can only explain the actual model of 4.4% so the rest is explained by other factors of 95.6% the value of the correlation coefficient obtained was 0.002, which means that the relationship between sea surface temperature and the catch of *K. pelamis* is not tight.

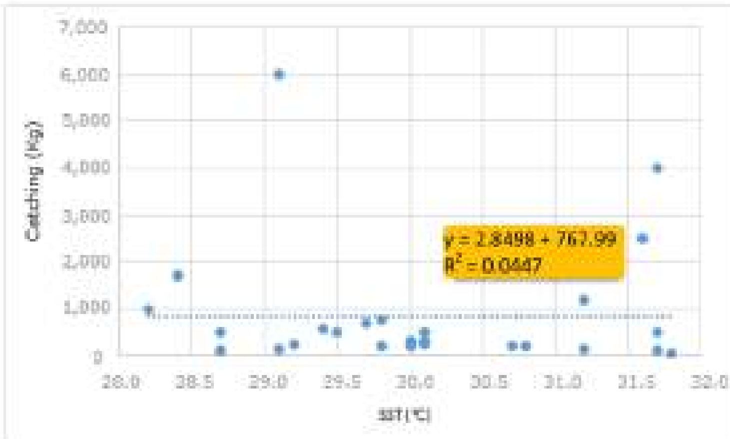

Figure 8. Relationship between SST and *Katsuwonus pelamis* catches.

The relationship between catch and non-tight sea surface temperature is also clearly seen in Figure 9. In Figure 9 it can be seen that there is no clear pattern that shows the increase or decrease in catch if the sea surface temperature rises or falls.

Figure 9. SST relationship with the catch of each setting.

The relationship of sea surface temperature to the length of the *K. pelamis* can be calculated using simple linear regression. The regression of Y = 0.2095x + 36.517 obtained with a coefficient of determination of 4.6%, the value of the correlation coefficient obtained was 0.682, which means that the relationship between sea surface temperature and fish length is not tight. However, based on Figure 10 it can be seen a pattern or trend which shows that small size fish are more dominantly caught at high temperatures while large fish remain both at high and low temperatures.

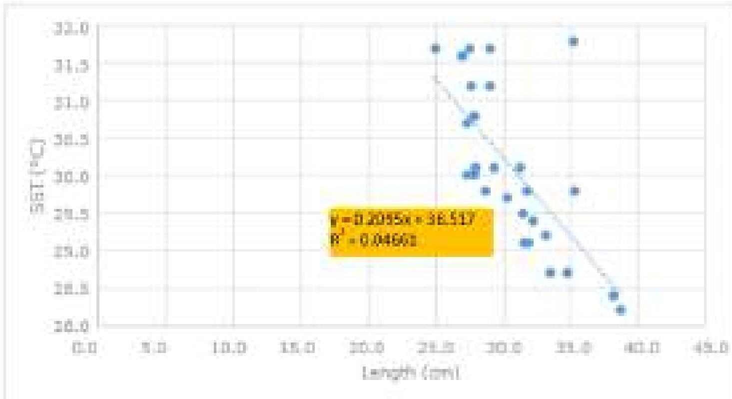

Figure 10. Relationship of SST with length size of *Katsuwonus pelamis*.

There is a pattern that shows that small-sized *K. pelamis* tend to be caught on warmer SST while large *K. pelamis* are caught in warm and cold SST. The regression test results showed that sea surface temperature did not affect the amount of *K. pelamis* caught in the Banda Sea. This is because the SST range at the time of research (28-31°C) is still at the temperature of catching *K. pelamis* (Figure 11).

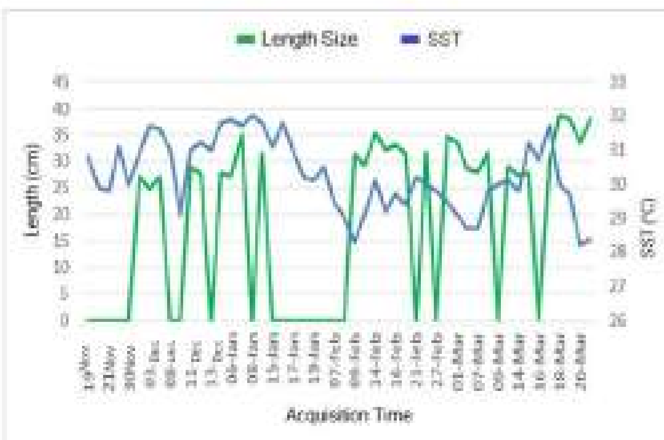

Figure 11. Relationship of SST with length of *Katsuwonus pelamis* each setting.

