Submission journal : Biology and fishery status of skipjack (Katsuwonus pelamis) in the Banda Sea, Maluku - Indonesia

Kotak Masuk ×

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Sen, 6 Mar, 14.19

Dear Dr. Eni
Here we send our manuscript with tittle : Biology and fishery status of skipjack *(Katsuwonus pelamis)* in the Banda Sea, Maluku - Indonesia.
we hope tis manuscript can be publish in your journal.

Thank You.

Best regards

Mira Maulita
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# Submission letter

Article title: **Biology and fishery status of skipjack *(Katsuwonus pelamis)* in the Banda Sea, Maluku - Indonesia**

Hereby I would like to submit the manuscript entitled **Biology and fishery status of skipjack *(Katsuwonus pelamis)* in the Banda Sea, Maluku - Indonesia** to Aquaculture, Aquarium, Conservation & Legislation - International Journal of the Bioflux Society.

This manuscript was not submitted or published to any other journal. The authors declare that the manuscript is an original paper and contain no plagiarized text. All authors declare that they are not currently affiliated or sponsored by any organization with a direct economic interest in subject of the article. My co-authors have all contributed to this manuscript and approve this submission.

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Date: March 06, 2023

# Biology and fishery status of skipjack (*Katsuwonus pelamis*) in the Banda Sea, Maluku - Indonesia

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**Abstract.** One of the marine biological resources that has quite high economic value in Indonesia is the *K. pelamis* fishery. One of the waters that has become a potential fishing ground for large pelagic fish in eastern Indonesia is the Banda Sea. This study aims to examine the aspects of biology and fisheries, examine efforts to manage and use *K. pelamis* in the Maluku region. This research was conducted in Maluku province for 90 days starting from March 4 to May 25, 2019. The method used was purposive sampling, the data collected were primary data and secondary data. *K. pelamis* in the Banda Sea has an MSY value of 57,837 tons with a fishing effort of 202,473 trips and the MEY value is at 48,866 tons for a fishing effort of 122,732 trips. The results of this study obtained data on the distribution of frequency distribution on *K. pelamis* with the shortest FL being 28.5 cm and the longest being 77.3 cm. Calculation of the growth pattern of large pelagic fish was carried out using the $t_{test}$ ($t_{count}$ = 0.05 tab) at a 95% confidence interval (ɑ 0.05). The growth pattern obtained by *K. pelamis* is positive allometric. The sex ratio obtained was 1 male : 1 female. The level of gonadal maturity was dominated by GML II (39%). Based on the calculation of Lc and Lm caught on the purse seine has Lc (40.12 cm) > Lm (44.81 cm). The actual catch of 70,251 tons shows that utilization has exceeded the maximum value of sustainable potential and economically, the catch of *K. pelamis* has passed the MEY condition. The fishery aspect of *K. pelamis* is in a condition where production continues to increase with a low level of gear selectivity. So that there is a need for regulation of fishing gear and its supervision.
**Keyword:** Skipjack

**Introduction.** Indonesian waters are considered to have living fish resources with the highest level of biodiversity (Sugara et al 2022; Yaskun & Sugiarto 2017; Hutomo & Moosa 2005). These resources cover at least 37% of the world's fish species (Mahmud et al 2021; Adnyani et al 2019). The resources of Skipjack *(Katsuwonus pelamis)* are grouped into large pelagic fish resources, including tuna *(Thunnus sp.)* and mackerel *(Euthynnus affinis)* (Jakson et al 2014; Bintoro et al 2022; Lintang et al 2012).

*K. pelamis* fisheries are one of the products that are of interest to general consumers and the highest economic value (Hutajulu et al 2019; Afriliani et al 2020; Genti et al 2016) and waters in eastern Indonesia are known as centers for production of *K. pelamis* in Indonesia (Manurung 2016). One of the waters that has become a potential fishing ground for large pelagic fish in Eastern Indonesia is the Banda Sea (Hidayat et al 2014).

The Banda Sea is the waters of the Eastern Indonesian Region which is included in the waters of the West Pacific Ocean and is bordered by the Indian Ocean (Chodrijah & Nugraha 2013). The Banda Sea has also become a very potential fishing area for *K. pelamis* in Maluku Province (Tadjuddah et al 2017; Satrioajie et al 2018) with the utilization of *K. pelamis* resources in the Banda Sea carried out throughout the year (Tangke et al 2014).

*K. pelamis* is a type of fish that belongs to the Scrombidae family (Afifi et al 2022; Mardlijah et al 2021; Chakma et al 2020). The Scrombidae family basically occurs in marine waters and is classified as a pelagic fish (Ollé et al 2022; Paulangan et al 2020). Based on their size, tuna are divided into two groups: *Thunnus* species are grouped into large tuna and *K. pelamis* species are classified as small tuna (Nugraha et al 2020; Chodrijah 2011).

Exploitation of this resource is carried out by various forms of fishing activities, including purse seine, pole and line, handline (Jaleel & Smith 2022; Mardlijah et al 2021; Widodo & Nugraha 2009). Based on the magnitude of the potential and the condition of the available large pelagic fish resources. So it is necessary to study the status of large pelagic fisheries, especially *K. pelamis* in the Banda Sea.

This study aims to examine several aspects of *K. pelamis* including; a) biological aspects including length-weight relationship; b) Assess fisheries aspects including production trends, fishing effort, fishing grounds, fishing season, fishing gear and CPUE; and c) Assess efforts to manage and utilize *K. pelamis* which includes calculation of catch rate, Maximum Sustainable Yield, Maximum Economic Yield, and Number of Allowed Catches in the Maluku region.

**MATERIAL AND METHODS**

The research was conducted for 90 days, from 4 March to 25 May 2019 in the Banda Sea. Data collection was carried out at several sampling points as shown in Figure 1.

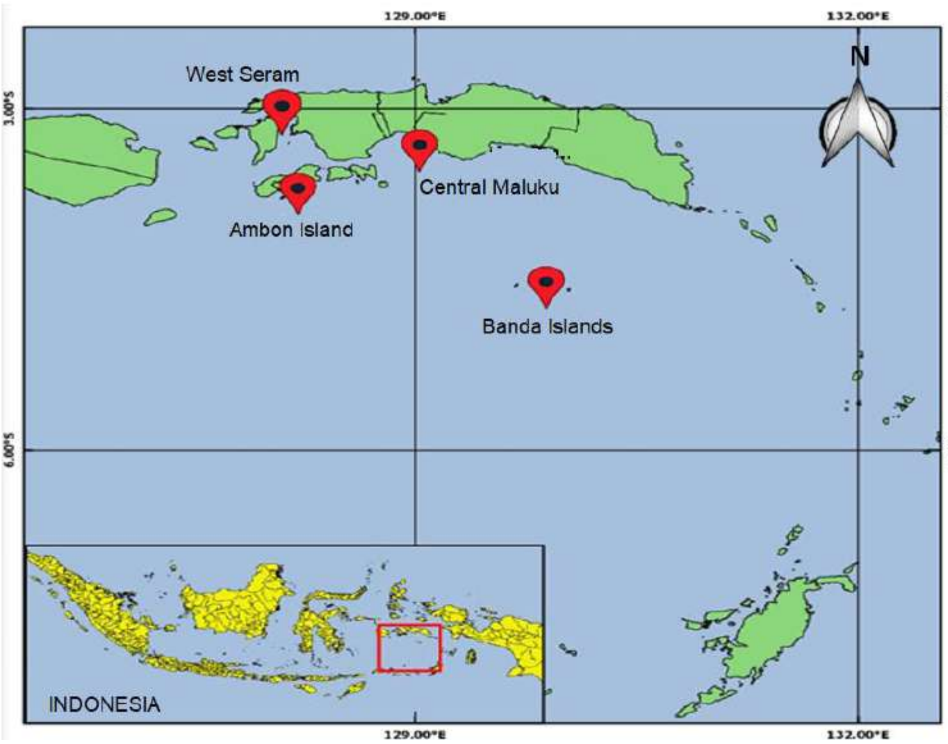

Figure 1. Map of Research Locations.

The tools and materials used in this study are as follows: ruler, tape measure, digital scales, camera, stationery, identification label, and several samples of *K. pelamis.*

***Data Retrieval Method***

In this study a survey method was used, namely by observing in the field the observed fish samples. Determination of locations and fishing gear is carried out by purposive sampling, namely collecting data deliberately according to the desired conditions (Mukhsin et al 2017). While the determination of respondents was carried out by accidental sampling, namely the determination of fishermen by accident.

Data collection for *K. pelamis* sampling was carried out using the simple random sampling method, namely simple random sampling by taking samples to measure the length and weight of fish as much as 10% of the total catch. Secondary data needed is in the form of periodic data (time series) of catches and fishing effort for 5 to 10 years.

**Data analysis**
**Data collection**

Primary data collection was carried out by direct observation and measurement of *K. pelamis* which were landed, the data collected included: fork length, total weight, sex, gonadal maturity level. Secondary data needed is in the form of periodic data (time series) of catches and fishing effort for the last 10 years.

***Long Frequency Distribution***

How to obtain the frequency distribution by determining the class interval, class median, and frequency in each length group. The long frequency distribution that has been determined with the same class intervals can then be formed in a diagram to see the results of the long frequency distribution.

**Length-Weight Relationship**

The model used in estimating the relationship between length and weight is an exponential relationship with the following equation (Andamari et al 2012):

$$W = aL^b$$

Information :

W : Weight of fish (grams)
l : standard length/fish fork (cm)
a : The constant number or intercept that is sought from the regression calculation
b : Exponent or tangential angle

To determine the value of a and b, a linear regression analysis is needed or by taking the logarithm of the formula above. The linear equation becomes:

$$Ln\ W = Ln\ a + b\ Ln\ L$$

Then a simple linear equation can be made:

$$Y = a + bX$$

Where:
Y = dependent variable
X = Free change
a' = Antilog Intercept
b = Slope (slope)

If you pay more attention, then the possible prices for b that appear are b<3, b=3, and b>3. According to Effendi (1979) each price b can be interpreted as follows:

1) If b<3, then the increase in length is faster than the increase in weight or it is called negative allometric
2) If b>3, then the weight gain is faster than the increase in length or it is called positive allometric
3) If b=3, then the increase in length and weight increase are balanced or called isometric

***Sex Ratio***

Comparison of the sex of the biota was carried out by visual observation of a number of male and female individuals obtained as samples at the study site. The sex ratio is known using the formula (Diningrum et al 2019):

$$X = \frac{X}{(X+Y)} \times 100\%$$

$$Y = \frac{Y}{(X+Y)} \times 100\%$$

Where:
X = number of male fish
Y = number of female fish

After the sex comparison in percentage is obtained, to find out whether there is a significant difference between the male and female individual comparisons, it is carried out through testing and the '$X^2$' (chi square) test with the formula according to Effendi (1979):

$$X^2 = \frac{(fo-fh)^2}{fh}$$

Where:
$X^2$ = chi square
$f_0$ = observed biota frequency
$f_h$ = expected biota frequency

The $X^2$ value is obtained from this calculation, then the value is compared with the table $X^2$ value with a 95% confidence level and degrees of freedom (db) = 1 (one) with the hypothesis:
$H_0$ = no significant difference between the number of male and female fish
$H_1$ = there is a significant difference between the number of male and female fish

If, $X^2_{count} < X^2_{table}$ = $H_0$ is accepted, $H_1$ is rejected
$X^2_{count} > X^2_{table}$ = $H_0$ is rejected, $H_1$ is accepted

***Gonad Maturity Level (GML)***

GML was determined by visual observation of gonadal morphology. Furthermore, the observed characteristics are adjusted to the characteristics of the level of maturity.

***Size at first maturity (Lm)***

The value of Lm can be estimated by the Soerman-Karber formula proposed by (Udupa 1986) as follows:

$$m = xk + \frac{d}{2} - (X \sum Pi)$$

$$M = \text{antilog}\ (m \pm 1{,}96\ \sqrt{x^2 \Sigma \frac{pi*qi}{n_i - 1}}\ )$$

Information:
m = logarithm of the long class at its first maturity
d = difference in the logarithm of the increase in the median length
k = number of long classes
*xk* = logarithm of the median length where the fish is 100% gonadal mature (or where $p_i = 1$)
$p_i$ = proportion of mature fish in length class i to the number of fish on the long interval i
$n_i$ = number of fish in class i length
$q_i = 1 - p_i$
M = length of fish at first maturity equal to anti-log m, if $\propto = 0.05$, then the confidence interval is 95% of m.

**Size First Caught (Lc)**

The size of Lc is estimated by the method (Sparre & Venema 1999):

$$SL = \frac{1}{a + \exp(a-bL)}$$

The Lc value is obtained by plotting the cumulative frequency percentage of fish caught with the standard length, where the intersection point between the 50% cumulative frequency curve is the length when 50% of the fish are caught. The Lc value can be calculated through the formula:

$$Lc = \frac{-a}{b}$$

### *Catch Per Unit Effort (CPUE)*

Catch data and fishing effort obtained are then tabulated to determine CPUE. The fishing effort can be in the form of operating days or months of operation, the number of fishing trips or the number of fleets conducting fishing operations. In this study the fishing effort (effort) used is the number of trips. The formula that can be used to determine the CPUE value is as follows (Noija et al 2014):

$$CPUE_i = \frac{Catch_i}{Effort_i}$$

Where :
$CPUE_i$ = catch per unit of fishing effort in year i (tonnes/unit)
$Catch_i$ = catch in year i (tons)
$Effort_I$ = fishing effort in year i (trip)

### *Standardization of Fishing Gear*

Standardization is done by finding the value of the fishing power factor or Fishing Power Index (FPI) of each fishing gear. The fishing gear used as standard has an FPI value equal to one, while the FPI value for other fishing gear is obtained from the CPUE of other fishing gear divided by the CPUE of standard fishing gear. The formula for calculating FPI is as follows:

$$RFP_i = \frac{Ci/Ei}{Cs/Es}$$

Information:
$RFP_i$ = catch power factor of the fishing unit which will be standardized in year i
$C_i$ = number of catches of the type of fishing unit that will be standardized in year i
$C_s$ = number of catches of the type of fishing unit used as standard in year i
Ei = number of fishing effort for the type of fishing unit that will be standardized in year i
$E_s$ = number of fishing efforts for the type of fishing unit used as standard in year i.

After obtaining the $RFP_i$ value, to calculate the standardized effort results use the formula:

$$\text{Standard Effort} = FPI_i \times \text{Effort}$$

### *The Production Surplus Model*

The purpose of using the Production Surplus Model is to determine the optimum level of effort, which is an effort that can produce a maximum sustainable catch without affecting long-term stock productivity (MSY) which is estimated by using the Schaefer model from catch data and fishing effort in several years. MSY can be estimated using the formula (Sparre & Venema 1998):

$$CPUE = \frac{Y}{f} = \frac{Y(i)}{f(i)}, i = 1, 2, \ldots\ldots n$$

Keterangan:
Y(i) = catch in the year i, i=1,2,......n
f(i) = fishing effort in the year i, i=1,2......n

Determining the value of a (*intercept*) and b (*slope*) requires a linear regression f(i) to Y(i)/f(i). After the values of a and b are obtained, fMSY and MSY can be calculated using the formula:

$$f_{MSY} = -\frac{a}{2b} \text{ and } MSY = -\frac{a^2}{4b}$$

Furthermore, to determine the level of utilization of fish resources as a percentage of the number of catches in a certain year with the maximum production value (MSY) (Simbolon 2011):

$$\text{Utilization rate} = \frac{Ci}{MSY} \times 100\%$$

Information:
Ci = number of fish caught in year i
MSY = *Maximum Sustainable Yield*

**RESULTS AND DISCUSSION**

***Long Frequency Distribution of K. pelamis***

Based on the results of observations of 1022 samples of K. pelamis, it was obtained data on the distribution of frequency distributions with the shortest size being 28.5 cm and the longest being 77.3 cm. The distribution of fish length during observation is presented in Figure 2.

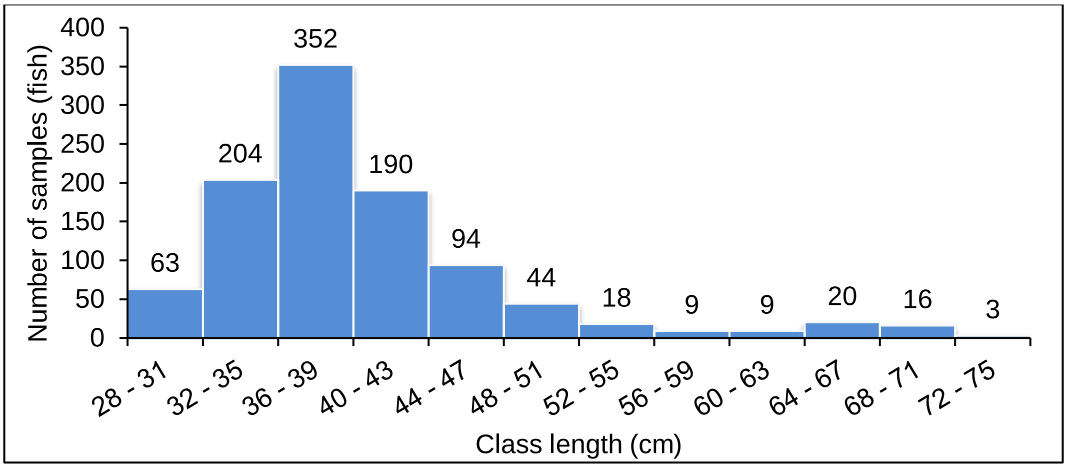


Figure 2. Long Frequency Distribution of *K. pelamis.*

Overall, the longest mode of measurement in the sample was found at class intervals of 36 – 39.9 cm. This happens because of the use of FADs so that many small or immature gonads are caught.

***Long Relationship Weight K. pelamis***

The relationship between length and weight obtained is presented in Figure 3 according to the characteristics of the fish growth pattern.

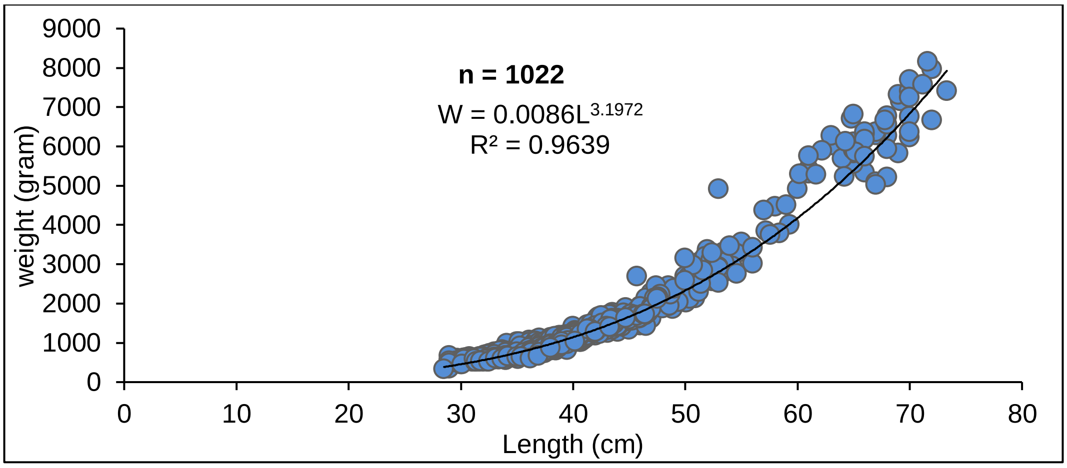


Figure 3. The relationship between the length and weight of *K. pelamis.*

From the results of the analysis of the length-weight relationship in Figure 3, it is obtained that the length-weight relationship of *K. pelamis* is $W = 0.0086L^{3.1972}$, with a value of b = 3.1972. Then a t test was performed on the value of b at a 95% confidence interval, it was obtained $t_{count} > t_{table}$ ($t_{count} = 10.1975$; $t_{table} = 1.962$), then $H_0$ was rejected which means that the increase in length and weight is significantly different. So that it can be said that the increase in length is not proportional to the increase in weight and based on the value b = 3.1972 it shows that the growth pattern is positive allometric, where the weight gain is faster than the increase in length.

Calculation of the growth pattern of *K. pelamis* using the $t_{test}$ ($t_{count} = 0.05$) at a 95% confidence interval (α 0.05) shows that by producing a coefficient of determination (R) of 0.9818 this shows a correlation coefficient (r) close to 1. This also shows that the increase in length will affect weight gain by showing that the correlation or relationship between length and fish weight is close and positive.

***Sex ratio of K. pelamis***

From the results of observations of 100 *K. pelamis*, the sex ratio showed that 51 male fish (51%) and 49 female fish (49%) had a sex ratio of 1:1. According to Senen et al (2011), the balance of the sex ratio also indicates that one male fish will fertilize one female fish. It is said to be balanced if the number of males and females in a waters shows the number 1:1. The number of female fish is a determinant of the sustainability of a population because during the mating season or looking for a partner there will be high competition so that the natural mortality of males is higher. The sex ratio of *K. pelamis* is presented in Figure 4.

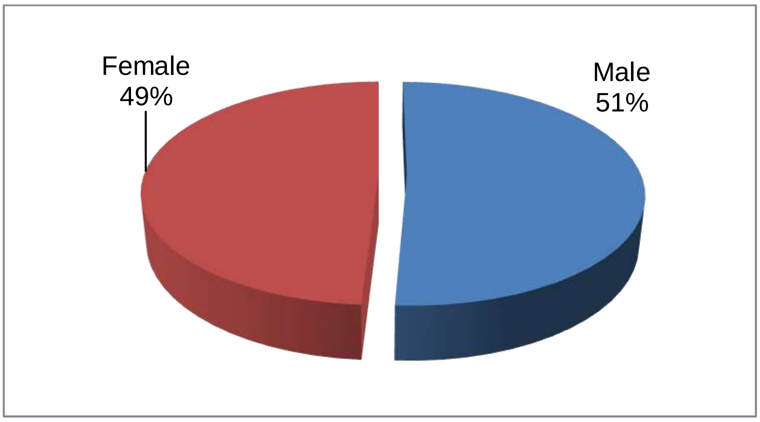


Figure 4. Sex Ratio of *K. pelamis*

To find out the accuracy of whether the comparison is balanced or not, it is necessary to calculate the sex ratio using the chi-square test presented in Table 1.

Table 1

*Sex Ratio K. pelamis*

| Sex | N | $t_{count}$ | $t_{table}$ |
|---|---|---|---|
| Male | 51 | 0.040 | 3.84 |
| Female | 49 | | |

The results of the chi-square test obtained $t_{count}$ is 0.040 and $t_{table}$ is 3.84 so that $t_{count} < t_{table} = H_0$ is accepted, which means there is no real difference between the male and female populations of *K. pelamis.*

***Gonad Maturity Level of K. pelamis***

The level of maturity of the male gonads can be seen from the size and color of the gonads while in the female gonads it can be seen from the size, color of the gonads and the presence or absence of eggs in the gonads. The results of gonadal observations can be seen in Table 2.

Table 2

Percentage of Gonad Maturity Level of *K. pelamis*

| Sex | Amount (N) | GML (%) | | | |
|---|---|---|---|---|---|
| | | I | II | III | IV |
| Male | 51 | 41.18 | 31.37 | 19.61 | 7.84 |
| Female | 49 | 26.53 | 46.94 | 18.37 | 8.16 |
| Combined | 100 | 34 | 39 | 19 | 8 |

For male fish, the number of mature gonads was 27.45% and those that were immature were 72.55%. And for female fish, the number of mature gonads was 26.53% and those that were immature were 83.47%. Overall (males and females), the number of mature fish was 27% and 73% immature. This indicates that more fish are caught before the gonads mature, it is suspected that the fish have not yet had time to spawn so this will affect recruitment in the fishing area.

**Length at first mature (Lm)**

The results of observations made for the level of gonad maturity and length size distribution against 100 *K. pelamis*, it is suspected that the length at first maturity of the gonads was 44.81 cm. By using a 95% confidence level, the confidence limit for predictions that have started to mature gonads is at 43.39-46.28 cm. Following are the results of the study for the value of Lm *K. pelamis* at other locations presented in Table 3.

Table 3

Several grades of Lm *K. pelamis* at other locations

| Lm value (FL)(cm) | Research Location | Source |
|---|---|---|
| 42.8 | South Seram island waters | Manik (2007) |
| 42.9 | Eastern Indian Ocean Waters | Jatmiko et al (2015) |
| 43 | West and South waters of North Maluku | Karman et al (2016) |
| 43 | West Indian Ocean Waters | Norungee & Kawol (2011) |
| 46.5 | Bay of Bone, South Sulawesi | Jamal et al (2011) |

***Length at first capture (Lc)***

Calculation of Lc is done by using data on the length distribution and the number of fish in the purse seine. Based on the results of observations of 226 fish caught by purse seine, it was found that the length of the first caught was 40.12 cm. Lc *K. pelamis* is presented in Figure 5.

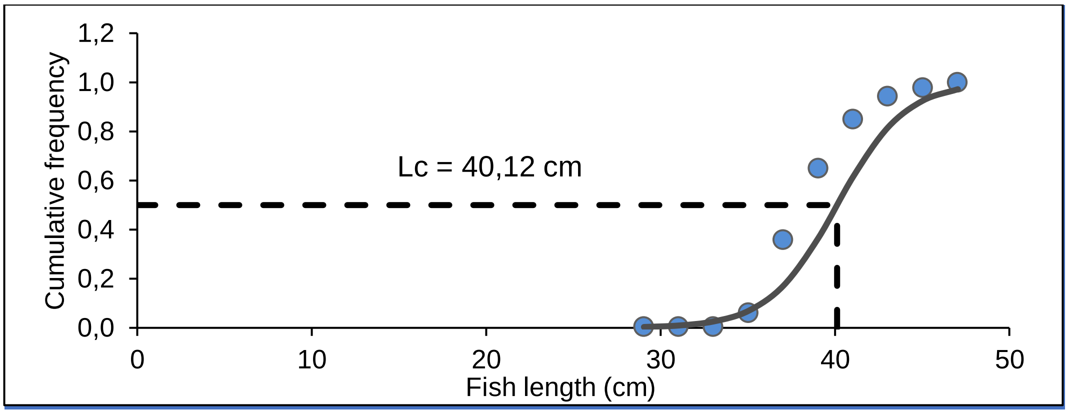


Figure 5. Lc *K. pelamis* on a purse seine.

Then a comparison is made between the values of Lm and Lc, it is suspected that the fish caught by the purse seine has a value (Lc<Lm) where the fish when caught have not had time to spawn beforehand. Thus, this is thought to cause a significant decrease in the population of *K. pelamis.*

***Fisheries Aspect***

*K. pelamis* is generally caught using pole and liner, trolling liner and purse seiner less than 30 GT with trips that vary from one day fishing to one week fishing. Fishermen in the Banda Maluku Sea mostly have vessels under 30 GT.

***Fishing Ground***

The dominant fishing grounds for *K. pelamis* are in the Banda Sea, where these waters are areas that are usually approached by fish due to environmental factors, food availability and are spawning and egg-laying areas. To get the maximum catch, the right season is needed for catching where the highest catch occurs when it enters the East season or is called the harvest season. The harvest season occurs between October – December, the lean season occurs between May – July, the western season occurs between December – January and the transition season occurs between April – May. The catches obtained depend on the season, currents and wind which are obstacles for fishermen to go to sea and make catches.

***Stock status of K. pelamis in the Banda Sea***

***Catch per Unit Effort (CPUE) and Maximum Sustainable Yield (MSY)***

Production and fishing efforts of *K. pelamis* in the Banda Sea are carried out using 4 types of fishing gear including handline, troll line, purse seine and pole and line. Production and effort of catching *K. pelamis* can be seen in Table 4.

Table 4

Production and Catching Efforts of *K. pelamis* in the Banda Sea

| Year | Production | | | | | Trip | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Purse seiner | Trolling liner | Handliner | Pole and liner | Total | Purse seiner | Trolling liner | Handliner | Pole and liner |
| 2008 | 9,186.63 | 9,775.52 | 301.40 | 16,214.11 | 35,477.65 | 23,419 | 427,899 | 123,472 | 157,717 |
| 2009 | 9,137.30 | 9,491.48 | 745.91 | 17,312.00 | 36,686.68 | 21,373 | 392,497 | 248,406 | 123,316 |
| 2010 | 10,253.94 | 13,137.78 | 1,516.36 | 18,689.02 | 43,597.11 | 43,622 | 474,562 | 311,339 | 140,968 |
| 2011 | 11,712.66 | 14,313.94 | 408.27 | 20,519.92 | 46,954.79 | 35,888 | 433,171 | 191,396 | 25,248 |
| 2012 | 12,318.24 | 15,724.01 | 4,232.45 | 16,727.68 | 49,002.38 | 42,027 | 432,897 | 226,447 | 98,277 |
| 2013 | 26,305.18 | 6,484.45 | 5,226.45 | 22,949.42 | 60,965.51 | 32,010 | 536,119 | 186,753 | 217,374 |
| 2014 | 14,806.04 | 15,786.37 | 5,952.18 | 16,749.75 | 53,294.35 | 39,017 | 209,321 | 293,614 | 92,577 |
| 2015 | 14,726.79 | 16,392.38 | 4,127.07 | 19,208.60 | 54,454.84 | 34,787 | 499,933 | 85,352 | 187,803 |
| 2016 | 18,079.96 | 17,311.33 | 4,616.49 | 20,836.71 | 60,844.49 | 41,596 | 497,222 | 204,868 | 165,692 |
| 2017 | 18,272.12 | 18,172.17 | 5,210.66 | 23,064.41 | 64,719.36 | 38,453 | 386,606 | 191,767 | 148,278 |
| 2018 | 20,681.51 | 19,426.73 | 5,158.88 | 24,984.11 | 70,251.22 | 48,078 | 447,850 | 157,874 | 167,308 |

There are differences in fishing productivity between handline, trolling line, purse seine, and pole and line. it is necessary to standardize productivity, to obtain the Fishing Power Index (FPI). Can be seen in Table 5.

Table 5

Productivity and Fishing Power Index (FPI) on *K. pelamis*

| Year | Productivity (Ton/trip) | | | |
|---|---|---|---|---|
| | Purse seiner | Trolling liner | Handliner | Pole and liner |
| 2008 | 0.3923 | 0.0228 | 0.0024 | 0.1028 |
| 2009 | 0.4275 | 0.0242 | 0.0030 | 0.1404 |
| 2010 | 0.2351 | 0.0277 | 0.0049 | 0.1326 |
| 2011 | 0.3264 | 0.0330 | 0.0021 | 0.8127 |
| 2012 | 0.2931 | 0.0363 | 0.0187 | 0.1702 |
| 2013 | 0.8218 | 0.0121 | 0.0280 | 0.1056 |
| 2014 | 0.3795 | 0.0754 | 0.0203 | 0.1809 |
| 2015 | 0.4233 | 0.0328 | 0.0484 | 0.1023 |
| 2016 | 0.4347 | 0.0348 | 0.0225 | 0.1258 |
| 2017 | 0.4752 | 0.0470 | 0.0272 | 0.1555 |
| 2018 | 0.4302 | 0.0434 | 0.0327 | 0.1493 |
| Average | 0.4217 | 0.0354 | 0.0191 | 0.1980 |
| Index | Purse seiner | Trolling liner | Handliner | Pole and liner |
| CPUE | 0.4217 | 0.0354 | 0.0191 | 0.1980 |
| FPI | 1 | 0.084 | 0.045 | 0.47 |

Based on Table 5, the purse seine is used as a standard fishing gear, because its productivity is greater than other fishing gear. Furthermore, the standardization process is by multiplying the FPI with each fishing gear to get a standard effort with the results that can be seen in Table 6.

Table 6

Standardization of Catching Efforts for *K. pelamis*

| Year | Purse seiner | Trolling liner | Hand liner | Pole and liner | Standard Total Effort | CPUE (Ton/trip) |
|---|---|---|---|---|---|---|
| 2008 | 23.419 | 35.935 | 5.593 | 74.053 | 139.000 | 0.2552 |
| 2009 | 21.373 | 32.962 | 11.252 | 57.901 | 123.488 | 0.2971 |
| 2010 | 43.622 | 39.854 | 14.103 | 66.189 | 163.768 | 0.2662 |
| 2011 | 35.888 | 36.378 | 8.670 | 11.855 | 92.790 | 0.5060 |
| 2012 | 42.027 | 36.355 | 10.258 | 46.145 | 134.784 | 0.3636 |
| 2013 | 32.010 | 45.023 | 8.459 | 102.065 | 187.557 | 0.3250 |
| 2014 | 39.017 | 17.579 | 13.300 | 43.468 | 113.364 | 0.4701 |
| 2015 | 34.787 | 41.984 | 3.866 | 88.180 | 168.818 | 0.3226 |
| 2016 | 41.596 | 41.757 | 9.280 | 77.798 | 170.431 | 0.3570 |
| 2017 | 38.453 | 32.467 | 8.687 | 69.622 | 149.229 | 0.4337 |
| 2018 | 48.078 | 37.611 | 7.151 | 78.557 | 171.397 | 0.4099 |

From the effort and yield data shown in Table 6, it will produce CPUE fluctuations (Figure 6) every year, the CPUE linear equation relationship.

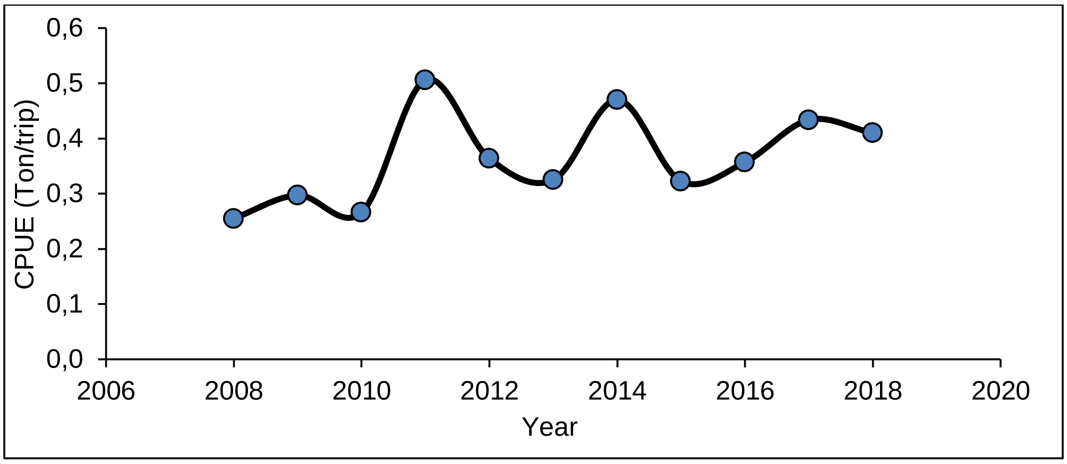

Figure 6. *K. pelamis* CPUE fluctuations in the Banda Sea.

From Figure 6 it can be concluded that 2011 was the highest CPUE point. The phenomenon of fluctuations in CPUE values when observing the relationship between effort and CPUE is strongly influenced by; (1) the size and number of vessels in operation, (2) type and size of fishing gear, (3) Illegal level, Unreported and Unregulated (IUU) fishing. (4) HR capabilities on board, (5) fishing ground location, (6) the number of fish caught (yield) landed, (7) natural conditions during fishing operations, and (8) the discipline of the fishing fleet on the specified fishing ground (not fishing in waters that are not in accordance with the permit) (Krisdiana et al 2014).

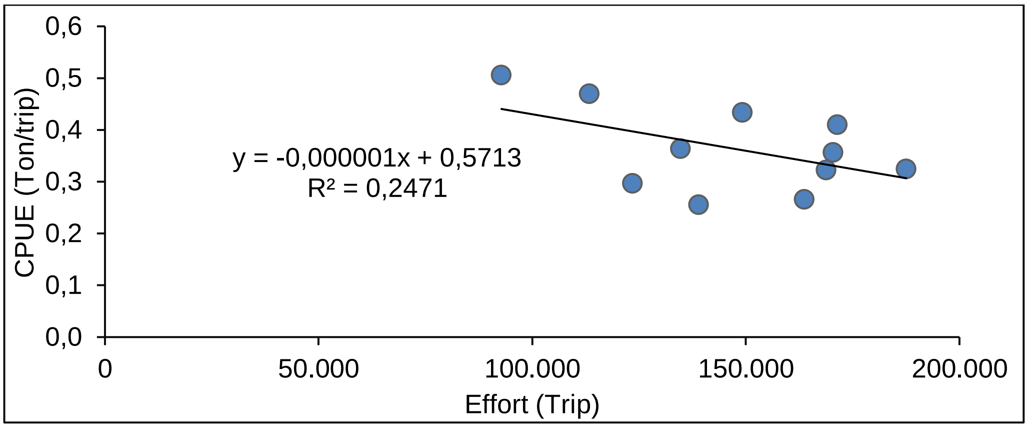

Figure 7. Linear Equation of CPUE & Effort K. pelamis.

The relationship between CPUE and effort in Figure 7 shows that the value of the estimation parameter for K. pelamis is obtained by intercept (a) = 0.5731 and slope (b) = -0.000001 so that it forms a Linear Schaefer equation CPUE = -0.000001x + 0.5731. This relationship can be interpreted that by catching x units per year, it will reduce the CPUE value by 0.000001 tons per year. The conditions described in the linear equation produce a value of $R^2$= 0.24, which means about 24% the influence of the variables used. namely effort and yield. Thus the $R^2$ value is statistically considered not strong enough to represent the influence of the variables used in this model because the closer the $R^2$ value is to 100%, the stronger the variable influence.

MSY and EMSY calculation data for K. pelamis in the Banda Sea using the Schaefer Linear method are presented in Table 7. The results of biological analysis using the Schaefer Linear model approach can produce an MSY value of 57,837 tonnes with a standard effort/EMSY of 202,473 trips.

Table 7

MSY and EMSY Estimation of *K. pelamis* Based on Schaefer Linear Model Calculations

| Year | Catch number (Ton) | Total Effort Standard | CPUE (Schaefer) |
|---|---|---|---|
| I | Yi | X | Y |
| 2008 | 35.477.7 | 139.000 | 0.2552 |
| 2009 | 36.686.7 | 123.488 | 0.2971 |
| 2010 | 43.597.1 | 163.768 | 0.2662 |
| 2011 | 46.954.8 | 92.790 | 0.5060 |
| 2012 | 49.002.4 | 134.784 | 0.3636 |
| 2013 | 60.965.5 | 187.557 | 0.3250 |
| 2014 | 53.294.3 | 113.364 | 0.4701 |
| 2015 | 54.454.8 | 168.818 | 0.3226 |
| 2016 | 60.844.5 | 170.431 | 0.3570 |
| 2017 | 64.719.4 | 149.229 | 0.4337 |
| 2018 | 70.251.2 | 171.397 | 0.4099 |
| Amount | 576.248.3662 | 1.614.628 | 4.0064 |
| Average value | 52.386.22 | 146.784 | 0.3642 |
| Intercept a | | | 0.57131 |
| Slope b | | | -0.000001 |
| MSY Schaefer; -a^2/4b | | | 57,837 |
| E MSY Schaefer : -a/2b | | | 202,473 |
| *Total Allowable Catch (TAC)* 80% MSY | | | 46,269.77 |

Based on the calculation of the Linear model. Biological overfishing has occurred in *K. pelamis* in the Banda Sea which is indicated by the actual catch having passed MSY. This is evidenced by the actual catch in 2018 which reached 70,251.2 tons. and exceeds the Total Allowable Catch (TAC) potential of 80% of the MSY value of 46,269.77 tons. The MSY *K. pelamis* curve can be seen in Figure 8.

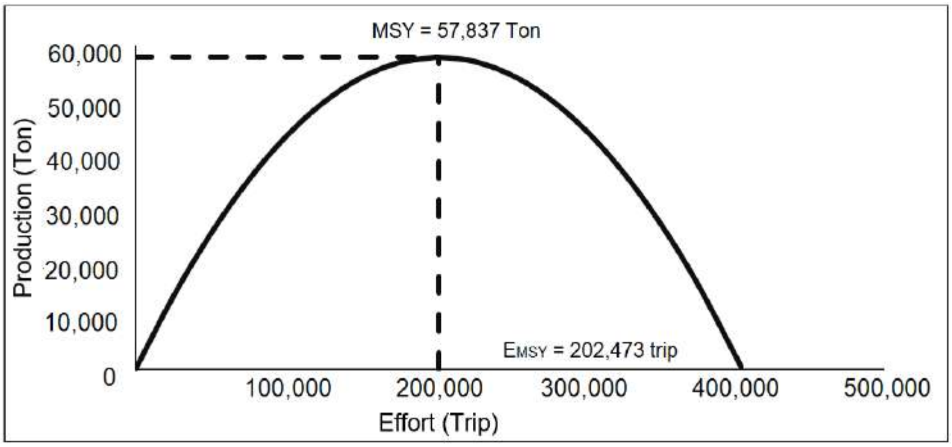


Figure 8. Stock balance curve (MSY) for *K. pelamis*

## Conclusions

1. Biological aspects of *K. pelamis* in the Banda Sea show a positive allometric growth pattern. *K. pelamis* experienced a state of being caught before spawning (Lc < Lm). This catching can result in an imbalance in stocks in nature because if the fish caught have not spawned, recruitment can be disrupted.

2. The fishery aspect of *K. pelamis* is in a condition where production continues to increase with a low level of gear selectivity. So that there is a need for regulation of fishing gear and its supervision.
3. *K. pelamis* utilization activities have shown catches that exceed the maximum point of sustainable production and MEY. This is shown from the actual effort and production values that exceed the MEY value so that the profit earned decreases.

**References**


Adnyani L. P., Nurmawati, Anggriani I. 2019 [Analysis of Potential and Utilization Level of Fish Resources in Balikpapan Waters. East Kalimantan]. Gorontalo Fisheries Journal 2(2):55-68 [in Indonesian].

Afifi M. A. M., El-Sadek A., El-Haddad K. M. 2022 First record of skipjack tuna (*Katsuwonus pelamis*) from Dahab in the Gulf of Aqaba. Red Sea. Egypt. Egyptian Journal of Aquatic Biology & Fisheries 26(3): 699–710.

Afriliani W., Anna Z., Handaka A. A., Khan A. M. A. 2020 Typology of Skipjack (*Katsuwonus pelamis*) Fisheries at Nizam Zachman Oceanic Fishing Port. Jakarta. Indonesia. Asian Journal of Fisheries and Aquatic Research 7(2):39-50.

Andamari R., Hutapea J. R., Prisantoso B. I. 2012 [Reproduction aspects of the yellowfin tuna (*Thunnus albacares*)]. Journal of Tropical Marine Science and Technology 4(1):89-96 [in Indonesian].

Bintoro G., Yulianto E. S., Lelono T. D., Prasetyo D. T., Rahman M. A., Sari W. K. 2022 Utilization status and bioeconomic performance of skipjack tuna (*Katsuwonus pelamis*) fishery in the south coast of Malang waters. East Java. Indonesia. IOP Conference Series: Earth and Environmental Science 1033:1-10.

Chakma S., Saha S., Hasan Md. N., Rahman Md. A., Akter M., Hoque Md. S., Ullah Md. R., Sujan K. M., Shahriar Al. 2020 Effect of frozen storage on the biochemical. microbial and sensory attributes of Skipjack Tuna (*Katsuwonus pelamis*) fish loins. Journal of Applied Biology & Biotechnology 8(4):58-64.

Chodrijah U. 2011. [Several Aspects of Reproductive Biology of Yellowfin Tuna *(Thunnus albacares)* from Banda Sea Waters]. Proceedings of the 8th National Fish Seminar p. 401-409 [in Indonesian].

Chodrijah U., Nugraha B. 2013 [Size Distribution of Longline Tuna Catches and Catching Areas in Banda Sea Waters]. Indonesian Fisheries Research Journal 19(1): 9-16 [in Indonesian].

Diningrum T. D. B., Triyono H., Jabbar M. A. 2019 [Biological Aspects of Skipjack Tuna in Southeast Celebes]. Journal of Fisheries and Maritime Extension 13(2): 139-147 [in Indonesian].