The relationship between catch and non-tight sea surface temperature is also clearly seen in Figures 12-18. In the figures it can be seen that there is no clear pattern that shows the increase or decrease in catch if the sea surface temperature rises or falls per month.

Figure 12. Relationship between SST and catch in December 2017.

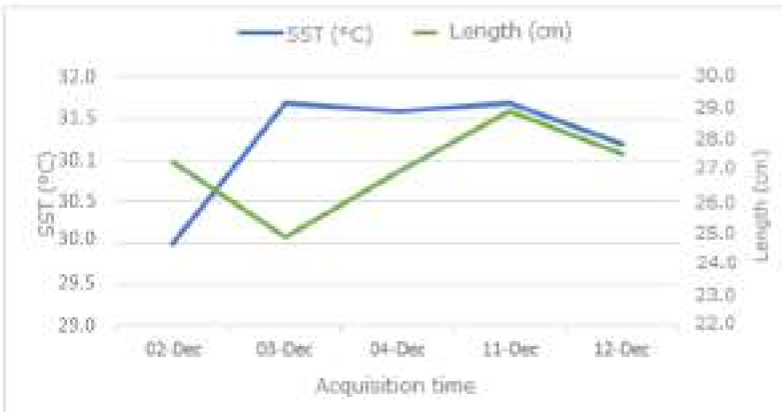

Figure 13. Relationship of SST with the length of *Katsuwonus pelamis* in December 2017.

Figures 12 and 13 show the pattern of *K. pelamis* catches with a temperature range of 29-31.5°C is in the range of 300 kg to 4,000 kg with length ranging from 25 cm to 29.3 cm. But when confronting the results, the temperature rises a lot, but the length of *K. pelamis* decreases, then the catch decreasing and the temperature continues to rise and the length of the *K. pelamis* increases.

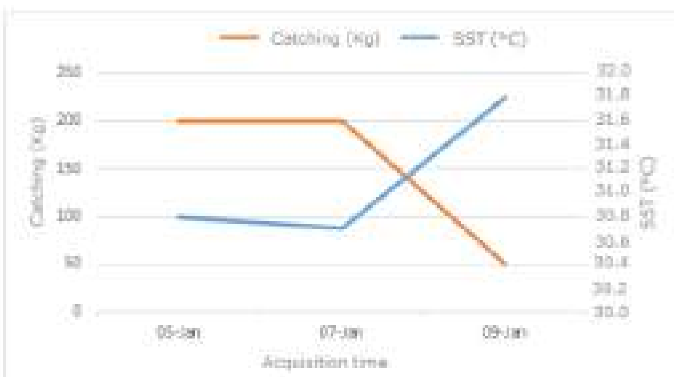

Figure 14. Relationship between SST and catch in January 2018.

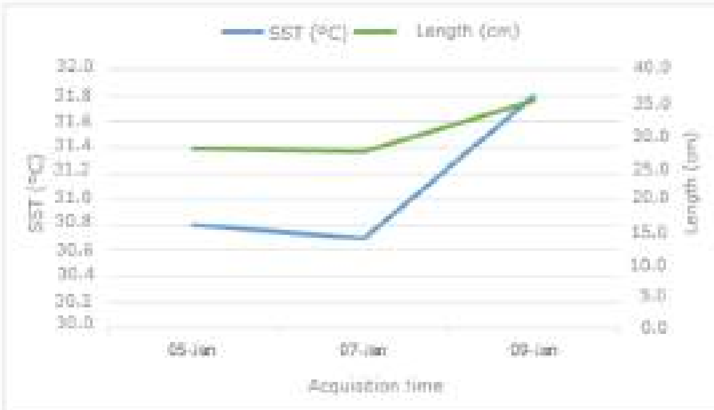

Figure 15. Relationship between SST and the length of *Katsuwonus pelamis* in January 2018.

In January 2018 the catch of *K. pelamis* decreased but the temperature increased and the size of *K. pelamis* also increased, with a temperature range of 30.8-31.8°C. Catches ranged from 50 to 200 kg, with a length range of 27.8-35.2 cm.

Figure 16. Relationship between SST and catches in February 2018.