Effendie M. I. 1979 [Fisheries Biology Method]. Bogor: Dewi Sri Foundation [in Indonesian].

Genti J. G., Marsoedi. Afandhi A. 2016 The Utilization of Skipjack tuna *Katsuwonus pelamis* (Linnaeus. 1758) Availability for Sustainable Fisheries Management in Prigi. East Java. J-PAL 7(2):122-127.

Hidayat T., Chodrijah U., Noegroho T. 2014. [Characteristics of trolling fisheries in the Banda Sea]. Indonesian Fisheries Research Journal 20(1):43-51 [in Indonesian].

Hutajulu H., Imran Z., Budiharsono S., Kusumastanto T. 2019 Economic structure analysis in the development of skipjack tuna *(Katsuwonus pelamis)* fisheries industry in Jayapura City, Papua, Indonesia. AACL Bioflux 12(5):1726-1737

Hutomo M., Moosa M. K. 2005 Indonesian marine and coastal biodiversity: Present status. Indian Journal of Marine Sciences 34(1):88-97.

Jackson A. M., Ambariyanto, Erdmann M. V., Toha A. H. A., Stevens L. A., Barber P. H. 2014 Phylogeography of commercial tuna and mackerel in the Indonesian Archipelago. Bulletin of Marine Science 90(1):471–492.

Jaleel A., Smith H. D. 2022 The Maldives Tuna Fishery: An Example of Best Practice. Ocean Yearbook Online 36(1):314-345.

Jamal M., Sondita M. F. A., Haluan J., Wiryawan B. 2011 [Utilization of Skipjack Biological Data *(Katsuwonus pelamis)* in the Framework of Responsible Fisheries Management

in the Waters of Bone Bay]. Journal of Indonesian Nature 14(1): 107-113 [in Indonesian].
Jatmiko I., Hartaty H., Bahtiar A. 2015 [Reproductive Biology of Skipjack Fish *(Katsuwonus pelamis)* in the Eastern Indian Ocean]. Bawal 7 (2): 87-94 [in Indonesian].
Karman A., Martasuganda S., Sondita M. F. A., Baskoro M. S. 2016 [Biological base of skipjack as the foundation for sustainable fisheries management in the North Maluku Province]. Journal of Tropical Marine Science and Technology 8(1): 159-173 [in Indonesian].
Krisdiana R. D., Iriana D., Djunaedi O. S., Dhahiyat Y. 2014 [Bioeconomic analysis of yellowfin tuna (*Thunnus albacares* Bonnaterre 1788) in the Indonesian Fisheries Management Area (WPPNRI) 573]. (Desertation). Faculty of Agriculture, University of Padjadjaran p. 1-15.
Lintang C. J., Labaro I. L., Telleng A. T. 2012 [Study of the fishing season for tuna using handline fishing gear in the Maluku Sea]. Journal of Capture Fisheries Science and Technology 1(1):6-9 [in Indonesian].
Mahmud, Sinrang A. D. B., Massiseng A. N. A. 2021 Prospects of Fisheries Industry Development in Indonesia Through Online Publication Media. International Journal of Applied Biology 5(2):117-129.
Manik N. 2007 [Several aspects of the biology of skipjack tuna (*Katsuwonus pelamis*) in the waters around South Seram Island and Nusa Laut Island]. Oceanology and Limnology in Indonesia 33:17-25 [in Indonesian].
Manurung V. T. 2016 [Performance and Institutional Credit for Small-Scale Tuna Fishing Business in Eastern Indonesia]. In the Agro-Economy research forum 16(2):60-74) [in Indonesian].
Mardlijah S., Pane A. R. P., Panggabean A. S. 2021 The Stock Status of Skipjack Tuna (*Katsuwonus pelamis*) in Tomini Bay and Its Surrounding Areas. Indonesia. IOP Conference Series: Earth and Environmental Science 934:1-9.
Mukhsin R., Mappigau P., Tenriawaru A. N. 2017 [The Effect of Entrepreneur's Orientation on the Survival of Small and Medium Enterprises of the Fishery Processing Groups in Makassar City]. Journal of Analysis 6(2):188–193 [in Indonesian].
Noija D., Martasuganda S., Murdiyanto B., Taurusman A. A. 2014 [Potential and level of utilization of demersal fish resources in the waters of Ambon Island, Maluku Province]. Journal of Fisheries and Marine Technology 5(1): 55-64 [in Indonesian].
Norungee D., Kawol D. 2011 Macroskopic study on some aspects of the reproductive biology of skipjack tuna (*Katsuwonus pelamis*) in the Western Indian Ocean. In I: Proceeding Working Party on Tropical Tunas of the IOTC 2011
Nugraha E., Yudho G. S., Jaenudin A., Yusrizal, Kusmedy B., Kusnidar A., Husen E. S. 2020 Relationship between length and weight of skipjack tuna (*Katsuwonus pelamis*) purse seine catching in the Maluku Sea. Indonesia. AACL Bioflux 13(1):330-345.
Ollé J., Vilà-Valls L., Alvarado-Bremer J., Cerdenares G., Duong T. Y., Hajjej G., Lino P. G., Muñoz-Lechuga R., Sow F. N., Diaha N. C., Araguas R. M., Sanz N., Viñas J., 2022 Population genetics meets phylogenetics: new insights into the relationships among members of the genus *Euthynnus (family Scombridae).* Hydrobiologia 849:47–62.
Paulangan Y. P., Rumbiak K., Barapadang B. 2020 Fishing season and participatory mapping of the fishing ground of target fish in Depapre Bay. Jayapura Regency. Papua Indonesia. IOP Conference Series: Earth and Environmental Science 584:1-8.
Satrioajie W. N., Suyadi, Syahailatua A., Wouthuyzen S. 2018 The importance of the Banda Sea for tuna conservation area: A review of studies on the biology and the ecology of tuna. IOP Conference Series: Earth and Environmental Science. 184:1-11.
Senen B., Sulistiono S., Ismudi M. 2011 [Biological aspects of the flying catfish (Decapterus macrosoma) in Banda Neira waters. Maluku. Indonesia]. Agricultural Journal UMMI 1: 35-40 [in Indonesian].
Simbolon D., Wiryawan B., Wahyuningrum P. I., Wahyudi H. 2011 [Utilization level and seasonal patterns of fishing for lemuru in the Bali Strait waters. Bulletin PSP 19(3): 293-307 [in Indonesian].
Sparre P., Venema S. C., 1999 Introduction to Tropical Fish Stock Assessment. Part 1. FAO Fishing Technology Paper No.306/1.Rev.2. Rome. FAO. 407p.

Sugara A., Nolisa A., Anggoro A., Suci A. N. N., Suhendri R. 2022 [Diversity Species Identification of Fish Catched By Fishermen Tapak Paderi Bengkulu City]. Samakia: Journal of Fisheries Science 13(1):1-7 [in Indonesian].

Tadjuddah M., Anadi L., Mustafa A., Arami H., Abdullah. Kamri S., Wianti N. I. 2017 Growth pattern and size structure of skipjack tuna caught in Banda Sea. Indonesia. AACL Bioflux 10(2):227-233.

Tangke U. 2014 [Estimation of Pelagic Fishing Area Based on Sea Surface Temperature and Chlorophyll-A Approaches in the Maluku Sea]. Scientific Journal of Agribusiness and Fisheries (AGRIKAN UMMU-Ternate) 7(1):74–81 [in Indonesian].

Udupa K. S. 1986 Statistical method of estimating the size at first maturity offishes. Fishbyte 4(2):8-10.

Widodo A. A., Nugraha B. 2009 [Kendari-based tuna fishery. Southeast Sulawesi]. BAWAL 299–307 [in Indonesian].

Yaskun M., Sugiarto E. 2017 [Analysis of the potential of marine fisheries products on the welfare of fishermen and the community in Lamongan Regency]. EKBIS Journal 17(1):867-875 [in Indonesian].

*** FAO. 2010 Biological characteristics of tuna. Text by Michel Goujon and Jacek Majkowski.

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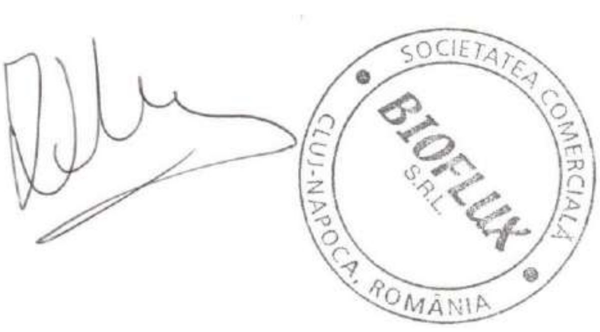

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# Skipjack's (*Katsuwonus pelamis*) Biology biology and its fishery fisheries status of skipjack (*Katsuwonus pelamis*) in the Banda Sea, Maluku - Indonesia

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**Abstract**. *K. pelamis* fish is a One of the marine biological resources that has a quite high economic value in Indonesia is the *K. pelamis* fishery. One of the waters that has becomeA a potential fishing ground for large pelagic fish in eastern Indonesia is the Banda Sea. This study aims to examine the aspects of biology and fisheries, examinethe efforts to management and useof *K. pelamis* exploitation in the Maluku region. This research was conducted in Maluku province for 90 days starting from March 4th to May 25th, 2019. The method used was the purposive sampling and, the data collected were primary data and secondary data. *K. pelamis* in the Banda Sea has an maximum sustainable yield (MSY) value of 57,837 tons with a fishing effort of 202,473 trips and the maximum economic yield (MEY) value is at 48,866 tons for a fishing effort of 122,732 trips. The results of this study providobtained data on the distribution of frequency distribution ofn *K. pelamis* with the shortest fork length (FL) being 28.5 cm and the longest being 77.3 cm. Calculation of the growth pattern of large pelagic fish was carried out using the t $_{test}$ (t $_{count}$ = 0.05 tab) at a 95% confidence interval (α= 0.05). The growth pattern obtained by for *K. pelamis* is positive allometric. The sex ratio obtained was 1 male : 1 female. The level of gonadal maturity was dominated by GML II (39%). Based on the calculation of Lc and Lm Fish specimens caught on with the purse seine haves the first caught size (Lc= (40.12 cm) > size at first maturity (Lm= (44.81 cm). The actual catch of 70,251 tons shows that the species utilization has exceeded the maximum value of sustainable potential and, economically, the catch of *K. pelamis* has passed the MEY condition. The fishery aspect of *K. pelamis* fisheries is in a condition where increase their production, continues to increase with a low level of gear selectivity. , sSo that there is a need for regulation of fishing gear and its supervision.

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**Introduction**. Indonesian waters are considered to have living fish resources with the highest level of biodiversity (Sugara et al 2022; Yaskun & Sugiarto 2017; Hutomo & Moosa 2005). These resources cover at least 37% of the world's fish species (Mahmud et al 2021; Adnyani et al 2019). The resources of Skipjack (*Katsuwonus pelamis*) are grouped into large pelagic fish resources, including tuna (*Thunnus* sp.) and mackerel (*Euthynnus affinis*) (Jakson et al 2014; Bintoro et al 2022; Lintang et al 2012).

*K. pelamis* fisheries are one of the fishery products that are of interest to for the general consumers and the of a highest economic value (Hutajulu et al 2019; Afriliani et al 2020; Genti et al 2016). Wand waters in eastern Indonesia are known as centers for of production of *K. pelamis* production in Indonesia (Manurung 2016). One of the waters that has become a potential fishing ground for large pelagic fish in Eastern Indonesia is the Banda Sea (Hidayat et al 2014). The Banda Sea is the waters of the Eastern Indonesian Region which is included in the waters of the West Pacific Ocean and is bordered by the Indian Ocean (Chodrijah & Nugraha 2013). The Banda Sea has also become became a very potential fishing area for *K. pelamis* in Maluku Province (Tadjuddah et al 2017; Satrioajie et al 2018)~~ with the utilization of *K. pelamis* resources in the Banda Sea carried out~~ throughout the year (Tangke et al 2014).

*K. pelamis* is a type of fish that belongs to the Scrombidae family (Afifi et al 2022; Mardlijah et al 2021; Chakma et al 2020). The Scrombidae family basically occurs in marine waters and is classified as ~~a~~ pelagic fish (Ollé et al 2022; Paulangan et al 2020). Based on their size, tuna are divided into two groups: *Thunnus* species are grouped into large tuna and *K. pelamis* species are classified as small tuna (Nugraha et al 2020; Chodrijah 2011). Exploitation of this resource is carried out by various forms of fishing activities, including purse seine, pole and line~~,~~ and handline (Jaleel & Smith 2022; Mardlijah et al 2021; Widodo & Nugraha 2009). ~~Based on~~Due to the magnitude of the potential and to the condition of the available large pelagic fish resources,~~.~~ ~~So~~ it is necessary to study the status of large pelagic fisheries, especially those targeting *K. pelamis* in the Banda Sea.

This study aims to examine several aspects of *K. pelamis* including~~;~~ : a) biological aspects, in particular the ~~including~~ length-weight relationship~~;~~ , b) ~~Assess~~ fisheries ~~aspects~~ characteristics, including production trends, fishing effort, fishing grounds, fishing season, fishing gear and CPUE~~;~~ and c) ~~Assess~~ the ~~efforts to~~ management ~~and utilize~~of the *K. pelamis* populations ant their exploitation, which includes the calculation of the catch rate, Maximum Sustainable Yield, Maximum Economic Yield, and the Number of Allowed Catches in the Maluku region.

## Material and Method

The research was conducted for 90 days, from 4 March to 25 May 2019 in the Banda Sea. Data collection was carried out at several sampling points as shown in Figure 1.

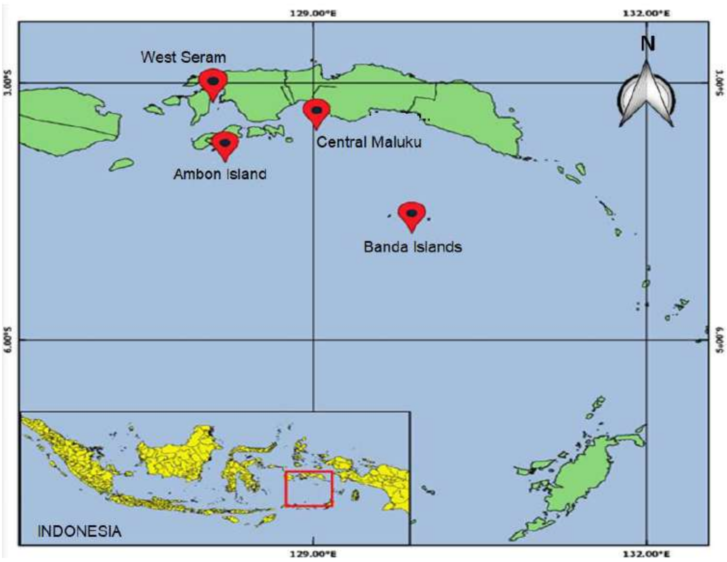


Figure 1. Map of research locations.

The tools and materials used in this study are as follows: ruler, tape measure, digital scales, camera, stationery, identification label, and several samples of *K. pelamis.*

***Data retrieval method***. In this study a survey method was used, namely by observing fish samples in the field~~ the observed fish samples~~. Determination of locations and fishing gear wa~~i~~s carried out by purposive sampling, namely by collecting data deliberately according to the desired conditions (Mukhsin et al 2017),~~.~~ ~~While~~ while the determination of

respondents was carried out by accidental sampling~~, namely the determination of fishermen by accident~~. Data collection for *K. pelamis* sampling was carried out using the simple random sampling method, ~~namely simple random sampling~~ by ~~taking samples to measure~~ measuring the ~~length and weight~~ fork length, total weight, sex and gonadal maturity level of ~~fish as much as~~ 10% of the total catch. Secondary data ~~needed is in~~were ~~the form of~~ periodic data (time series) of catches and fishing effort for 5 to 10 years.
~~***Data collection***. Primary data collection was carried out by direct observation and measurement of *K. pelamis* which were landed, the data collected included: fork length, total weight, sex, gonadal maturity level. Secondary data needed is in the form of periodic data (time series) of catches and fishing effort for the last 10 years.~~

***Lengthong frequency distribution***. ~~How to obtain the~~ Ffrequency distribution was obtained by determining the class interval, median class~~ median,~~ and frequency in each length group. The ~~long~~ length frequency distribution that has been determined with the same class intervals can then be ~~formed~~ put in a diagram to ~~see~~ show the results~~ of the long frequency distribution~~.

***Length-weight relationship***. The model used in estimating the relationship between length and weight is an exponential relationship with the following equation (Andamari et al 2012):

$$W = aL^b$$

Where:
W - weight of fish (g~~rams~~);
L - standard~~ length/~~ fish fork length (cm);
A - the constant number or intercept ~~that is sought from~~of the regression calculation;
B - exponent or tangential angle.

To determine the value of a and b, a linear regression analysis is needed ~~or~~ by ~~taking~~ considering the logarithm of the formula above. The linear equation becomes:

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

Then a simple linear equation can be made:

$$Y = a + bX$$

Where:
Y ~~=~~ - dependent variable;
X ~~=~~ - free change;
a' ~~=~~ - antilog intercept;
b ~~=~~ - slope (slope).

~~If you pay more attention, then~~ Tthe ~~possible prices for~~ b ~~that appear~~ ~~are~~ values, b<3, b=3~~,~~ and b>3~~.~~, ~~According~~ according to Effendi (1979), ~~each price b can be interpreted~~discriminate among the allometric type, as follows:

1) If b<3, then the increase in length is faster than the increase in weight~~ or~~; it is called negative allometric
2) If b>3, then the weight gain is faster than the increase in length~~ or~~; it is called positive allometric
3) If b=3, then the increase in length and weight ~~increase~~ gain are balanced, which is ~~or~~ called isometric

**Commented [WU3]:** Effendie in the reference

***Sex ratio***. Comparison of the sex of the biota was carried out by visual observation of a number of male and female individuals obtained as samples at the study site. The sex ratio is ~~known~~ calculated using the formula (Diningrum et al 2019):

$$X(\%) = \frac{X}{(X+Y)} \times 100~~\%~~$$

$$Y(\%) = \frac{Y}{(X+Y)} \times 100\%$$

Where:
X = - number of male fish;
Y = - number of female fish.

After the sex comparison ratio in percentage is obtained, comparisons are carried out to find out whether there is a significant difference between the male and female individualpopulation comparisons, it is carried out through by testing andusing the 'X$^2$' (chi square) test, with the formula (according to Effendi (1979):

$$X^2 = \frac{(fo-fh)^2}{fh}$$

Where:
$X^2$ = - chi square;
$f_0$ = - observed biota frequency;
$f_h$ = - expected biota frequency.

The $X^2$ $_{count}$ value is obtained from this calculation, then the value is compared with the table of $X^2$ $_{table}$ value, with a 95% confidence level and the degrees of freedom (db) = 1, (one) with the hypothesis:
$H_0$ = no significant difference between the number of male and female fish
$H_1$ = there is a significant difference between the number of male and female fish

If, $X^2_{count} < X^2_{table}$ = $H_0$ is accepted, $H_1$ is rejected
$X^2_{count} > X^2_{table}$ = $H_0$ is rejected, $H_1$ is accepted

***Gonad Maturity Level (GML)***. GML was determined by visual observation of the gonadal morphology. Furthermore, the observed characteristics are adjusted to the characteristics of the level of maturity.

***Size at first maturity (Lm)***. The value of Lm can be estimated by the Soerman-Karber formula proposed by (Udupa (1986), as follows:

$$m = xk + \frac{d}{2} - (X \sum Pi)$$

$$M = \text{antilog}\ (m \pm 1{,}96 \sqrt{x^2 \Sigma \frac{pi*qi}{n_i-1}})$$

Where:
m = - logarithm of the lengthong class at its first maturity;
d - = difference in the logarithm of the increase in the median length;
k - = number of lengthong classes;
xk - = logarithm of the median length, where the fish is 100% at gonadal mature maturity (or where $p_i$ = 1);
$p_i$ = - proportion of mature fish in the i$^{th}$ length class, related i to the number of fish on in the lengthong interval i;
$n_i$ = - number of fish in the i$^{th}$ class of i length;
$q_i$ = - 1 – $p_i$;
M = - length of fish at first maturity equal to the anti-log m, - (if ∝ = 0.05, then the confidence interval of m is 95% of m).

Commented [WU4]: this statement is not consistent with the M formula above

***~~Size first~~ First caught size (Lc)***. The size of Lc is estimated by the method (of Sparre & Venema (1999):

$$SL = \frac{1}{a + \exp(a-bL)}$$

The Lc value is obtained by plotting the cumulative frequency percentage of fish caught with ~~the~~ a standard length, where the intersection point between the 50% cumulative frequency curve is the length ~~when~~ of 50% of the ~~fish are caught~~catch. The Lc value can be calculated through the formula:

Commented [WU5]: citation needed, who developed the formula?

$$Lc = \frac{-a}{b}$$

***Catch Per Unit Effort (CPUE)***. Catch data and fishing effort obtained are then tabulated to determine the CPUE. The fishing effort can be in the form of operating days or months of operation, the number of fishing trips or the number of fleets conducting fishing operations. In this study the fishing effort (effort) used is the number of trips. The formula that can be used to determine the CPUE value is as follows (Noija et al 2014):

$$CPUE_i = \frac{Catch_i}{Effort_i}$$

Where:
$CPUE_i$ ~~=~~ - catch per unit of fishing effort in year i (tonnes/unit);
$Catch_i$ ~~=~~ - catch in year i (tons);
$Effort_I$ ~~=~~ - fishing effort in year i (trip).

***Standardization of fishing gear***. Standardization is done by finding the value of the fishing power factor or Fishing Power Index (FPI) of each fishing gear. The fishing gear used as standard has an FPI value equal to one, while the FPI value for other fishing gear is obtained from the CPUE of other fishing gear divided by the CPUE of standard fishing gear. The formula for calculating FPI is as follows:

Commented [WU6]: citation needed, who developed the formula?

$$RFP_i = \frac{Ci/Ei}{Cs/Es}$$

Where:
$RFP_i$ ~~=~~ - catch power factor of the fishing unit which will be standardized in year i;
$C_i$ ~~=~~ - number of catches of the type of fishing unit that will be standardized in year i;
$C_s$ ~~=~~ - number of catches of the type of fishing unit used as standard in year i;
Ei ~~=~~ - number of fishing efforts for the type of fishing unit that will be standardized in year i;
$E_s$ ~~=~~ - number of fishing efforts for the type of fishing unit used as standard in year i.

After obtaining the $RFP_i$ value, the following formula is used to calculate the standardized effort ~~results use the formula~~:

$$\text{Standard Effort} = FPI_i \times \text{Effort}$$

***The production surplus model***. The purpose of using the Production Surplus Model is to determine the optimum level of effort, which is an effort that can produce a maximum sustainable catch without affecting the long-term stock productivity (MSY) ~~which~~ and is estimated by using the Schaefer model ~~from~~ for catch data and fishing effort recorded ~~in~~ over several years. MSY can be estimated using the formula (Sparre & Venema 1998):

Commented [WU7]: 1999 in the reference list

$$CPUE = \frac{Y}{f} = \frac{Y(i)}{f(i)}, i = 1, 2, \ldots n$$

Where:
Y(i) ~~=~~ - catch in the year i, i=1,2,......n;
f(i) ~~=~~ - fishing effort in the year i, i=1,2......n.

Determining the value of a (intercept) and b (slope) requires a linear regression f(i) to Y(i)/f(i). After the values of a and b are obtained, $f_{MSY}$ and MSY can be calculated using the formula:

$$f_{MSY} = -\frac{a}{2b} \text{ and } MSY = -\frac{a^2}{4b}$$

Furthermore, to determine the level of utilization of fish resources as a percentage of the maximum allowable number of catches in a certain year, according to ~~with~~ the maximum production value (MSY), the following formula is used (Simbolon 2011):

$$\text{Utilization rate } (\%) = \frac{Ci}{MSY} \times 100~~\%~~$$

Where:
Ci ~~=~~ - number of fish caught in year i;
MSY ~~=~~ - maximum sustainable yield.

**Results and discussion**

***~~Long~~ Length frequency distribution of K. pelamis***. Based on the results of observations of 1022 samples of K. pelamis, ~~it was obtained data on the distribution of~~ length frequency distribution~~s~~ data was obtained, with the shortest size being 28.5 cm and the longest being 77.3 cm. The distribution of fish length during the observation is presented in Figure 2.

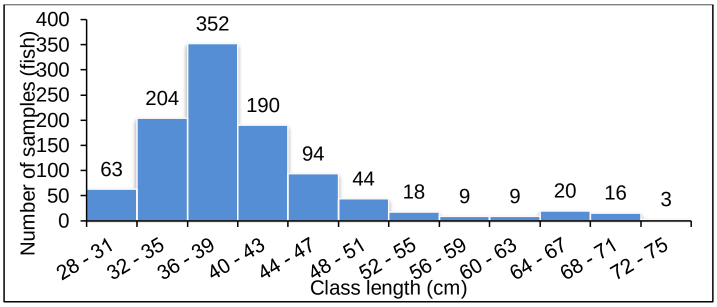


Figure 2. Long frequency distribution of *Katsuwonus ~~K.~~ pelamis.*

Overall, the ~~longest~~ mode of ~~measurement in~~ the sample was found ~~at~~ in the class ~~intervals~~ of 36–39.9 cm~~. ,~~ ~~This happens because of~~due to the use of Fish Aggregating Devices (FADs)~~FADs~~ which causes the capture of ~~so that~~ many specimens with small or immature gonads ~~are caught~~.

***~~Long~~ Length-weight relationship in ~~weight~~ K. pelamis***. The relationship between length and weight obtained is presented in Figure 3, according to the characteristics of the fish growth pattern.

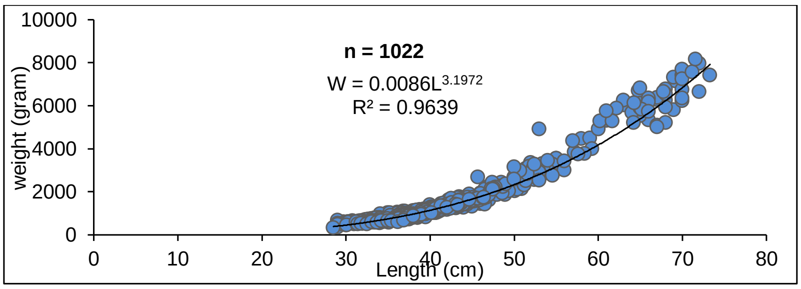


Figure 3. The relationship between the length and weight of *Katsuwonus ~~K.~~ pelamis.*

From ~~the results of the analysis of~~ the length-weight relationship ~~in Figure 3,~~ it ~~is obtained~~resulted that the length-weight relationship of *K. pelamis* is W = $0.0086L^{3.1972}$, with a value of b = 3.1972. Then from a t test ~~was~~ performed on the value of b, at a 95% confidence interval, it resulted~~was obtained~~ $t_{count} > t_{table}$ ($t_{count}$ = 10.1975; $t_{table}$ = 1.962), ~~then $H_0$ was rejected~~ which means that the increase rates in length and weight ~~is~~ were significantly different~~. So that it can be said that~~or the increase in length is not proportional to the increase in weight. ~~Tand based on t~~he value b = 3.1972 it ~~shows~~ showed ~~that thea growth pattern is~~ positive allometric growth pattern, where the weight gain is faster than the increase in length.

Calculation of the growth pattern of *K. pelamis* using the $t_{test}$ ($t_{count}$ = 0.05) at a 95% confidence interval (α ~~-~~= 0.05) ~~shows~~ showed that by producing a coefficient of determination (R) of 0.9818 this shows a correlation coefficient (r) close to 1. This also shows that the increase in length will affect weight gain by showing that the correlation or relationship between length and fish weight is close and positive.

***Sex ratio of K. pelamis***. ~~From the results of observations of~~The observed sample of 100 *K. pelamis*, ~~the sex ratio showed that~~of which 51 male fish (51%) and 49 female fish (49%), had a sex ratio of 1:1. According to Senen et al (2011), ~~the~~ a balanced ~~of the~~ sex ratio also indicates that one male fish will fertilize one female fish~~. It is said to be balanced if the number of males and females in a waters shows the number 1:1~~. The number of female fish is a determinant of the sustainability of a population because during the mating season ~~or looking for a partner~~ there will be a high competition, so that the natural mortality of males is higher. The sex ratio of *K. pelamis* is presented in Figure 4.

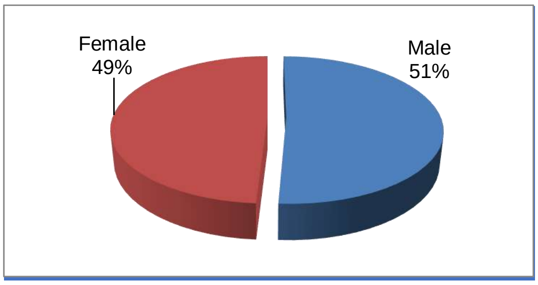


Figure 4. Sex ratio of *Katsuwonus ~~K.~~ pelamis.*

To find out the accuracy of whether the comparison is balanced or not, it is necessary to calculate the sex ratio using the chi-square test presented in Table 1.

Table 1

*Sex ratio Katsuwonus ~~K.~~ pelamis*

| *Sex* | *N* | $t_{count}$ | $t_{table}$ |
|---|---|---|---|
| Male | 51 | 0.040 | 3.84 |
| Female | 49 | | |

The results of the chi-square test are~~obtained~~ $t_{count}$ ~~is~~ = 0.040 and $t_{table}$ ~~is~~ = 3.84, so that $t_{count} < t_{table}$ ~~=~~ and $H_0$ is accepted, which means there is no real difference between the male and female populations of *K. pelamis.*

***Gonad maturity level of K. pelamis***. The level of maturity of the male gonads can be seen from the size and color of the gonads, while in the female gonads it can be seen from the gonads' size~~,~~ and color ~~of the gonads~~ and from the presence or absence of eggs in the gonads. The results of gonadal observations can be seen in Table 2.



**Commented [WU8]:** Carefully reformulate this paragraph to make it semantically correct and scientifically sound. Use the appropriate English language.

Table 2

Percentage of gonad maturity level of *Katsuwonus ~~K.~~ pelamis*

| *Sex* | *Amount (N)* | *GML (%)* | | | |
|---|---|---|---|---|---|
| | | *I* | *II* | *III* | *IV* |
| Male | 51 | 41.18 | 31.37 | 19.61 | 7.84 |
| Female | 49 | 26.53 | 46.94 | 18.37 | 8.16 |
| Combined | 100 | 34 | 39 | 19 | 8 |

For male fish, the number of mature gonads was 27.45% and ~~those that were immature were~~ 72.55% were immature~~%~~. F~~And f~~or female fish, the number of mature gonads was 26.53% and ~~those that were immature were~~ 83.47%~~.~~ were immature. Overall (males and females), the number of mature fish was 27% and 73% were immature. This indicates that more fish are caught before the gonads ~~mature~~maturity, ~~it is suspected~~suggesting that the fish have not yet had time to spawn, which ~~so this will~~ affects the recruitment in the fishing area.

***Length at first ~~mature~~ maturity (Lm)***. ~~The results of~~From the observations ~~made for~~on the level of gonad maturity and length size distribution against 100 *K. pelamis*, it ~~is suspected~~resulted that the length at first maturity of the gonads was 44.81 cm. By using a 95% confidence level, the confidence ~~limit~~ interval for size predictions ~~that have started to~~ at ~~mature~~ maturity of gonads is ~~at~~ 43.39-46.28 cm. For comparison, t~~Following are t~~he ~~results of the study for the value of~~ Lm of *K. pelamis* recorded at other locations are presented in Table 3.

Table 3

~~Several grades of~~ Lm of *Katsuwonus ~~K.~~ pelamis* at other locations

| *Lm value (FL)(cm)* | *Research location* | *Source* |
|---|---|---|
| 42.8 | South Seram island waters | Manik (2007) |
| 42.9 | Eastern Indian Ocean Waters | Jatmiko et al (2015) |
| 43 | West and South waters of North Maluku | Karman et al (2016) |
| 43 | West Indian Ocean Waters | Norungee & Kawol (2011) |
| 46.5 | Bay of Bone, South Sulawesi | Jamal et al (2011) |

***Length at first capture (Lc)***. Calculation of Lc is done by using data on the length distribution and the number of fish in the purse seine. Based on ~~the results of~~ observations of 226 fish caught by purse seine, it was found that the length of the first caught was 40.12 cm. Lc of *K. pelamis* is presented in Figure 5.

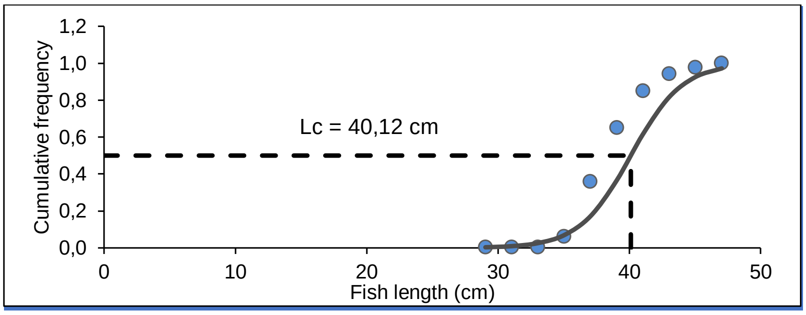


Figure 5. Lc *Katsuwonus ~~K.~~ pelamis* on a purse seine.

Then a comparison ~~is~~ was made between the values of Lm and Lc, ~~it is suspected~~showing that for the fish caught by the purse seine has a value ~~(~~Lc<Lm~~)~~ ~~where the fish when caught~~and it ~~have not had time to~~was captured before spawning, ~~beforehand. Thus, this is~~which is thought to cause a significant decrease in the population of *K. pelamis.*

***Fisheries aspect***. *K. pelamis* is generally caught using pole and liner, trolling liner and purse seiner from less than 30 GT vessels, with trips that vary from one day fishing to one week fishing. Fishermen in the Banda Maluku Sea mostly have vessels under 30 GT.

***Fishing ground***. The dominant fishing grounds for *K. pelamis* are in the Banda Sea, ~~where these waters are areas that are usually approached by fish~~ due to environmental factors, food availability and ~~are~~ because they are spawning and egg-laying areas. T~~o get the maximum catch, the right season is needed for catching where t~~he highest catch occurs ~~when it enters~~at the beginning of the East season ~~or is~~, also called the harvest season, ~~. The harvest season occurs~~ between October ~~–~~and December. T~~, t~~he lean season occurs between May ~~–~~and July, the western season occurs between December ~~–~~and January and the transition season occurs between April ~~–~~and May. The catches obtained depend on the season, currents and wind, which are obstacles for fishermen to go to sea ~~and make catches~~.

***Stock status of K. pelamis in the Banda Sea***

***Catch per Unit Effort (CPUE) and Maximum Sustainable Yield (MSY)***. Production and fishing efforts of *K. pelamis* in the Banda Sea are carried out using 4 types of fishing gear including handline, troll line, purse seine and pole and line. Production and effort of catching *K. pelamis* can be seen in Table 4.

Table 4

Production and catching efforts of *Katsuwonus* ~~*K.*~~ *pelamis* in the Banda Sea

| *Year* | *Production (T)* | | | | | *Trips* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* | *Total* | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* |
| 2008 | 9,186.63 | 9,775.52 | 301.40 | 16,214.11 | 35,477.65 | 23,419 | 427,899 | 123,472 | 157,717 |
| 2009 | 9,137.30 | 9,491.48 | 745.91 | 17,312.00 | 36,686.68 | 21,373 | 392,497 | 248,406 | 123,316 |
| 2010 | 10,253.94 | 13,137.78 | 1,516.36 | 18,689.02 | 43,597.11 | 43,622 | 474,562 | 311,339 | 140,968 |
| 2011 | 11,712.66 | 14,313.94 | 408.27 | 20,519.92 | 46,954.79 | 35,888 | 433,171 | 191,396 | 25,248 |
| 2012 | 12,318.24 | 15,724.01 | 4,232.45 | 16,727.68 | 49,002.38 | 42,027 | 432,897 | 226,447 | 98,277 |
| 2013 | 26,305.18 | 6,484.45 | 5,226.45 | 22,949.42 | 60,965.51 | 32,010 | 536,119 | 186,753 | 217,374 |
| 2014 | 14,806.04 | 15,786.37 | 5,952.18 | 16,749.75 | 53,294.35 | 39,017 | 209,321 | 293,614 | 92,577 |
| 2015 | 14,726.79 | 16,392.38 | 4,127.07 | 19,208.60 | 54,454.84 | 34,787 | 499,933 | 85,352 | 187,803 |
| 2016 | 18,079.96 | 17,311.33 | 4,616.49 | 20,836.71 | 60,844.49 | 41,596 | 497,222 | 204,868 | 165,692 |
| 2017 | 18,272.12 | 18,172.17 | 5,210.66 | 23,064.41 | 64,719.36 | 38,453 | 386,606 | 191,767 | 148,278 |
| 2018 | 20,681.51 | 19,426.73 | 5,158.88 | 24,984.11 | 70,251.22 | 48,078 | 447,850 | 157,874 | 167,308 |

There are differences in fishing productivity between handline, trolling line, purse seine, and pole and line. it is necessary to standardize productivity, in order to ~~obtain~~ calculate the Fishing Power Index (FPI), which~~.~~ c~~C~~an be seen in Table 5.

Table 5

Productivity and Fishing Power Index (FPI) on *Katsuwonus* ~~*K.*~~ *pelamis*

| *Year* | *Productivity (Ton ~~/~~trip$^{-1}$)* | | | |
|---|---|---|---|---|
| | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* |
| 2008 | 0.3923 | 0.0228 | 0.0024 | 0.1028 |

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| | | | | |
|---|---|---|---|---|
| 2009 | 0.4275 | 0.0242 | 0.0030 | 0.1404 |
| 2010 | 0.2351 | 0.0277 | 0.0049 | 0.1326 |
| 2011 | 0.3264 | 0.0330 | 0.0021 | 0.8127 |
| 2012 | 0.2931 | 0.0363 | 0.0187 | 0.1702 |
| 2013 | 0.8218 | 0.0121 | 0.0280 | 0.1056 |
| 2014 | 0.3795 | 0.0754 | 0.0203 | 0.1809 |
| 2015 | 0.4233 | 0.0328 | 0.0484 | 0.1023 |
| 2016 | 0.4347 | 0.0348 | 0.0225 | 0.1258 |
| 2017 | 0.4752 | 0.0470 | 0.0272 | 0.1555 |
| 2018 | 0.4302 | 0.0434 | 0.0327 | 0.1493 |
| Average | 0.4217 | 0.0354 | 0.0191 | 0.1980 |
| Index | Purse seiner | Trolling liner | Handliner | Pole and liner |
| CPUE | 0.4217 | 0.0354 | 0.0191 | 0.1980 |
| FPI | 1 | 0.084 | 0.045 | 0.47 |

Based on Table 5, the purse seine is used as a standard fishing gear, because its productivity is greater than for other fishing gear. Furthermore, the standardization process is performed by multiplying the FPI with the effort numbers (trips) of each fishing gear to get a standard effort. T~~with t~~he results that can be seen in Table 6.

Table 6

Standardization of catching efforts for *Katsuwonus ~~K.~~ pelamis*

| *Year* | *Purse seiner* | *Trolling liner* | *Hand liner* | *Pole and liner* | *Standard total effort* | *CPUE (Ton ~~/~~trip$^{-1}$)* |
|---|---|---|---|---|---|---|
| 2008 | 23.419 | 35.935 | 5.593 | 74.053 | 139.000 | 0.2552 |
| 2009 | 21.373 | 32.962 | 11.252 | 57.901 | 123.488 | 0.2971 |
| 2010 | 43.622 | 39.854 | 14.103 | 66.189 | 163.768 | 0.2662 |
| 2011 | 35.888 | 36.378 | 8.670 | 11.855 | 92.790 | 0.5060 |
| 2012 | 42.027 | 36.355 | 10.258 | 46.145 | 134.784 | 0.3636 |
| 2013 | 32.010 | 45.023 | 8.459 | 102.065 | 187.557 | 0.3250 |
| 2014 | 39.017 | 17.579 | 13.300 | 43.468 | 113.364 | 0.4701 |
| 2015 | 34.787 | 41.984 | 3.866 | 88.180 | 168.818 | 0.3226 |
| 2016 | 41.596 | 41.757 | 9.280 | 77.798 | 170.431 | 0.3570 |
| 2017 | 38.453 | 32.467 | 8.687 | 69.622 | 149.229 | 0.4337 |
| 2018 | 48.078 | 37.611 | 7.151 | 78.557 | 171.397 | 0.4099 |

T~~From t~~he CPUE linear equation relationship derived from the effort and yield data (shown in Table 6)~~,~~ ~~it will produce~~shows CPUE yearly fluctuations (Figure 6)~~ every year, the CPUE linear equation relationship~~.

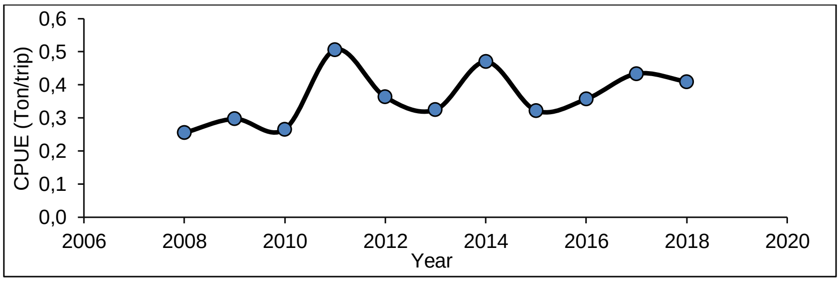


Figure 6. *Katsuwonus ~~K.~~ pelamis* CPUE fluctuations in the Banda Sea.

From Figure 6, it can be concluded that in 2011 there was the highest CPUE ~~point~~peak. The phenomenon of fluctuations in CPUE ~~values when observing the relationship~~

~~between effort and CPUE~~ is strongly influenced by; (1) the size and number of vessels in operation, (2) type and size of fishing gear, (3) Illegal level, Unreported and Unregulated (IUU) fishing~~.~~, (4) HR capabilities on board, (5) fishing ground location, (6) the number of fish captures ~~caught (yield)~~ landed (yield), (7) natural conditions during fishing operations~~,~~ and (8) the discipline of the fishing fleet ~~on~~ with respect to the specified fishing ground (not fishing in waters that are not in accordance with the permit) (Krisdiana et al 2014).

The relationship between CPUE and effort ~~in~~(~~-~~Figure 7) shows that ~~the value of~~ the estimation parameters for *K. pelamis* ~~is obtained by~~ , the intercept (a) = 0.5731 and the slope (b) = -0.000001, ~~so that it~~ forms~~s~~ a Linear Schaefer equation CPUE = -0.000001x + 0.5731. This relationship can be interpreted that ~~by catching~~ x ~~units~~ supplementary units of effort (trips) per year ~~, it~~ will reduce the CPUE value by 0.000001 tons per year. The ~~he conditions described in the~~ linear equation ~~produce~~ has a value of $R^2$= 0.24, which means that the effort's ~~about 24% the~~ influence on the CPUE is of 24%~~of the variables used. namely effort and yield~~. ~~Thus~~ Thus, the value of $R^2$ (representing the influence of the variables used in this model) ~~value~~ is statistically considered not strong enough ~~to represent the influence of the variables used in this model because the closer the R² value is to 100%, the stronger the variable influence~~.

MSY and EMSY calculation data for *K. pelamis* in the Banda Sea using the Schaefer Linear method are presented in Table 7. The results of biological analysis using the Schaefer Linear model approach can produce an MSY value of 57,837 tonnes with a standard effort/EMSY of 202,473 trips.