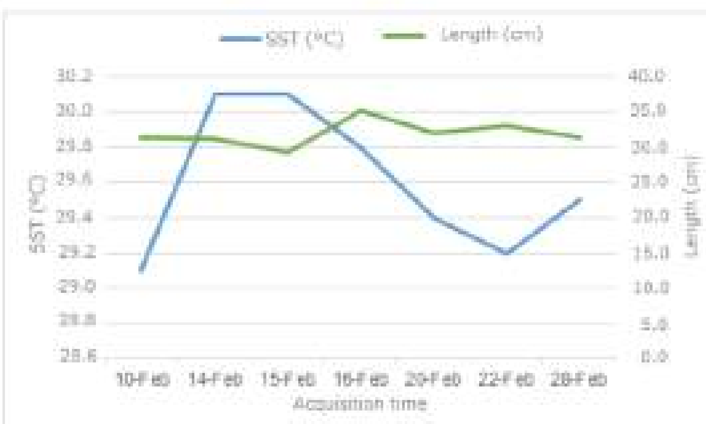

Figure 17. Relationship of SST and length of *Katsuwonus pelamis* in February 2018.

In February 2018 chart shows that at high temperatures the range is 29.8°C to 30.1°C, the catch decreases in the range of 6,000 kg to 250 kg, but the size of the length is stable, namely the range of 29.3 to 35.3 cm.

Figure 18. Relationship of SST and catches in March 2018.

Figure 19. Relationship of SST with the length of *Katsuwonus pelamis* in March 2018.

In March the temperature fluctuated as well as the catch and the length *of K. pelamis*. When the temperature raised the catch decreases but in March there is also an increase in temperature but also of catches, from 100 kg to 1,700 kg. With a temperature range of 28.2-31.7°C and a decent length with a range of 27.5-38.7 cm is close to the size of 40 cm.

Variability of K. pelamis catches. The highest number of catches was in December 2017, then following February and March 2018 and lowest in November 2017 and January 2018 (Figure 2). However, tuna caught in February 2018 was still compared to March 2018.

The daily catches in February and March were almost the same, but cumulatively the tuna fish catch in February is higher than in March. This is because the data collection in March did not reach the 30th, because the ship that was used as the research had already taken 11 trips and had already been distributed for the distribution of books or the distribution of salaries of fish catches during the 11 trips.

Low catches in November 2017 and January 2018 are due to the fact that ships operate very close to the Port and while operating in areas close to the island of Saponda it is very rare for *K. pelamis* to be caught, only tuna and other small pelagic fish were caught.

Figure 4 shows that the proportion of large-size fish obtained in trawl fishing trip periods from November 2017 to March 2018 for *K. pelamis* was only 9% (2,520 kg) of the total catch of 28,000 kg. The catch in December 2017 with large size specimens was only 1%, 6% in January 2018 and in February only 10% and in March 2018 only 13% (Figure 5).

Temporal and spatial distribution of SST in the Banda Sea. In general, the SST in the Banda Sea in November is warm, but in certain regions it is dominated by low temperatures. Then in December 2017 the temperature remains the same but warmer than the previous month. In January 2018 it decreased by being dominated by low temperatures. Whereas in February and March 2018, most of the Banda Sea area tends to warm up again but entering the late March, the temperature returns to decline even though in certain regions low temperatures are still recorded.

The sea surface temperature in November 2018 is warm due to the southeast monsoon. In December 2017 - January 2018 it is still the southeastern monsoon season but there are a few weeks of big waves and bad weather so that sometimes changes in temperature and February to March 2018 found drastic temperature fluctuations such as from February 22 to March 2 and March 18 to date March 27, 2018. This is closely related to the emergence of the transitional season in February and March.

Determination of the sea surface temperature range for each fishing operation using satellite imagery still has weaknesses. The large sweep of the MODIS sensor results in the SST range being obtained in a large area (low resolution). In addition, the Aqua MODIS satellite surrounds the earth at night so that the SST data at the time of the fishing operation is still inaccurate because fishing operations are only carried out at night. However, changes in daily temperature in tropical waters are not very significant.

Effect of SST on K. pelamis catches. The range of sea surface temperature at the time of the study ranged from 28 to 31°C. This condition proves that *K. pelamis* can still tolerate cold sea surface temperatures of 28°C 17d hot temperatures up to 31°C. However, the most catches of *K. pelamis* are found in the temperature range of 29-30°C. This shows that the temperature suitable for catching *K. pelamis* in Banda Sea is 29-30°C. No catch at SST above 32°C is probably due to the fact that tuna going to swim deeper so that the trawl net cannot reach it. Based on information from trawler ring fishermen in Kendari, the trawl fishing gear operated at a depth of approximately 100 meters.