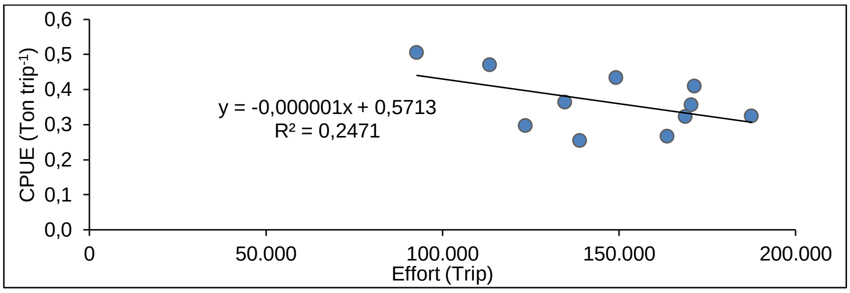


Figure 7. Linear equation of CPUE ~~&~~ and effort *Katsuwonus* ~~K.~~ *pelamis*.

Table 7

MSY and EMSY estimation of *Katsuwonus* ~~K.~~ *pelamis* based on Schaefer linear model calculations

| *Year* | *Catch number (Ton)* | *Total Effort Standard* | *CPUE (Schaefer)* |
|---|---|---|---|
| *I* | *Yi* | *X* | *Y* |
| 2008 | 35.477.7 | 139.000 | 0.2552 |
| 2009 | 36.686.7 | 123.488 | 0.2971 |
| 2010 | 43.597.1 | 163.768 | 0.2662 |
| 2011 | 46.954.8 | 92.790 | 0.5060 |
| 2012 | 49.002.4 | 134.784 | 0.3636 |
| 2013 | 60.965.5 | 187.557 | 0.3250 |
| 2014 | 53.294.3 | 113.364 | 0.4701 |
| 2015 | 54.454.8 | 168.818 | 0.3226 |
| 2016 | 60.844.5 | 170.431 | 0.3570 |
| 2017 | 64.719.4 | 149.229 | 0.4337 |
| 2018 | 70.251.2 | 171.397 | 0.4099 |
| Amount | 576.248.3662 | 1.614.628 | 4.0064 |
| Average value | 52.386.22 | 146.784 | 0.3642 |
| | Intercept a | | 0.57131 |
| | Slope b | | -0.000001 |

| | |
|---|---|
| MSY Schaefer; -a^2/4b | 57,837 |
| E MSY Schaefer~~-~~: -a/2b | 202,473 |
| Total Allowable Catch (TAC) 80% MSY | 46,269.77 |

Based on the calculation of the ~~Linear~~ linear model~~. ~~, b~~B~~iological overfishing has occurred in *K. pelamis* in the Banda Sea, which is indicated by the actual catch having passed MSY. This is evidenced by the actual catch in 2018 which reached 70,251.2 tons,~~.~~ ~~and~~ exceedings the Total Allowable Catch (TAC) potential of 80% of the MSY value of 46,269.77 tons. The MSY *K. pelamis* curve can be seen in Figure 8.

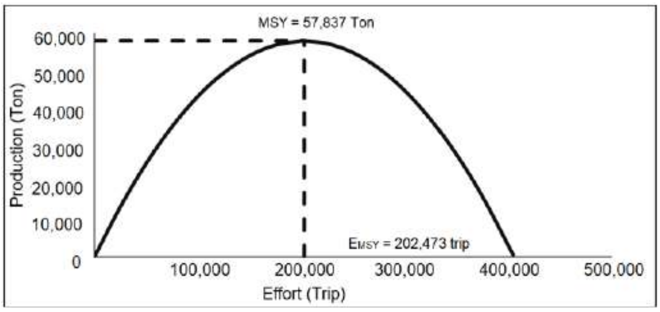


Figure 8. Stock balance curve (MSY) for *Katsuwonus*~~*K.*~~ *pelamis.*

**Conclusions**. Biological aspects of *K. pelamis* in the Banda Sea show a positive allometric growth pattern. *K. pelamis* ~~experienced a state of being~~risks to be caught before spawning (Lc < Lm),~~. This catching can~~ resulting in an imbalance in natural stocks, since~~ in nature because if~~ the fish caught have not yet spawned, therefore the recruitment can be disrupted. The fishery *K. pelamis* fisheries increase their production,– with a low level of gear selectivity, so that there is a need for regulation of fishing gear and supervision. ~~The fishery aspect of *K. pelamis* is in a condition where production continues to increase with a low level of gear selectivity. So that there is a need for regulation of fishing gear and its supervision.~~ *K. pelamis* resources ~~utilization activities have shown catches that~~exploitation exceeds the maximum point of sustainable production and also the MEY, ~~. This is shown from the actual effort and production values that exceed the MEY value~~, so that the profit ~~earned~~ decreases, as shown by the actual effort and production values.

**Conflict of interest**. The authors declare no conflict of interest.

**References**


Adnyani L. P., Nurmawati, Anggriani I., 2019 [Analysis of Potential and Utilization Level of Fish Resources in Balikpapan Waters. East Kalimantan]. Gorontalo Fisheries Journal 2(2):55-68 [in Indonesian].

Afifi M. A. M., El-Sadek A., El-Haddad K. M., 2022 First record of skipjack tuna (*Katsuwonus pelamis*) from Dahab in the Gulf of Aqaba. Red Sea. Egypt. Egyptian Journal of Aquatic Biology & Fisheries 26(3):~~-~~699–710.

Afriliani W., Anna Z., Handaka A. A., Khan A. M. A., 2020 Typology of skipjack (*Katsuwonus pelamis*) fisheries at Nizam Zachman Oceanic Fishing Port. Jakarta. Indonesia. Asian Journal of Fisheries and Aquatic Research 7(2):39-50.

Andamari R., Hutapea J. R., Prisantoso B. I., 2012 [Reproduction aspects of the yellowfin tuna (*Thunnus albacares*)]. Journal of Tropical Marine Science and Technology 4(1):89-96. [In Indonesian].

Bintoro G., Yulianto E. S., Lelono T. D., Prasetyo D. T., Rahman M. A., Sari W. K., 2022 Utilization status and bioeconomic performance of skipjack tuna (*Katsuwonus* *pelamis*) fishery in the south coast of Malang waters. East Java. Indonesia. IOP Conference Series: Earth and Environmental Science 1033:1-10.

Chakma S., Saha S., Hasan Md. N., Rahman Md. A., Akter M., Hoque Md. S., Ullah Md. R., Sujan K. M., Shahriar A., 2020 Effect of frozen storage on the biochemical. microbial and sensory attributes of Skipjack Tuna (*Katsuwonus pelamis*) fish loins. Journal of Applied Biology & Biotechnology 8(4):58-64.

Chodrijah U., 2011 [Several aspects of reproductive biology of yellowfin tuna *(Thunnus albacares)* from Banda Sea waters]. Proceedings of the 8th National Fish Seminar, pp. 401-409. [In Indonesian].

Chodrijah U., Nugraha B., 2013 [Size distribution of longline tuna catches and catching areas in Banda Sea Waters]. Indonesian Fisheries Research Journal 19(1): 9-16. [In Indonesian].

Diningrum T. D. B., Triyono H., Jabbar M. A., 2019 [Biological aspects of skipjack tuna in southeast Celebes]. Journal of Fisheries and Maritime Extension 13(2):139-147. [In Indonesian].

Effendie M. I., 1979 [Fisheries biology method]. Dewi Sri Foundation, Bogor, ... [In Indonesian].

Genti J. G., Marsoedi, Afandhi A., 2016 The Utilization of Skipjack tuna *Katsuwonus pelamis* (Linnaeus. 1758) Availability for Sustainable Fisheries Management in Prigi. East Java. J-PAL 7(2):122-127.

Hidayat T., Chodrijah U., Noegroho T., 2014. [Characteristics of trolling fisheries in the Banda Sea]. Indonesian Fisheries Research Journal 20(1):43-51. [In Indonesian].

Hutajulu H., Imran Z., Budiharsono S., Kusumastanto T., 2019 Economic structure analysis in the development of skipjack tuna *(Katsuwonus pelamis)* fisheries industry in Jayapura City, Papua, Indonesia. AACL Bioflux 12(5):1726-1737

Hutomo M., Moosa M. K., 2005 Indonesian marine and coastal biodiversity: Present status. Indian Journal of Marine Sciences 34(1):88-97.

Jackson A. M., Ambariyanto, Erdmann M. V., Toha A. H. A., Stevens L. A., Barber P. H., 2014 Phylogeography of commercial tuna and mackerel in the Indonesian Archipelago. Bulletin of Marine Science 90(1):471–492.

Jaleel A., Smith H. D., 2022 The Maldives tuna fishery: An example of best practice. Ocean Yearbook Online 36(1):314-345.

Jamal M., Sondita M. F. A., Haluan J., Wiryawan B., 2011 [Utilization of Skipjack Biological Data *(Katsuwonus pelamis)* in the Framework of Responsible Fisheries Management in the Waters of Bone Bay]. Journal of Indonesian Nature 14(1):107-113. [In Indonesian].

Jatmiko I., Hartaty H., Bahtiar A., 2015 [Reproductive biology of skipjack fish *(Katsuwonus pelamis)* in the Eastern Indian Ocean]. Bawal 7(2):87-94. [In Indonesian].

Karman A., Martasuganda S., Sondita M. F. A., Baskoro M. S., 2016 [Biological base of skipjack as the foundation for sustainable fisheries management in the North Maluku Province]. Journal of Tropical Marine Science and Technology 8(1):159-173. [In Indonesian].

Krisdiana R. D., Iriana D., Djunaedi O. S., Dhahiyat Y., 2014 [Bioeconomic analysis of yellowfin tuna (*Thunnus albacares* Bonnaterre 1788) in the Indonesian Fisheries Management Area (WPPNRI) 573]. (Desertation). Faculty of Agriculture, University of Padjadjaran p. 1-15.

Lintang C. J., Labaro I. L., Telleng A. T., 2012 [Study of the fishing season for tuna using handline fishing gear in the Maluku Sea]. Journal of Capture Fisheries Science and Technology 1(1):6-9. [In Indonesian].

Mahmud, Sinrang A. D. B., Massiseng A. N. A., 2021 Prospects of fisheries industry development in indonesia through online publication media. International Journal of Applied Biology 5(2):117-129.

Manik N., 2007 [Several aspects of the biology of skipjack tuna (*Katsuwonus pelamis*) in the waters around South Seram Island and Nusa Laut Island]. Oceanology and Limnology in Indonesia 33:17-25. [In Indonesian].

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Manurung V. T., 2016 [Performance and Institutional Credit for Small-Scale Tuna Fishing Business in Eastern Indonesia]. ~~In~~ The Agro-Economy Research Forum 16(2):60-74~~)~~. [In Indonesian].
Mardlijah S., Pane A. R. P., Panggabean A. S., 2021 The stock status of skipjack tuna (*Katsuwonus pelamis*) in Tomini Bay and Its Surrounding Areas. Indonesia. IOP Conference Series: Earth and Environmental Science 934:1-9.
Mukhsin R., Mappigau P., Tenriawaru A. N., 2017 [The effect of entrepreneur's orientation on the survival of small and medium enterprises of the fishery processing groups in Makassar City]. Journal of Analysis 6(2):188–193. [In Indonesian].
Noija D., Martasuganda S., Murdiyanto B., Taurusman A. A., 2014 [Potential and level of utilization of demersal fish resources in the waters of Ambon Island, Maluku Province]. Journal of Fisheries and Marine Technology 5(1):~~-~~55-64. [In Indonesian].
Norungee D., Kawol D., 2011 Macroskopic study on some aspects of the reproductive biology of skipjack tuna (*Katsuwonus pelamis*) in the Western Indian Ocean. Proceeding Working Party on Tropical Tunas of the IOTC 2011, PAGES
Nugraha E., Yudho G. S., Jaenudin A., Yusrizal, Kusmedy B., Kusnidar A., Husen E. S., 2020 Relationship between length and weight of skipjack tuna (*Katsuwonus pelamis*) purse seine catching in the Maluku Sea. Indonesia. AACL Bioflux 13(1):330-345.
Ollé J., Vilà-Valls L., Alvarado-Bremer J., Cerdenares G., Duong T. Y., Hajjej G., Lino P. G., Muñoz-Lechuga R., Sow F. N., Diaha N. C., Araguas R. M., Sanz N., Viñas J., 2022 Population genetics meets phylogenetics: new insights into the relationships among members of the genus *Euthynnus (family Scombridae).* Hydrobiologia 849:47–62.
Paulangan Y. P., Rumbiak K., Barapadang B., 2020 Fishing season and participatory mapping of the fishing ground of target fish in Depapre Bay. Jayapura Regency. Papua Indonesia. IOP Conference Series: Earth and Environmental Science 584:1-8.
Satrioajie W. N., Suyadi, Syahailatua A., Wouthuyzen S., 2018 The importance of the Banda Sea for tuna conservation area: A review of studies on the biology and the ecology of tuna. IOP Conference Series: Earth and Environmental Science. 184:1-11.
Senen B., Sulistiono S., Ismudi M., 2011 [Biological aspects of the flying catfish (*Decapterus macrosoma*) in Banda Neira waters. Maluku. Indonesia]. Agricultural Journal UMMI 1:~~-~~35-40. [In Indonesian].
Simbolon D., Wiryawan B., Wahyuningrum P. I., Wahyudi H., 2011 [Utilization level and seasonal patterns of fishing for lemuru in the Bali Strait waters. Bulletin PSP 19(3): 293-307. [In Indonesian].
Sparre P., Venema S. C., 1999 Introduction to Tropical Fish Stock Assessment. Part 1. FAO Fishing Technology Paper No.306/1.Rev.2. Rome~~.~~, FAO~~.~~, 407 p.
Sugara A., Nolisa A., Anggoro A., Suci A. N. N., Suhendri R., 2022 [Diversity Species Identification of fish catched by fishermen Tapak Paderi Bengkulu City]. Samakia: Journal of Fisheries Science 13(1):1-7. [In Indonesian].
Tadjuddah M., Anadi L., Mustafa A., Arami H., Abdullah. Kamri S., Wianti N. I., 2017 Growth pattern and size structure of skipjack tuna caught in Banda Sea. Indonesia. AACL Bioflux 10(2):227-233.
Tangke U., 2014 [Estimation of pelagic fishing area based on sea surface temperature and chlorophyll-a approaches in the Maluku Sea]. Scientific Journal of Agribusiness and Fisheries (AGRIKAN UMMU-Ternate) 7(1):74–81. [In Indonesian].
Udupa K. S., 1986 Statistical method of estimating the size at first maturity offishes. Fishbyte 4(2):8-10.
Widodo A. A., Nugraha B. 2009 [Kendari-based tuna fishery. Southeast Sulawesi]. BAWAL 299–307. [In Indonesian].
Yaskun M., Sugiarto E., 2017 [Analysis of the potential of marine fisheries products on the welfare of fishermen and the community in Lamongan Regency]. EKBIS Journal 17(1):867-875. [In Indonesian].
*** FAO,~~.~~ 2010 Biological characteristics of tuna. Text by Michel Goujon and Jacek Majkowski.


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# Skipjack's (*Katsuwonus pelamis*) biology and its fisheries status in the Banda Sea, Maluku - Indonesia

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**Abstract**. *K. pelamis* fish is a marine biological resource that has a quite high economic value in Indonesia. A potential fishing ground for large pelagic fish in eastern Indonesia is the Banda Sea. This study aims to examine the aspects of biology and the management of *K. pelamis* exploitation in the Maluku region. This research was conducted in Maluku province for 90 days starting from March $4^{th}$ to May $25^{th}$ 2019. The method used was the purposive sampling and the data collected were primary data and secondary data. *K. pelamis* in the Banda Sea has a maximum sustainable yield (MSY) value of 57,837 tons with a fishing effort of 202,473 trips and the maximum economic yield (MEY) value is at 48,866 tons for a fishing effort of 122,732 trips. The study provided data on the frequency distribution of *K. pelamis* with the shortest fork length (FL) being 28.5 cm and the longest being 77.3 cm. Calculation of the growth pattern of large pelagic fish was carried out using the $t_{test}$ ($t_{count}$=0.05 tab) at a 95% confidence interval (α=0.05). The growth pattern obtained for *K. pelamis* is positive allometric. The sex ratio obtained was 1 male:1 female. The level of gonadal maturity was dominated by GML II (39%). The *K. pelamis* that ~~Fish specimens~~ caught with the purse seine have the first caught size (Lc=40.12 cm) > size at first maturity (Lm=44.81 cm). The actual catch of 70,251 tons shows that the species utilization has exceeded the maximum value of sustainable potential and, economically, the catch of *K. pelamis* has passed the MEY condition. The *K. pelamis* fisheries increase their production, with a low level of gear selectivity, so that there is a need for regulation of fishing gear and supervision.

**Key Words**: ~~Skipjack~~ Sex ratio, fork length, total weight, gonadal maturity level.

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**Introduction**. Indonesian waters are considered to have living fish resources with the highest level of biodiversity (Sugara et al 2022; Yaskun & Sugiarto 2017; Hutomo & Moosa 2005). These resources cover at least 37% of the world's fish species (Mahmud et al 2021; Adnyani et al 2019). The resources of Skipjack (*Katsuwonus pelamis*) are grouped into large pelagic fish resources, including tuna (*Thunnus* sp.) and mackerel (*Euthynnus affinis*) (Jakson et al 2014; Bintoro et al 2022; Lintang et al 2012).

*K. pelamis* are fishery products of interest for the general consumers and of a high economic value (Hutajulu et al 2019; Afriliani et al 2020; Genti et al 2016). Waters in eastern Indonesia are known as centers of *K. pelamis* production (Manurung 2016). One of the waters that has become a potential fishing ground for large pelagic fish in Eastern Indonesia is the Banda Sea (Hidayat et al 2014). The Banda Sea is the waters of the Eastern Indonesian Region which is included in the waters of the West Pacific Ocean and is bordered by the Indian Ocean (Chodrijah & Nugraha 2013). The Banda Sea became a potential fishing area for *K. pelamis* in Maluku Province (Tadjuddah et al 2017; Satrioajie et al 2018) throughout the year (Tangke et al 2014).

*K. pelamis* is a type of fish that belongs to the Scrombidae family (Afifi et al 2022; Mardlijah et al 2021; Chakma et al 2020). The Scrombidae family basically occurs in marine waters and is classified as pelagic fish (Ollé et al 2022; Paulangan et al 2020). Based on

their size, tuna are divided into two groups: *Thunnus* species are grouped into large tuna and *K. pelamis* species are classified as small tuna (Nugraha et al 2020; Chodrijah 2011). Exploitation of this resource is carried out by various forms of fishing activities, including purse seine, pole and line and handline (Jaleel & Smith 2022; Mardlijah et al 2021; Widodo & Nugraha 2009). Due to the magnitude of the potential and to the condition of the available large pelagic fish resources, it is necessary to study the status of large pelagic fisheries, especially those targeting *K. pelamis* in the Banda Sea.

This study aims to examine several aspects of *K. pelamis* including: a) biological aspects, in particular the length-weight relationship, b) fisheries characteristics, including production trends, fishing effort, fishing grounds, fishing season, fishing gear and CPUE and c) the management of the *K. pelamis* populations ant their exploitation, which includes the calculation of the catch rate, Maximum Sustainable Yield, Maximum Economic Yield, and the Number of Allowed Catches in the Maluku region.

**Material and Method**

The research was conducted for 90 days, from 4 March to 25 May 2019 in the Banda Sea. Data collection was carried out at several sampling points as shown in Figure 1.

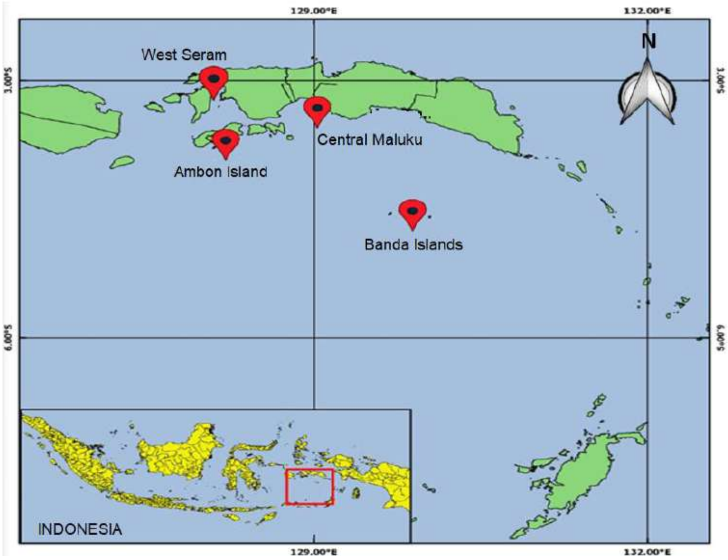

Figure 1. Map of research locations.

The tools and materials used in this study are as follows: ruler, tape measure, digital scales, camera, stationery, identification label, and several samples of *K. pelamis.*

***Data retrieval method***. In this study a survey method was used, namely by observing fish samples in the field. Determination of locations and fishing gear was carried out by purposive sampling, namely by collecting data deliberately according to the desired conditions (Mukhsin et al 2017), while the determination of respondents was carried out by accidental sampling. Data collection for *K. pelamis* sampling was carried out using the simple random sampling method, by measuring the fork length, total weight, sex and gonadal maturity level of 10% of the total catch. Secondary data were periodic data (time series) of catches and fishing effort for 5 to 10 years.

***Length frequency distribution***. Frequency distribution was obtained by determining the class interval, median class and frequency in each length group. The length frequency distribution that has been determined with the same class intervals can then be put in a diagram to show the results.

***Length-weight relationship***. The model used in estimating the relationship between length and weight is an exponential relationship with the following equation (Andamari et al 2012):

$$W = aL^b$$

Where:
W - weight of fish (g);
L - standard fish fork length (cm);
A - the constant number or intercept of the regression calculation;
B - exponent or tangential angle.

To determine the value of a and b, a linear regression analysis is needed by considering the logarithm of the formula above. The linear equation becomes:

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

Then a simple linear equation can be made:

$$Y = a + bX$$

Where:
Y - dependent variable;
X - free change;
a' - antilog intercept;
b - slope (slope).