In the results of statistical calculations it can be seen that only 4.4% of SST can predict the catch of *K. pelamis* in the Banda Sea. To get more complete results, a calculation that involves other water characteristics, such as current, salinity, chlorophyll-A, and others is needed. Besides that, the influence of technical production factors such as the skills of fishermen, fishing gear, etc. is needed in further studies.

Based on statistical tests as presented in Figure 10, SST does not significantly influence the length of *K. pelamis*. However, based on Figure 11, there is a pattern that shows that small-scale *K. pelamis* tend to be caught on warmer SST while large *K. pelamis* are caught in warm and cold SST. The regression test results showed that sea surface temperature did not affect the amount of *K. pelamis* caught in the Banda Sea. This is because the SST range at the time of research (28-31°C) is still at the temperature of catching *K. pelamis*.

Distribution of K. pelamis fishing areas. The potential fishing ground for catching *K. pelamis* routinely during November 2017 - March 2018 is in the far Banda Sea FAD. Furthermore, the fishing ground during November 2017 - March 2018 is found in FADs near Saponda Island. This is based on the frequency of occurrence of potential fishing ground categories more frequently compared to moderate and poor fishing ground categories. While the medium category fishing ground is in FADs near not far from Wowoni Island, Central Saponda, North Saponda. This is based on the incident, which is where the frequency of potential fishing ground categories is slightly lower during the period November 2017 - March 2018 (Table 3).

Table 3

Evaluation of fishing ground based on number of fish, size and distribution of SST

No.	Fishing ground	*Fishing ground category (Month)*					*Combined fishing ground category*
		November	*December*	*January*	*February*	*March*	
1	Saponda Island	-	-	Poor	Medium	-	Poor
2.	Banda Sea	Medium	Potential	Medium	Potential	Potential	Potential

The most potential fishing position was obtained in December 2017, namely in the Banda Sea. In January 2018 there was less potential fishing ground for *K. pelamis* in the Banda Sea. The potential frequency of fishing ground in December 2017 was more frequent when compared to February 2018 and March 2018. This could occur because in December 2017 the ship operated far away so that many fishermen carried out fishing in the Banda Sea. Different from the beginning of January 2018 more fishermen caught fish near the port, which is near of Saponda island because in that month there were lots of tuna but less *K. pelamis* and even rarely got *K. pelamis*, only tuna, kite and other small pelagic fish, but more efficient for costs because the ship operates far requires a fairly large cost different from the ship operating close to the land.

Conclusions. The distribution of SST in the Banda Sea from November 2017 to March 2018 ranged from 28 to 31°C. In November 2017 the SST in the Banda Sea ranged from 29 to 29.5°C. With a dominant temperature of 29.5°C near of Saponda Island but no *K. pelamis* was caught. Satellite images in December 2017 showed that the SST in the Banda Sea was not much different from November ranged from 29 to 30°C, with a dominant temperature of 30°C and catches of *K. pelamis* ranged from 300 kg to 4,000 kg with a length of 25-29.3 cm individual^{-1}. In January 2018 the image of sea surface temperature was lower than the previous month with a ranged of 27-30°C. With a dominant 29°C and the catch of *K. pelamis* ranged from 50 to 200 kg with a length range of 27.8-35.2 cm. In February the image of the sea surface temperature ranged from 29.8°C to 30.1°C and the catch of *K. pelamis* ranged from 6,000 kg to 250 kg, with a length ranging from 29.3 to 35.3 cm. In March 2018 the image of the sea surface temperature ranged from 28.2 to 31.7°C, and the catch of *K. pelamis* ranged from 100 to 1,700 kg with a length range of 27.5-38.7 cm.

Sea surface temperature has no significant effect on the number and size of caught *K. pelamis* in the Banda Sea. However, there is a pattern or trend that indicates that small size fish are more predominantly caught at high temperatures while large *K. pelamis* can be caught in warm and cold waters. The biggest catch of *K. pelamis* was in the SST range of 29-30°C.

Potential catching area of *K. pelamis* was in the surrounding waters close to the hunting island or at a position around 03°09'18S - 124°45'07E, because in December, February and March there were significant catches in that position.

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Received: 19 November 2019. Accepted: 23 December 2019. Published online: 03 January 2020.
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How to cite this article:
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