The b- values, b<3, b=3 and b>3, according to Effendie (1979), discriminate among the allometric type, as follows:

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1) If b<3, then the increase in length is faster than the increase in weight; it is called negative allometric
2) If b>3, then the weight gain is faster than the increase in length; it is called positive allometric
3) If b=3, then the increase in length and weight gain are balanced, which is called isometric

***Sex ratio***. Comparison of the sex of the biota was carried out by visual observation of a number of male and female individuals obtained as samples at the study site. The sex ratio is calculated using the formula (Diningrum et al 2019):

$$X(\%) = \frac{X}{(X+Y)} \times 100$$
$$Y(\%) = \frac{Y}{(X+Y)} \times 100$$

Where:
X - number of male fish;
Y - number of female fish.

After the sex ratio in percentage is obtained, comparisons are carried out to find out whether there is a significant difference between the male and female population, by using the '$X^2$' (chi square) test, with the formula (according to Effendie 1979):

$$X^2 = \frac{(fo-fh)^2}{fh}$$

Where:
$X^2$ - chi square;

$f_0$ - observed biota frequency;
$f_h$ - expected biota frequency.

The $X^2_{count}$ value is obtained from this calculation, then the value is compared with the table of $X^2_{table}$ value, with a 95% confidence level and the degrees of freedom (db) = 1, with the hypothesis:
$H_0$ = no significant difference between the number of male and female fish
$H_1$ = there is a significant difference between the number of male and female fish

If, $X^2_{count} < X^2_{table}$ = $H_0$ is accepted, $H_1$ is rejected
$X^2_{count} > X^2_{table}$ = $H_0$ is rejected, $H_1$ is accepted

***Gonad Maturity Level (GML)***. GML was determined by visual observation of the gonadal morphology. Furthermore, the observed characteristics are adjusted to the characteristics of the level of maturity.

***Size at first maturity (Lm)***. The value of Lm can be estimated by the Soerman-Karber formula proposed by Udupa (1986), as follows:

$$m = xk + \frac{d}{2} - (X \sum Pi)$$

$$M = \text{antilog}\left(m \pm 1{,}96 \sqrt{x^2 \Sigma \frac{pi*qi}{n_i - 1}}\right)$$

Where:
m - logarithm of the length class at first maturity;
d - difference in the logarithm of the increase in the median length;
k - number of length classes;
xk - logarithm of the median length, where the fish is 100% at gonadal maturity (or where $p_i = 1$);
$p_i$ - proportion of mature fish in the $i^{th}$ length class, related to the number of fish in the length interval i;
$n_i$ - number of fish in the $i^{th}$ class of length;
$q_i$ - $1 - p_i$;
M - length of fish at first maturity equal to the anti-log m~~,~~ (if $\propto = 0.05$, then the confidence interval of m is 95% ~~of m~~).

***First caught size (Lc)***. The size of Lc is estimated by the method of Sparre & Venema (1999):

$$SL = \frac{1}{a + \exp(a - bL)}$$

The Lc value is obtained by plotting the cumulative frequency percentage of fish caught with a standard length, where the intersection point between the 50% cumulative frequency curve is the length of 50% of the catch. The Lc value can be calculated through the formula (Sparre et al 1989):

$$Lc = \frac{-a}{b}$$

***Catch Per Unit Effort (CPUE)***. Catch data and fishing effort obtained are then tabulated to determine the CPUE. The fishing effort can be in the form of operating days or months of operation, the number of fishing trips or the number of fleets conducting fishing operations. In this study the fishing effort (effort) used is the number of trips. The formula that can be used to determine the CPUE value is as follows (Noija et al 2014):

$$CPUE_i = \frac{Catch_i}{\quad}$$

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**Commented [WU8]:** citation needed, who developed the formula?

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$$\overline{\quad Effort_i \quad}$$

Where:
$CPUE_i$ - catch per unit of fishing effort in year i (tonnes/unit);
$Catch_i$ - catch in year i (tons);
$Effort_I$ - fishing effort in year i (trip).

***Standardization of fishing gear***. Standardization is done by finding the value of the fishing power factor or Fishing Power Index (FPI) of each fishing gear. The fishing gear used as standard has an FPI value equal to one, while the FPI value for other fishing gear is obtained from the CPUE of other fishing gear divided by the CPUE of standard fishing gear. The formula for calculating FPI is as follows:

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$$RFP_i = \frac{Ci/Ei}{Cs/Es}$$

Where:
$RFP_i$ - catch power factor of the fishing unit which will be standardized in year i;
$C_i$ - number of catches of the type of fishing unit that will be standardized in year i;
$C_s$ - number of catches of the type of fishing unit used as standard in year i;
Ei - number of fishing efforts for the type of fishing unit that will be standardized in year i;
$E_s$ - number of fishing efforts for the type of fishing unit used as standard in year i.

After obtaining the $RFP_i$ value, the following formula is used to calculate the standardized effort:

$$\text{Standard Effort} = FPI_i \times \text{Effort}$$

***The production surplus model***. The purpose of using the Production Surplus Model is to determine the optimum level of effort, which is an effort that can produce a maximum sustainable catch without affecting the long-term stock productivity (MSY) and is estimated by using the Schaefer model for catch data and fishing effort recorded over several years. MSY can be estimated using the formula (Sparre & Venema 1998):

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$$CPUE = \frac{Y}{f} = \frac{Y(i)}{f(i)}, i = 1, 2, \ldots\ldots n$$

Where:
Y(i) - catch in the year i, i=1,2,......n;
f(i) - fishing effort in the year i, i=1,2......n.

Determining the value of a (intercept) and b (slope) requires a linear regression f(i) to Y(i)/f(i). After the values of a and b are obtained, $f_{MSY}$ and MSY can be calculated using the formula:

$$f_{MSY} = \frac{a}{2b} \text{ and } MSY = \frac{a^2}{4b}$$

Furthermore, to determine the level of utilization of fish resources as a percentage of the maximum allowable number of catches in a certain year, according to the maximum production value (MSY), the following formula is used (Simbolon 2011):

$$\text{Utilization rate (\%)} = \frac{Ci}{MSY} \times 100$$

Where:
Ci - number of fish caught in year i;
MSY - maximum sustainable yield.

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**Results and discussion**

***Length frequency distribution of K. pelamis***. Based on the results of observations of 1022 samples of *K. pelamis*, length frequency distribution data was obtained, with the shortest size being 28.5 cm and the longest being 77.3 cm. The distribution of fish length during the observation is presented in Figure 2.

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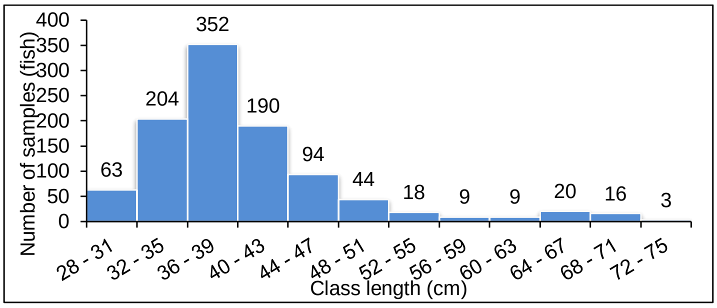


Figure 2. Long frequency distribution of *Katsuwonus pelamis.*

Overall, the mode of the sample was found in the class of 36–39.9 cm, due to the use of Fish Aggregating Devices (FADs) which causes the capture of many specimens with small or immature gonads.

***Length-weight relationship in K. pelamis***. The relationship between length and weight obtained is presented in Figure 3, according to the characteristics of the fish growth pattern.

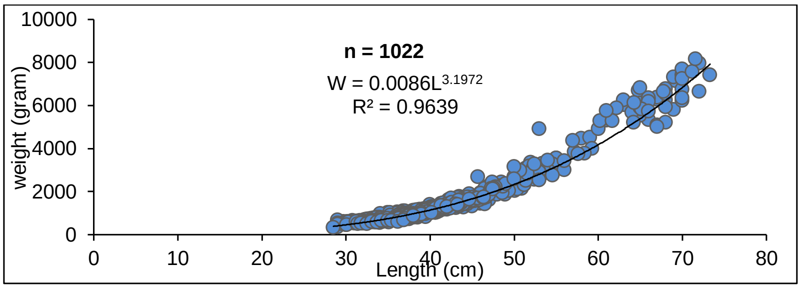


Figure 3. The relationship between the length and weight of *Katsuwonus pelamis.*

From the length-weight relationship it resulted that the length-weight relationship of *K. pelamis* is $W = 0.0086L^{3.1972}$, with a value of b = 3.1972. Then from a t test performed on the value of b, at a 95% confidence interval, it resulted $t_{count} > t_{table}$ ($t_{count} = 10.1975$; $t_{table} = 1.962$), which means that the increase rates in length and weight were significantly different or the increase in length is not proportional to the increase in weight. The value b = 3.1972 it showed a positive allometric growth pattern, where the weight gain is faster than the increase in length.

Calculation of the growth pattern of *K. pelamis* using the $t_{test}$ ($t_{count}$ = 0.05) at a 95% confidence interval (α=0.05) showed that by producing a coefficient of determination (R) of 0.9818 this shows a correlation coefficient (r) close to 1. This also shows that the increase in length will affect weight gain by showing that the correlation or relationship between length and fish weight is close and positive.

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***Sex ratio of K. pelamis***. The observed sample of 100 *K. pelamis*, of which 51 male fish (51%) and 49 female fish (49%), had a sex ratio of 1:1. According to Senen et al (2011), a balanced sex ratio also indicates that one male fish will fertilize one female fish. The number of female fish is a determinant of the sustainability of a population because during the mating season there will be a high competition, so that the natural mortality of males is higher. The sex ratio of *K. pelamis* is presented in Figure 4.

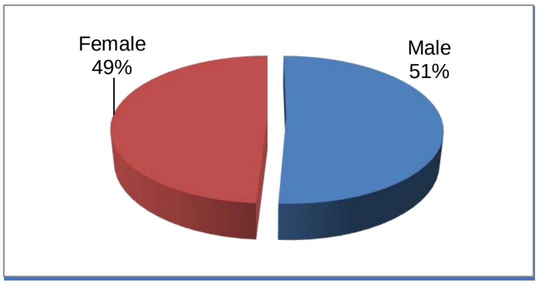


Figure 4. Sex ratio of *Katsuwonus pelamis.*

To find out the accuracy of whether the comparison is balanced or not, it is necessary to calculate the sex ratio using the chi-square test presented in Table 1.

Table 1

*Sex ratio Katsuwonus pelamis*

| *Sex* | *N* | $t_{count}$ | $t_{table}$ |
|---|---|---|---|
| Male | 51 | 0.040 | 3.84 |
| Female | 49 | | |

The results of the chi-square test are $t_{count}$=0.040 and $t_{table}$=3.84, so that $t_{count} < t_{table}$ and $H_0$ is accepted, which means there is no real difference between the male and female populations of *K. pelamis.*

***Gonad maturity level of K. pelamis***. The level of maturity of the male gonads can be seen from the size and color of the gonads, while in the female gonads it can be seen from the gonads' size and color and from the presence or absence of eggs in the gonads. The results of gonadal observations can be seen in Table 2.

Table 2

Percentage of gonad maturity level of *Katsuwonus pelamis*

| *Sex* | *Amount (N)* | *GML (%)* | | | |
|---|---|---|---|---|---|
| | | *I* | *II* | *III* | *IV* |
| Male | 51 | 41.18 | 31.37 | 19.61 | 7.84 |
| Female | 49 | 26.53 | 46.94 | 18.37 | 8.16 |
| Combined | 100 | 34 | 39 | 19 | 8 |

For male fish, the number of mature gonads was 27.45% and 72.55% were immature. For female fish, the number of mature gonads was 26.53% and 83.47% were immature. Overall (males and females), the number of mature fish was 27% and 73% were immature. This indicates that more fish are caught before the gonads maturity, suggesting that the fish have not yet had time to spawn, which affects the recruitment in the fishing area.

***Length at first maturity (Lm)***. From the observations on the level of gonad maturity and length size distribution against 100 *K. pelamis*, it resulted that the length at first maturity of the gonads was 44.81 cm. By using a 95% confidence level, the confidence interval for size prediction at maturity of gonads is 43.39-46.28 cm. For comparison, the Lm of *K. pelamis* recorded at other locations are presented in Table 3.

Table 3

Lm of *Katsuwonus pelamis* at other locations

| *Lm value (FL)(cm)* | *Research location* | *Source* |
|---|---|---|
| 42.8 | South Seram island waters | Manik (2007) |
| 42.9 | Eastern Indian Ocean Waters | Jatmiko et al (2015) |
| 43 | West and South waters of North Maluku | Karman et al (2016) |
| 43 | West Indian Ocean Waters | Norungee & Kawol (2011) |
| 46.5 | Bay of Bone, South Sulawesi | Jamal et al (2011) |

***Length at first capture (Lc)***. Calculation of Lc is done by using data on the length distribution and the number of fish in the purse seine. Based on observation of 226 fish caught by purse seine, it was found that the length of the first caught was 40.12 cm. Lc of *K. pelamis* is presented in Figure 5.

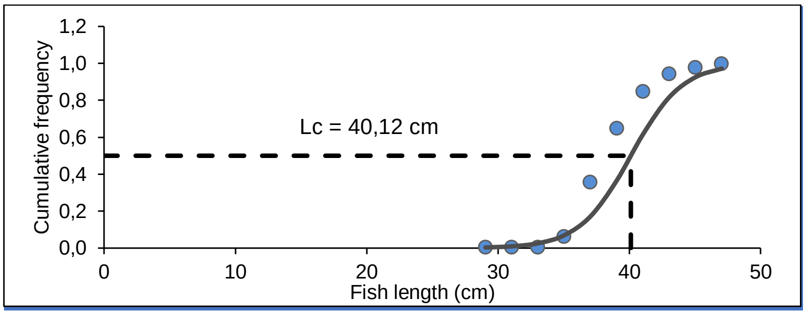


Figure 5. Lc *Katsuwonus pelamis* on a purse seine.

Then a comparison was made between the values of Lm and Lc, showing that for the fish caught by the purse seine has a value Lc<Lm and it was captured before spawning, which is thought to cause a significant decrease in the population of *K. pelamis.*

***Fisheries aspect***. *K. pelamis* is generally caught using pole and liner, trolling liner and purse seiner from less than 30 GT vessels, with trips that vary from one day fishing to one week fishing. Fishermen in the Banda Maluku Sea mostly have vessels under 30 GT.

***Fishing ground***. The dominant fishing grounds for *K. pelamis* are in the Banda Sea, due to environmental factors, food availability and because they are spawning and egg laying areas. The highest catch occurs at the beginning of the East season, also called the harvest season, between October and December. The lean season occurs between May and July, the western season occurs between December and January and the transition season occurs between April and May. The catches obtained depend on the season, currents and wind, which are obstacles for fishermen to go to sea.

***Stock status of K. pelamis in the Banda Sea***

***Catch per Unit Effort (CPUE) and Maximum Sustainable Yield (MSY)***. Production and fishing efforts of *K. pelamis* in the Banda Sea are carried out using 4 types of fishing

**Commented [n15]:** We deleted because it not including in Data retrieval method gear including handline, troll line, purse seine and pole and line. Production and effort of catching *K. pelamis* can be seen in Table 4.

Table 4

Production and catching efforts of *Katsuwonus pelamis* in the Banda Sea

| *Year* | *Production (T)* | | | | | *Trips* | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* | *Total* | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* |
| 2008 | 9,186.63 | 9,775.52 | 301.40 | 16,214.11 | 35,477.65 | 23,419 | 427,899 | 123,472 | 157,717 |
| 2009 | 9,137.30 | 9,491.48 | 745.91 | 17,312.00 | 36,686.68 | 21,373 | 392,497 | 248,406 | 123,316 |
| 2010 | 10,253.94 | 13,137.78 | 1,516.36 | 18,689.02 | 43,597.11 | 43,622 | 474,562 | 311,339 | 140,968 |
| 2011 | 11,712.66 | 14,313.94 | 408.27 | 20,519.92 | 46,954.79 | 35,888 | 433,171 | 191,396 | 25,248 |
| 2012 | 12,318.24 | 15,724.01 | 4,232.45 | 16,727.68 | 49,002.38 | 42,027 | 432,897 | 226,447 | 98,277 |
| 2013 | 26,305.18 | 6,484.45 | 5,226.45 | 22,949.42 | 60,965.51 | 32,010 | 536,119 | 186,753 | 217,374 |
| 2014 | 14,806.04 | 15,786.37 | 5,952.18 | 16,749.75 | 53,294.35 | 39,017 | 209,321 | 293,614 | 92,577 |
| 2015 | 14,726.79 | 16,392.38 | 4,127.07 | 19,208.60 | 54,454.84 | 34,787 | 499,933 | 85,352 | 187,803 |
| 2016 | 18,079.96 | 17,311.33 | 4,616.49 | 20,836.71 | 60,844.49 | 41,596 | 497,222 | 204,868 | 165,692 |
| 2017 | 18,272.12 | 18,172.17 | 5,210.66 | 23,064.41 | 64,719.36 | 38,453 | 386,606 | 191,767 | 148,278 |
| 2018 | 20,681.51 | 19,426.73 | 5,158.88 | 24,984.11 | 70,251.22 | 48,078 | 447,850 | 157,874 | 167,308 |

There are differences in fishing productivity between handline, trolling line, purse seine, and pole and line. it is necessary to standardize productivity, in order to calculate the Fishing Power Index (FPI), which can be seen in Table 5.

Table 5

Productivity and Fishing Power Index (FPI) on *Katsuwonus pelamis*

| *Year* | *Productivity (Ton trip$^{-1}$)* | | | |
|---|---|---|---|---|
| | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* |
| 2008 | 0.3923 | 0.0228 | 0.0024 | 0.1028 |
| 2009 | 0.4275 | 0.0242 | 0.0030 | 0.1404 |
| 2010 | 0.2351 | 0.0277 | 0.0049 | 0.1326 |
| 2011 | 0.3264 | 0.0330 | 0.0021 | 0.8127 |
| 2012 | 0.2931 | 0.0363 | 0.0187 | 0.1702 |
| 2013 | 0.8218 | 0.0121 | 0.0280 | 0.1056 |
| 2014 | 0.3795 | 0.0754 | 0.0203 | 0.1809 |
| 2015 | 0.4233 | 0.0328 | 0.0484 | 0.1023 |
| 2016 | 0.4347 | 0.0348 | 0.0225 | 0.1258 |
| 2017 | 0.4752 | 0.0470 | 0.0272 | 0.1555 |
| 2018 | 0.4302 | 0.0434 | 0.0327 | 0.1493 |
| Average | 0.4217 | 0.0354 | 0.0191 | 0.1980 |
| Index | Purse seiner | Trolling liner | Handliner | Pole and liner |
| CPUE | 0.4217 | 0.0354 | 0.0191 | 0.1980 |
| FPI | 1 | 0.084 | 0.045 | 0.47 |

Based on Table 5, the purse seine is used as a standard fishing gear, because its productivity is greater than for other fishing gear. Furthermore, the standardization process is performed by multiplying the FPI with the effort numbers (trips) of each fishing gear to get a standard effort. The results that can be seen in Table 6.

Table 6

Standardization of catching efforts for *Katsuwonus pelamis*

| Year | Purse seiner | Trolling liner | Hand liner | Pole and liner | Standard total effort | CPUE (Ton trip$^{-1}$) |
|---|---|---|---|---|---|---|
| 2008 | 23.419 | 35.935 | 5.593 | 74.053 | 139.000 | 0.2552 |
| 2009 | 21.373 | 32.962 | 11.252 | 57.901 | 123.488 | 0.2971 |
| 2010 | 43.622 | 39.854 | 14.103 | 66.189 | 163.768 | 0.2662 |
| 2011 | 35.888 | 36.378 | 8.670 | 11.855 | 92.790 | 0.5060 |
| 2012 | 42.027 | 36.355 | 10.258 | 46.145 | 134.784 | 0.3636 |
| 2013 | 32.010 | 45.023 | 8.459 | 102.065 | 187.557 | 0.3250 |
| 2014 | 39.017 | 17.579 | 13.300 | 43.468 | 113.364 | 0.4701 |
| 2015 | 34.787 | 41.984 | 3.866 | 88.180 | 168.818 | 0.3226 |
| 2016 | 41.596 | 41.757 | 9.280 | 77.798 | 170.431 | 0.3570 |
| 2017 | 38.453 | 32.467 | 8.687 | 69.622 | 149.229 | 0.4337 |
| 2018 | 48.078 | 37.611 | 7.151 | 78.557 | 171.397 | 0.4099 |

The CPUE linear equation relationship derived from the effort and yield data (shown in Table 6) shows CPUE yearly fluctuations (Figure 6).

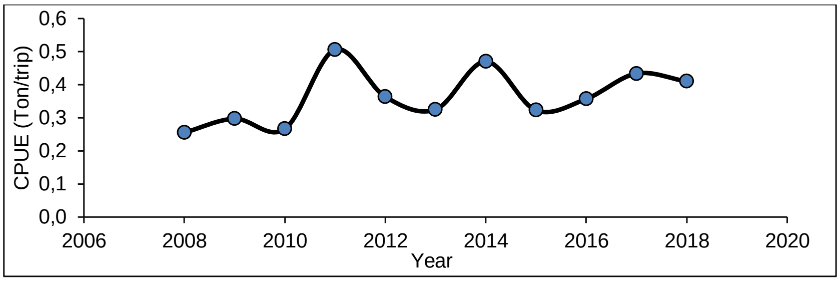


Figure 6. *Katsuwonus pelamis* CPUE fluctuations in the Banda Sea.

From Figure 6, it can be concluded that in 2011 there was the highest CPUE peak. The phenomenon of fluctuations in CPUE is strongly influenced by; (1) the size and number of vessels in operation, (2) type and size of fishing gear, (3) Illegal level, Unreported and Unregulated (IUU) fishing, (4) HR capabilities on board, (5) fishing ground location, (6) the number of fish captures landed (yield), (7) natural conditions during fishing operations and (8) the discipline of the fishing fleet with respect to the specified fishing ground (not fishing in waters that are not in accordance with the permit) (~~Krisdiana~~ Aritonang et al ~~2014~~2021).

The relationship between CPUE and effort (Figure 7) shows that the estimation parameters for *K. pelamis*, the intercept (a) = 0.5731 and the slope (b) = -0.000001, form a Linear Schaefer equation CPUE = -0.000001x + 0.5731. This relationship can be interpreted that x supplementary units of effort (trips) per year will reduce the CPUE value by 0.000001 tons per year. The linear equation has a value of $R^2$= 0.24, which means that the effort's influence on the CPUE is of 24%. Thus, the value of $R^2$ (representing the influence of the variables used in this model) is statistically considered not strong enough.

MSY and EMSY calculation data for *K. pelamis* in the Banda Sea using the Schaefer Linear method are presented in Table 7. The results of biological analysis using the Schaefer Linear model approach can produce an MSY value of 57,837 tonnes with a standard effort/EMSY of 202,473 trips.

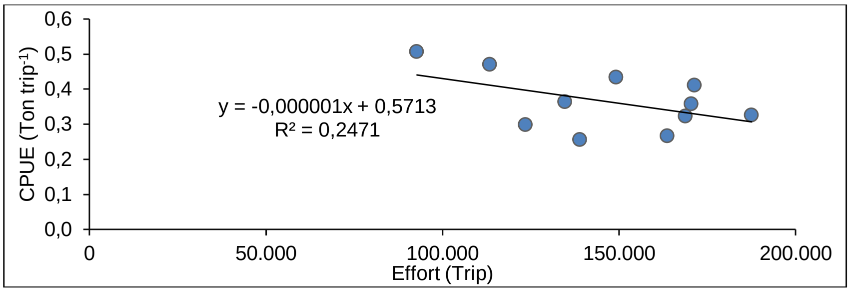

Figure 7. Linear equation of CPUE and effort *Katsuwonus pelamis*.

Table 7

MSY and EMSY estimation of *Katsuwonus pelamis* based on Schaefer linear model calculations

| *Year* | *Catch number (Ton)* | *Total Effort Standard* | *CPUE (Schaefer)* |
|---|---|---|---|
| *I* | *Yi* | *X* | *Y* |
| 2008 | 35.477.7 | 139.000 | 0.2552 |
| 2009 | 36.686.7 | 123.488 | 0.2971 |
| 2010 | 43.597.1 | 163.768 | 0.2662 |
| 2011 | 46.954.8 | 92.790 | 0.5060 |
| 2012 | 49.002.4 | 134.784 | 0.3636 |
| 2013 | 60.965.5 | 187.557 | 0.3250 |
| 2014 | 53.294.3 | 113.364 | 0.4701 |
| 2015 | 54.454.8 | 168.818 | 0.3226 |
| 2016 | 60.844.5 | 170.431 | 0.3570 |
| 2017 | 64.719.4 | 149.229 | 0.4337 |
| 2018 | 70.251.2 | 171.397 | 0.4099 |
| Amount | 576.248.3662 | 1.614.628 | 4.0064 |
| Average value | 52.386.22 | 146.784 | 0.3642 |
| Intercept a | | | 0.57131 |
| Slope b | | | -0.000001 |
| MSY Schaefer; -a^2/4b | | | 57,837 |
| E MSY Schaefer: -a/2b | | | 202,473 |
| Total Allowable Catch (TAC) 80% MSY | | | 46,269.77 |

Based on the calculation of the linear model, biological overfishing has occurred in *K. pelamis* in the Banda Sea, which is indicated by the actual catch having passed MSY. This is evidenced by the actual catch in 2018 which reached 70,251.2 tons, exceeding the Total Allowable Catch (TAC) potential of 80% of the MSY value of 46,269.77 tons. The MSY *K. pelamis* curve can be seen in Figure 8.

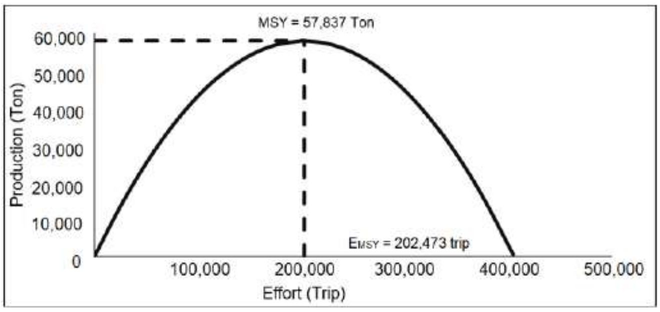

Figure 8. Stock balance curve (MSY) for *Katsuwonus pelamis.*

**Conclusions**. Biological aspects of *K. pelamis* in the Banda Sea show a positive allometric growth pattern. *K. pelamis* risks to be caught before spawning (Lc < Lm), resulting in an imbalance in natural stocks, since the fish caught have not yet spawned, therefore the recruitment can be disrupted. The fishery *K. pelamis* fisheries increase their production, with a low level of gear selectivity, so that there is a need for regulation of fishing gear and supervision. *K. pelamis* resources exploitation exceeds the maximum point of sustainable production and also the MEY, so that the profit decreases, as shown by the actual effort and production values.

**Conflict of interest**. The authors declare no conflict of interest.

**References**


Adnyani L. P., Nurmawati, Anggriani I., 2019 [Analysis of Potential and Utilization Level of Fish Resources in Balikpapan Waters. East Kalimantan]. Gorontalo Fisheries Journal 2(2):55-68 [in Indonesian].

Afifi M. A. M., El-Sadek A., El-Haddad K. M., 2022 First record of skipjack tuna (*Katsuwonus pelamis*) from Dahab in the Gulf of Aqaba. Red Sea. Egypt. Egyptian Journal of Aquatic Biology & Fisheries 26(3):699–710.

Afriliani W., Anna Z., Handaka A. A., Khan A. M. A., 2020 Typology of skipjack (*Katsuwonus pelamis*) fisheries at Nizam Zachman Oceanic Fishing Port. Jakarta. Indonesia. Asian Journal of Fisheries and Aquatic Research 7(2):39-50.

Andamari R., Hutapea J. R., Prisantoso B. I., 2012 [Reproduction aspects of the yellowfin tuna (*Thunnus albacares*)]. Journal of Tropical Marine Science and Technology 4(1):89-96. [In Indonesian].

Aritonang S. I. S., Jabbar M. A., Suharti R., Rahardjo P., Suyasa I. N., Zulkifli D., Sabariyah N., Bramana A., 2021 Fishing Season and Abundance of Scad Mackerel (*Decapterus russelli*) in Java Sea. Indonesian Fisheries Research Journal 27(4):179-186. [in Indonesian].

Bintoro G., Yulianto E. S., Lelono T. D., Prasetyo D. T., Rahman M. A., Sari W. K., 2022 Utilization status and bioeconomic performance of skipjack tuna (*Katsuwonus pelamis*) fishery in the south coast of Malang waters. East Java. Indonesia. IOP Conference Series: Earth and Environmental Science 1033:1-10.

Chakma S., Saha S., Hasan Md. N., Rahman Md. A., Akter M., Hoque Md. S., Ullah Md. R., Sujan K. M., Shahriar A., 2020 Effect of frozen storage on the biochemical. microbial and sensory attributes of Skipjack Tuna (*Katsuwonus pelamis*) fish loins. Journal of Applied Biology & Biotechnology 8(4):58-64.

Chodrijah U., 2011 [Several aspects of reproductive biology of yellowfin tuna *(Thunnus albacares)* from Banda Sea waters]. Proceedings of the 8th National Fish Seminar, pp. 401-409. [In Indonesian].

Chodrijah U., Nugraha B., 2013 [Size distribution of longline tuna catches and catching areas in Banda Sea Waters]. Indonesian Fisheries Research Journal 19(1):9-16. [In Indonesian].


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Diningrum T. D. B., Triyono H., Jabbar M. A., 2019 [Biological aspects of skipjack tuna in southeast Celebes]. Journal of Fisheries and Maritime Extension 13(2):139-147. [In Indonesian].
Effendie M. I., 1979 [Fisheries biology method]. Dewi Sri Foundation, Bogor, 112 pp.... [In Indonesian].
Genti J. G., Marsoedi, Afandhi A., 2016 The Utilization of Skipjack tuna *Katsuwonus pelamis* (Linnaeus. 1758) Availability for Sustainable Fisheries Management in Prigi. East Java. Indonesian Journal of Environment and Sustainable Development (J-PAL) 7(2):122-127.
Hidayat T., Chodrijah U., Noegroho T., 2014. [Characteristics of trolling fisheries in the Banda Sea]. Indonesian Fisheries Research Journal 20(1):43-51. [In Indonesian].
Hutajulu H., Imran Z., Budiharsono S., Kusumastanto T., 2019 Economic structure analysis in the development of skipjack tuna *(Katsuwonus pelamis)* fisheries industry in Jayapura City, Papua, Indonesia. AACL Bioflux 12(5):1726-1737
Hutomo M., Moosa M. K., 2005 Indonesian marine and coastal biodiversity: Present status. Indian Journal of Marine Sciences 34(1):88-97.
~~Jackson A. M., Ambariyanto, Erdmann M. V., Toha A. H. A., Stevens L. A., Barber P. H., 2014 Phylogeography of commercial tuna and mackerel in the Indonesian Archipelago. Bulletin of Marine Science 90(1):471-492.~~
Jaleel A., Smith H. D., 2022 The Maldives tuna fishery: An example of best practice. Ocean Yearbook Online 36(1):314-345.
Jamal M., Sondita M. F. A., Haluan J., Wiryawan B., 2011 [Utilization of Skipjack Biological Data *(Katsuwonus pelamis)* in the Framework of Responsible Fisheries Management in the Waters of Bone Bay]. Journal of Indonesian Nature 14(1):107-113. [In Indonesian].
Jatmiko I., Hartaty H., Bahtiar A., 2015 [Reproductive biology of skipjack fish *(Katsuwonus pelamis)* in the Eastern Indian Ocean]. Bawal 7(2):87-94. [In Indonesian].
Karman A., Martasuganda S., Sondita M. F. A., Baskoro M. S., 2016 [Biological base of skipjack as the foundation for sustainable fisheries management in the North Maluku Province]. Journal of Tropical Marine Science and Technology 8(1):159-173. [In Indonesian].
~~Krisdiana R. D., Iriana D., Djunaedi O. S., Dhahiyat Y., 2014 [Bioeconomic analysis of yellowfin tuna (*Thunnus albacares* Bonnaterre 1788) in the Indonesian Fisheries Management Area (WPPNRI) 573]. (Desertation). Faculty of Agriculture, University of Padjadjaran p. 1 15.~~
Lintang C. J., Labaro I. L., Telleng A. T., 2012 [Study of the fishing season for tuna using handline fishing gear in the Maluku Sea]. Journal of Capture Fisheries Science and Technology 1(1):6-9. [In Indonesian].
Mahmud, Sinrang A. D. B., Massiseng A. N. A., 2021 Prospects of fisheries industry development in indonesia through online publication media. International Journal of Applied Biology 5(2):117-129.
Manik N., 2007 [Several aspects of the biology of skipjack tuna (*Katsuwonus pelamis*) in the waters around South Seram Island and Nusa Laut Island]. Oceanology and Limnology in Indonesia 33:17-25. [In Indonesian].
Manurung V. T., 2016 [Performance and Institutional Credit for Small-Scale Tuna Fishing Business in Eastern Indonesia]. The Agro-Economy Research Forum 16(2):60-74. [In Indonesian].
Mardlijah S., Pane A. R. P., Panggabean A. S., 2021 The stock status of skipjack tuna (*Katsuwonus pelamis*) in Tomini Bay and Its Surrounding Areas. Indonesia. IOP Conference Series: Earth and Environmental Science 934:1-9.
Mukhsin R., Mappigau P., Tenriawaru A. N., 2017 [The effect of entrepreneur's orientation on the survival of small and medium enterprises of the fishery processing groups in Makassar City]. Journal of Analysis 6(2):188–193. [In Indonesian].
Noija D., Martasuganda S., Murdiyanto B., Taurusman A. A., 2014 [Potential and level of utilization of demersal fish resources in the waters of Ambon Island, Maluku Province]. Journal of Fisheries and Marine Technology 5(1):55-64. [In Indonesian].


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**Commented [WU24]:** 15 pages dissertation?!

Norungee D., Kawol D., 2011 Macroskopic study on some aspects of the reproductive biology of skipjack tuna (*Katsuwonus pelamis*) in the Western Indian Ocean. Proceeding Working Party on Tropical Tunas of the IOTC 2011, PAGES
Norungee D., Kawol., D. 2011. Macroscopic study on some aspects of the reproductive biology of skipjack tuna (*Katsuwonus pelamis*) in the Western Indian Ocean. Indian Ocean Tuna Commission, 13th Working Party on Tropical Tunas, Maldives. Document 25 Rev_1. 10 p.
Nugraha E., Yudho G. S., Jaenudin A., Yusrizal, Kusmedy B., Kusnidar A., Husen E. S., 2020 Relationship between length and weight of skipjack tuna (*Katsuwonus pelamis*) purse seine catching in the Maluku Sea. Indonesia. AACL Bioflux 13(1):330-345.
Ollé J., Vilà-Valls L., Alvarado-Bremer J., Cerdenares G., Duong T. Y., Hajjej G., Lino P. G., Muñoz-Lechuga R., Sow F. N., Diaha N. C., Araguas R. M., Sanz N., Viñas J., 2022 Population genetics meets phylogenetics: new insights into the relationships among members of the genus *Euthynnus (family Scombridae).* Hydrobiologia 849:47–62.
Paulangan Y. P., Rumbiak K., Barapadang B., 2020 Fishing season and participatory mapping of the fishing ground of target fish in Depapre Bay. Jayapura Regency. Papua Indonesia. IOP Conference Series: Earth and Environmental Science 584:1-8.
Satrioajie W. N., Suyadi, Syahailatua A., Wouthuyzen S., 2018 The importance of the Banda Sea for tuna conservation area: A review of studies on the biology and the ecology of tuna. IOP Conference Series: Earth and Environmental Science. 184:1-11.
Senen B., Sulistiono S., Ismudi M., 2011 [Biological aspects of the flying catfish (*Decapterus macrosoma*) in Banda Neira waters. Maluku. Indonesia]. Agricultural Journal UMMI 1:35-40. [In Indonesian].
Simbolon D., Wiryawan B., Wahyuningrum P. I., Wahyudi H., 2011 [Utilization level and seasonal patterns of fishing for lemuru in the Bali Strait waters. Bulletin PSP 19(3):293-307. [In Indonesian].
Sparre P., Ursine E., Venema S. C., 1989 Introduction to tropical fish stock assessment Part 1. Manual, FAO Fisheries Technical paper. No. 306.1 Rome, FAO p. 337.
Sparre P., Venema S. C., 1999 Introduction to Tropical Fish Stock Assessment. Part 1. FAO Fishing Technology Paper No.306/1.Rev.2. Rome, FAO, 407 p.
Sugara A., Nolisa A., Anggoro A., Suci A. N. N., Suhendri R., 2022 [Diversity Species Identification of fish catched by fishermen Tapak Paderi Bengkulu City]. Samakia: Journal of Fisheries Science 13(1):1-7. [In Indonesian].
Tadjuddah M., Anadi L., Mustafa A., Arami H., Abdullah. Kamri S., Wianti N. I., 2017 Growth pattern and size structure of skipjack tuna caught in Banda Sea. Indonesia. AACL Bioflux 10(2):227-233.
Tangke U., 2014 [Estimation of pelagic fishing area based on sea surface temperature and chlorophyll-a approaches in the Maluku Sea]. Scientific Journal of Agribusiness and Fisheries (AGRIKAN UMMU-Ternate) 7(1):74–81. [In Indonesian].
Udupa K. S., 1986 Statistical method of estimating the size at first maturity offishes. Fishbyte 4(2):8-10.
Widodo A. A., Nugraha B. 2009 [Kendari-based tuna fishery. Southeast Sulawesi]. BAWAL 299–307. [In Indonesian].
Yaskun M., Sugiarto E., 2017 [Analysis of the potential of marine fisheries products on the welfare of fishermen and the community in Lamongan Regency]. EKBIS Journal 17(1):867-875. [In Indonesian].
*** FAO, 2010 Biological characteristics of tuna. Text by Michel Goujon and Jacek Majkowski.

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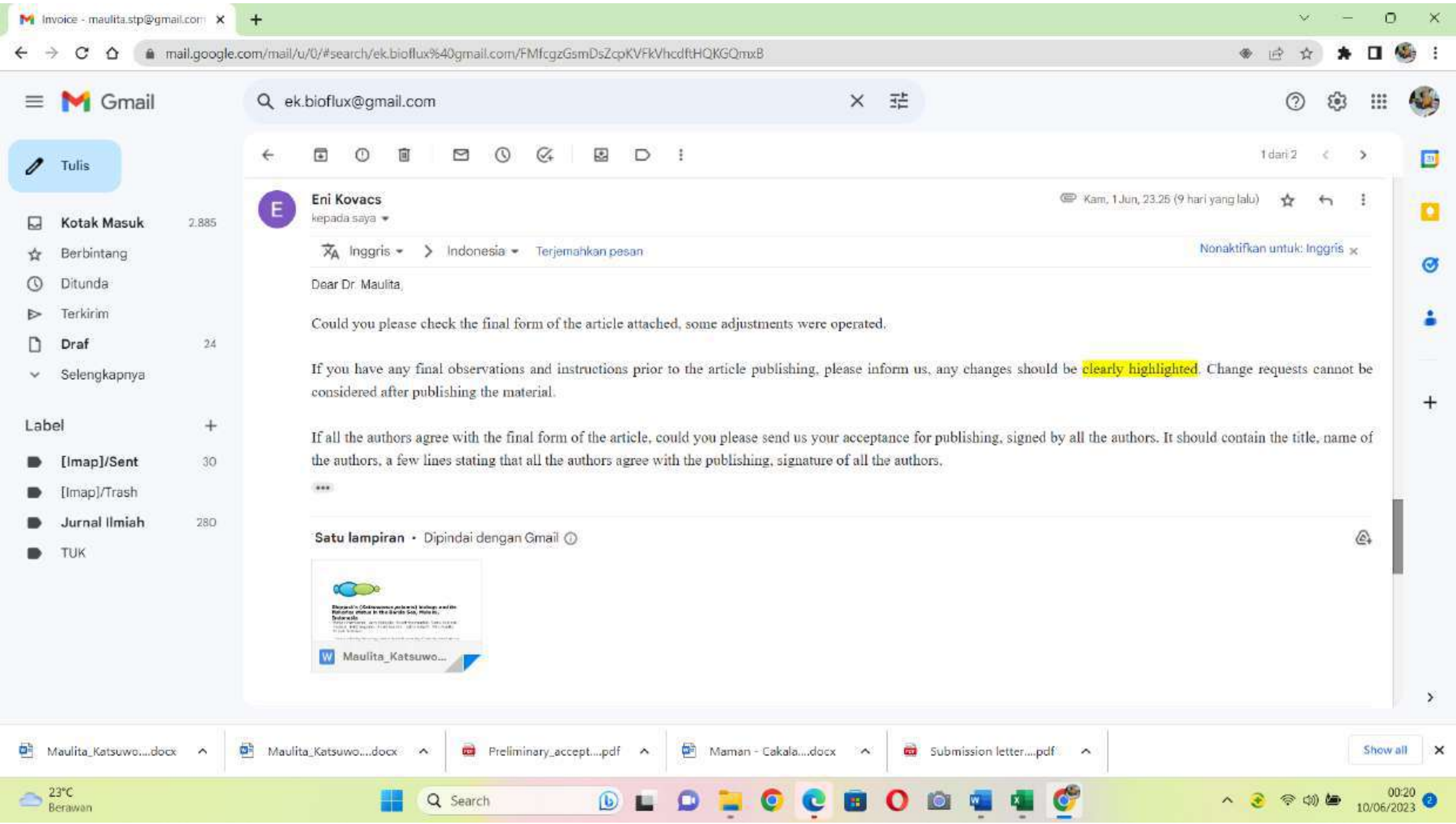

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# Skipjack's (*Katsuwonus pelamis*) biology and its fisheries status in the Banda Sea, Maluku, Indonesia

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**Abstract**. *Katsuwonus pelamis* fish is a marine biological resource that has a quite high economic value in Indonesia. A potential fishing ground for large pelagic fish in eastern Indonesia is the Banda Sea. This study aimed to examine the aspects of biology and the management of *K. pelamis* exploitation in the Maluku region. The research was conducted in Maluku province for 90 days starting from March 4th to May 25th 2019. The method used was the purposive sampling and the data collected were primary data and secondary data. *K. pelamis* in the Banda Sea had a maximum sustainable yield (MSY) value of 57,837 tons with a fishing effort of 202,473 trips and the maximum economic yield (MEY) value was at 48,866 tons for a fishing effort of 122,732 trips. The study provided data on the frequency distribution of *K. pelamis* with the shortest fork length (FL) being 28.5 cm and the longest being 77.3 cm. The calculation of the growth pattern of large pelagic fish was carried out using the $t_{test}$ ($t_{count}$=0.05 tab) at a 95% confidence interval (α=0.05). The growth pattern obtained for *K. pelamis* was positive allometric. The sex ratio obtained was 1 male:1 female. The level of gonadal maturity was dominated by GML II (39%). *K. pelamis* caught with the purse seine have the first caught size (Lc=40.12 cm) > size at first maturity (Lm=44.81 cm). The actual catch of 70,251 tons showed that the species utilization has exceeded the maximum value of sustainable potential and, economically, the catch of *K. pelamis* has passed the MEY condition. The *K. pelamis* fisheries increase their production, with a low level of gear selectivity, so that there is a need for regulation of fishing gear and supervision.
**Key Words**: sex ratio, fork length, total weight, gonadal maturity level.

**Introduction**. Indonesian waters are considered to have living fish resources with the highest level of biodiversity (Sugara et al 2022; Yaskun & Sugiarto 2017; Hutomo & Moosa 2005). These resources cover at least 37% of the world's fish species (Mahmud et al 2021; Adnyani et al 2019). The resources of Skipjack (*Katsuwonus pelamis*) are grouped into large pelagic fish resources, including tuna (*Thunnus* sp.) and mackerel (*Euthynnus affinis*) (Jakson et al 2014; Bintoro et al 2022; Lintang et al 2012). *K. pelamis* are fishery products of interest for the general consumers and of a high economic value (Hutajulu et al 2019; Afriliani et al 2020; Genti et al 2016). Waters in eastern Indonesia are known as centers of *K. pelamis* production (Manurung 2016). One of the waters that has become a potential fishing ground for large pelagic fish in Eastern Indonesia is the Banda Sea (Hidayat et al 2014). The Banda Sea is the waters of the Eastern Indonesian Region which is included in the waters of the West Pacific Ocean and is bordered by the Indian Ocean (Chodrijah & Nugraha 2013). The Banda Sea became a potential fishing area for *K. pelamis* in Maluku Province (Tadjuddah et al 2017; Satrioajie et al 2018) throughout the year (Tangke et al 2014).

*K. pelamis* is a type of fish that belongs to the Scrombidae family (Afifi et al 2022; Mardlijah et al 2021; Chakma et al 2020). The Scrombidae family basically occurs in marine waters and is classified as pelagic fish (Ollé et al 2022; Paulangan et al 2020). Based on

their size, tuna is divided into two groups: *Thunnus* species are grouped into large tuna and *K. pelamis* species are classified as small tuna (Nugraha et al 2020; Chodrijah 2011). Exploitation of this resource is carried out by various forms of fishing activities, including purse seine, pole and line and handline (Jaleel & Smith 2022; Mardlijah et al 2021; Widodo & Nugraha 2009). Due to the magnitude of the potential and to the condition of the available large pelagic fish resources, it is necessary to study the status of large pelagic fisheries, especially those targeting *K. pelamis* in the Banda Sea.

This study aimed to examine several aspects of *K. pelamis* including: a) biological aspects, in particular the length-weight relationship, b) fisheries characteristics, including production trends, fishing effort, fishing grounds, fishing season, fishing gear and CPUE and c) the management of the *K. pelamis* populations ant their exploitation, which includes the calculation of the catch rate, maximum sustainable yield, maximum economic yield, and the number of allowed catches in the Maluku region.

## Material and Method

***Research sites***. The research was conducted for 90 days, from 4 March to 25 May 2019 in the Banda Sea. Data collection was carried out at several sampling points as shown in Figure 1.

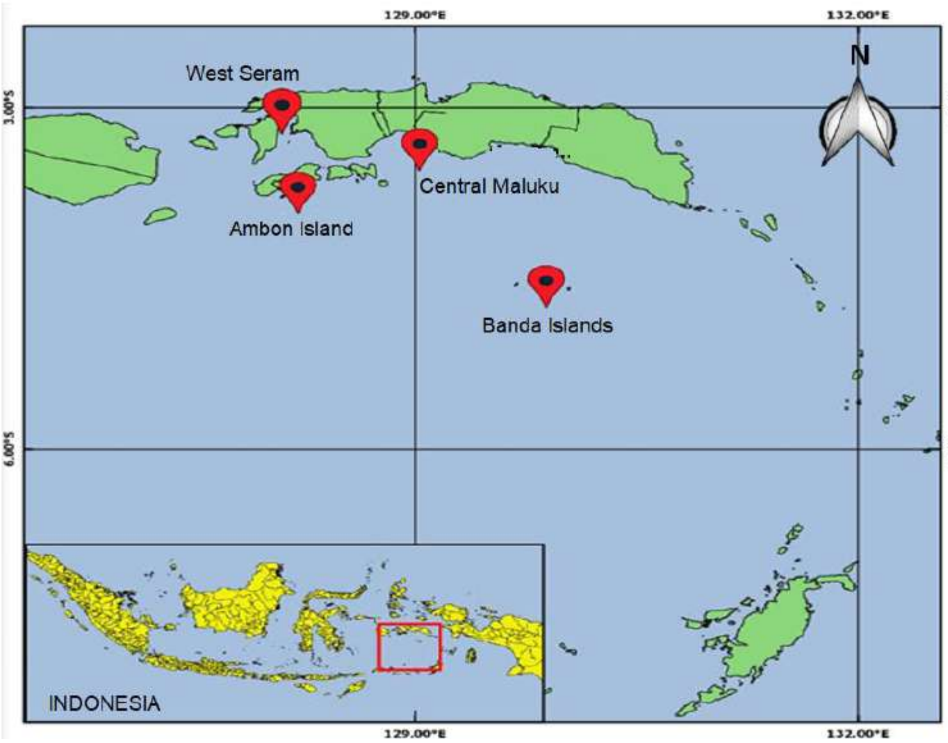


Figure 1. Map of research locations.

The tools and materials used in this study are as follows: ruler, tape measure, digital scales, camera, stationery, identification label, and several samples of *K. pelamis.*

***Data retrieval method***. In this study a survey method was used, namely by observing fish samples in the field. Determination of locations and fishing gear was carried out by purposive sampling, namely by collecting data deliberately according to the desired conditions (Mukhsin et al 2017), while the determination of respondents was carried out by accidental sampling. Data collection for *K. pelamis* sampling was carried out using the simple random sampling method, by measuring the fork length, total weight, sex and gonadal maturity level of 10% of the total catch. Secondary data were periodic data (time series) of catches and fishing effort for 5 to 10 years.

***Length frequency distribution***. Frequency distribution was obtained by determining the class interval, median class and frequency in each length group. The length frequency distribution that has been determined with the same class intervals can then be put in a diagram to show the results.

***Length-weight relationship***. The model used in estimating the relationship between length and weight is an exponential relationship with the following equation (Andamari et al 2012):

$$W = aL^b$$

Where:
W - weight of fish (g);
L - standard fish fork length (cm);
A - the constant number or intercept of the regression calculation;
B - exponent or tangential angle.

To determine the value of a and b, a linear regression analysis is needed by considering the logarithm of the formula above. The linear equation becomes:

$$Ln\ W = Ln\ a + b\ Ln\ L$$

Then a simple linear equation can be made:

$$Y = a + bX$$

Where:
Y - dependent variable;
X - free change;
a' - antilog intercept;
b - slope (slope).

The b values, b<3, b=3 and b>3, according to Effendie (1979), discriminate among the allometric type, as follows:

1) If b<3, then the increase in length is faster than the increase in weight; it is called negative allometric
2) If b>3, then the weight gain is faster than the increase in length; it is called positive allometric
3) If b=3, then the increase in length and weight gain are balanced, which is called isometric

***Sex ratio***. Comparison of the sex of the biota was carried out by visual observation of a number of male and female individuals obtained as samples at the study site. The sex ratio is calculated using the formula (Diningrum et al 2019):

$$X(\%) = \frac{X}{(X+Y)} \times 100$$

$$Y(\%) = \frac{Y}{(X+Y)} \times 100$$

Where:
X - number of male fish;
Y - number of female fish.

After the sex ratio in percentage is obtained, comparisons are carried out to find out whether there is a significant difference between the male and female population, by using the '$X^2$' (chi square) test, with the formula (according to Effendie 1979):

$$X^2 = \frac{(fo-fh)^2}{fh}$$

Where:
$X^2$ - chi square;

$f_0$ - observed biota frequency;
$f_h$ - expected biota frequency.

The $X^2_{count}$ value is obtained from this calculation, then the value is compared with the table of $X^2_{table}$ value, with a 95% confidence level and the degrees of freedom (db) = 1, with the hypothesis:
$H_0$ = no significant difference between the number of male and female fish
$H_1$ = there is a significant difference between the number of male and female fish
If, $X^2_{count} < X^2_{table}$ = $H_0$ is accepted, $H_1$ is rejected
$X^2_{count} > X^2_{table}$ = $H_0$ is rejected, $H_1$ is accepted

***Gonad Maturity Level (GML)***. GML was determined by visual observation of the gonadal morphology. Furthermore, the observed characteristics are adjusted to the characteristics of the level of maturity.

***Size at first maturity (Lm)***. The value of Lm can be estimated by the Soerman-Karber formula proposed by Udupa (1986), as follows:

$$m = xk + \frac{d}{2} - (X \sum Pi)$$

$$M = \text{antilog}\ (m \pm 1{,}96 \sqrt{x^2 \Sigma \frac{pi*qi}{n_i - 1}})$$

Where:
m - logarithm of the length class at first maturity;
d - difference in the logarithm of the increase in the median length;
k - number of length classes;
xk - logarithm of the median length, where the fish is 100% at gonadal maturity (or where $p_i = 1$);
$p_i$ - proportion of mature fish in the $i^{th}$ length class, related to the number of fish in the length interval i;
$n_i$ - number of fish in the $i^{th}$ class of length;
$q_i$ - 1 – $p_i$;
M - length of fish at first maturity equal to the anti-log m (if $\propto = 0.05$, then the confidence interval of m is 95%).

***First caught size (Lc)***. The size of Lc is estimated by the method of Sparre & Venema (1999):

$$SL = \frac{1}{a + \exp\ (a - bL)}$$

The Lc value is obtained by plotting the cumulative frequency percentage of fish caught with a standard length, where the intersection point between the 50% cumulative frequency curve is the length of 50% of the catch. The Lc value can be calculated through the formula (Sparre et al 1989):

$$Lc = \frac{-a}{b}$$

***Catch Per Unit Effort (CPUE)***. Catch data and fishing effort obtained are then tabulated to determine the CPUE. The fishing effort can be in the form of operating days or months of operation, the number of fishing trips or the number of fleets conducting fishing operations. In this study the fishing effort (effort) used is the number of trips. The formula that can be used to determine the CPUE value is as follows (Noija et al 2014):

$$CPUE_i = \frac{Catch_i}{Effort_i}$$

Where:
$CPUE_i$ - catch per unit of fishing effort in year i (tonnes/unit);
$Catch_i$ - catch in year i (tons);
$Effort_I$ - fishing effort in year i (trip).

**Results and discussion**

***Length frequency distribution of K. pelamis***. Based on the results of observations of 1022 samples of *K. pelamis*, length frequency distribution data was obtained, with the shortest size being 28.5 cm and the longest being 77.3 cm. The distribution of fish length during the observation is presented in Figure 2.

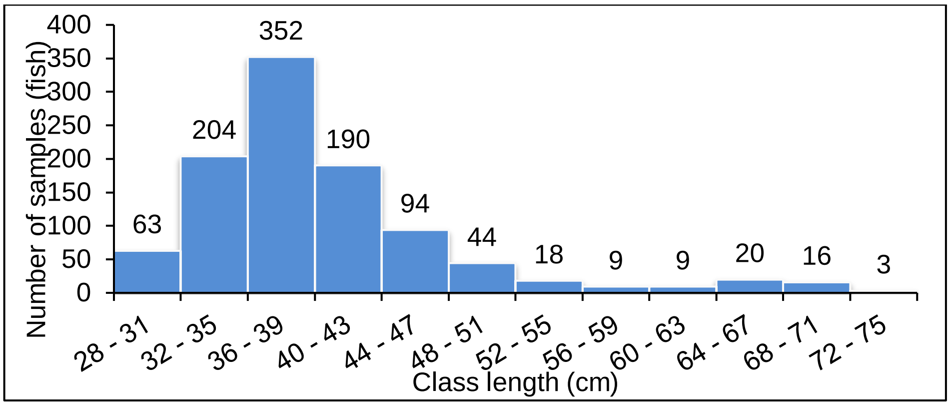

Figure 2. Long frequency distribution of *Katsuwonus pelamis.*

Overall, the mode of the sample was found in the class of 36–39.9 cm, due to the use of Fish Aggregating Devices (FADs) which causes the capture of many specimens with small or immature gonads.

***Length-weight relationship in K. pelamis***. The relationship between length and weight obtained is presented in Figure 3, according to the characteristics of the fish growth pattern.

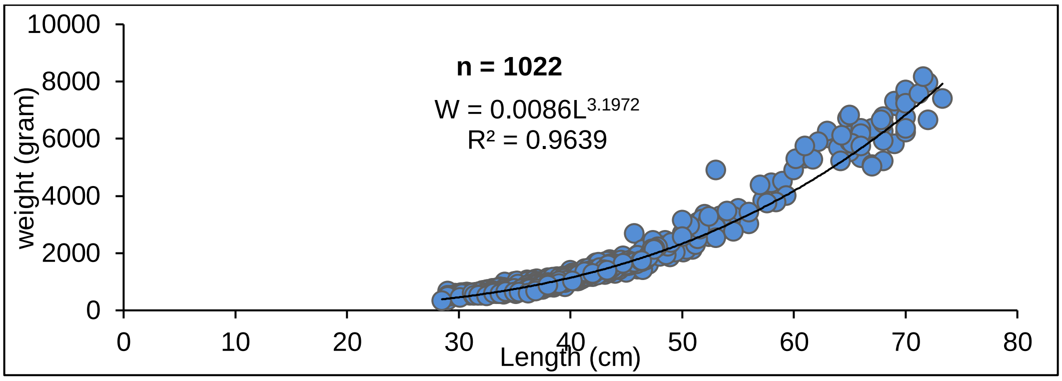

Figure 3. The relationship between the length and weight of *Katsuwonus pelamis.*

From the length-weight relationship it resulted that the length-weight relationship of *K. pelamis* is $W = 0.0086L^{3.1972}$, with a value of b = 3.1972. Then from a t test performed on the value of b, at a 95% confidence interval, it resulted $t_{count} > t_{table}$ ($t_{count}$ = 10.1975; $t_{table}$ = 1.962), which means that the increase rates in length and weight were significantly different or the increase in length is not proportional to the increase in weight. The value b = 3.1972 it showed a positive allometric growth pattern, where the weight gain is faster than the increase in length.

Calculation of the growth pattern of *K. pelamis* using the $t_{test}$ ($t_{count}$ = 0.05) at a 95% confidence interval (α=0.05) showed that by producing a coefficient of determination

(R) of 0.9818 shows a correlation coefficient (r) close to 1. This also shows that the increase in length will affect weight gain by showing that the correlation or relationship between length and fish weight is close and positive.

***Sex ratio of K. pelamis***. The observed sample of 100 *K. pelamis*, of which 51 male fish (51%) and 49 female fish (49%), had a sex ratio of 1:1. According to Senen et al (2011), a balanced sex ratio also indicates that one male fish will fertilize one female fish. The number of female fish is a determinant of the sustainability of a population because during the mating season there will be a high competition, so that the natural mortality of males is higher. The sex ratio of *K. pelamis* is presented in Figure 4.

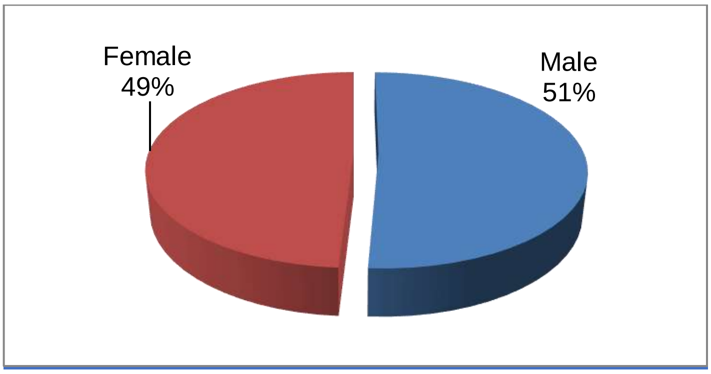


Figure 4. Sex ratio of *Katsuwonus pelamis.*

To find out the accuracy of whether the comparison is balanced or not, it is necessary to calculate the sex ratio using the chi-square test presented in Table 1.

Table 1

*Sex ratio Katsuwonus pelamis*

| *Sex* | *N* | $t_{count}$ | $t_{table}$ |
|---|---|---|---|
| Male | 51 | 0.040 | 3.84 |
| Female | 49 | | |

The results of the chi-square test are $t_{count}$=0.040 and $t_{table}$=3.84, so that $t_{count} < t_{table}$ and $H_0$ is accepted, which means there is no real difference between the male and female populations of *K. pelamis.*

***Gonad maturity level of K. pelamis***. The level of maturity of the male gonads can be seen from the size and color of the gonads, while in the female gonads it can be seen from the gonads' size and color and from the presence or absence of eggs in the gonads. The results of gonadal observations can be seen in Table 2.

Table 2

Percentage of gonad maturity level of *Katsuwonus pelamis*

| *Sex* | *Amount (N)* | *GML (%)* | | | |
|---|---|---|---|---|---|
| | | *I* | *II* | *III* | *IV* |
| Male | 51 | 41.18 | 31.37 | 19.61 | 7.84 |
| Female | 49 | 26.53 | 46.94 | 18.37 | 8.16 |
| Combined | 100 | 34 | 39 | 19 | 8 |

For male fish, the number of mature gonads was 27.45% and 72.55% were immature. For female fish, the number of mature gonads was 26.53% and 83.47% were immature. Overall (males and females), the number of mature fish was 27% and 73%

were immature. This indicates that more fish are caught before the gonads maturity, suggesting that the fish have not yet had time to spawn, which affects the recruitment in the fishing area.

***Length at first maturity (Lm)***. From the observations on the level of gonad maturity and length size distribution against 100 *K. pelamis*, it resulted that the length at first maturity of the gonads was 44.81 cm. By using a 95% confidence level, the confidence interval for size prediction at maturity of gonads is 43.39-46.28 cm. For comparison, the Lm of *K. pelamis* recorded at other locations are presented in Table 3.

Table 3

Lm of *Katsuwonus pelamis* at other locations

| *Lm value (FL)(cm)* | *Research location* | *Source* |
|---|---|---|
| 42.8 | South Seram island waters | Manik (2007) |
| 42.9 | Eastern Indian Ocean Waters | Jatmiko et al (2015) |
| 43 | West and South waters of North Maluku | Karman et al (2016) |
| 43 | West Indian Ocean Waters | Norungee & Kawol (2011) |
| 46.5 | Bay of Bone, South Sulawesi | Jamal et al (2011) |

***Length at first capture (Lc)***. Calculation of Lc is done by using data on the length distribution and the number of fish in the purse seine. Based on observation of 226 fish caught by purse seine, it was found that the length of the first caught was 40.12 cm. Lc of *K. pelamis* is presented in Figure 5.

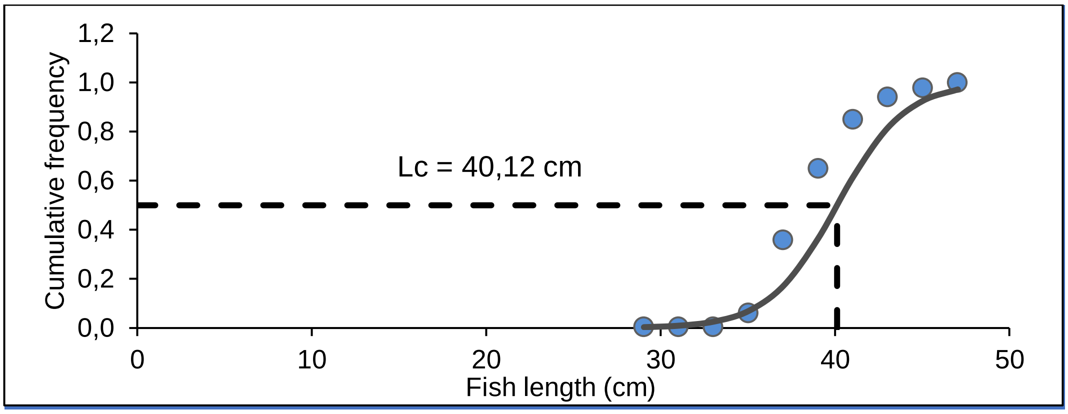


Figure 5. Lc *Katsuwonus pelamis* on a purse seine.

Then a comparison was made between the values of Lm and Lc, showing that for the fish caught by the purse seine has a value Lc<Lm and it was captured before spawning, which is thought to cause a significant decrease in the population of *K. pelamis.*

***Catch per Unit Effort (CPUE) and Maximum Sustainable Yield (MSY)***. Production and fishing efforts of *K. pelamis* in the Banda Sea are carried out using 4 types of fishing gear including handline, troll line, purse seine and pole and line. Production and effort of catching *K. pelamis* can be seen in Table 4.

Table 4

Production and catching efforts of *Katsuwonus pelamis* in the Banda Sea

| Year | Production (T) | | | | | Trips | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* | *Total* | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* |
| 2008 | 9,186.63 | 9,775.52 | 301.40 | 16,214.11 | 35,477.65 | 23,419 | 427,899 | 123,472 | 157,717 |
| 2009 | 9,137.30 | 9,491.48 | 745.91 | 17,312.00 | 36,686.68 | 21,373 | 392,497 | 248,406 | 123,316 |
| 2010 | 10,253.94 | 13,137.78 | 1,516.36 | 18,689.02 | 43,597.11 | 43,622 | 474,562 | 311,339 | 140,968 |
| 2011 | 11,712.66 | 14,313.94 | 408.27 | 20,519.92 | 46,954.79 | 35,888 | 433,171 | 191,396 | 25,248 |
| 2012 | 12,318.24 | 15,724.01 | 4,232.45 | 16,727.68 | 49,002.38 | 42,027 | 432,897 | 226,447 | 98,277 |
| 2013 | 26,305.18 | 6,484.45 | 5,226.45 | 22,949.42 | 60,965.51 | 32,010 | 536,119 | 186,753 | 217,374 |
| 2014 | 14,806.04 | 15,786.37 | 5,952.18 | 16,749.75 | 53,294.35 | 39,017 | 209,321 | 293,614 | 92,577 |
| 2015 | 14,726.79 | 16,392.38 | 4,127.07 | 19,208.60 | 54,454.84 | 34,787 | 499,933 | 85,352 | 187,803 |
| 2016 | 18,079.96 | 17,311.33 | 4,616.49 | 20,836.71 | 60,844.49 | 41,596 | 497,222 | 204,868 | 165,692 |
| 2017 | 18,272.12 | 18,172.17 | 5,210.66 | 23,064.41 | 64,719.36 | 38,453 | 386,606 | 191,767 | 148,278 |
| 2018 | 20,681.51 | 19,426.73 | 5,158.88 | 24,984.11 | 70,251.22 | 48,078 | 447,850 | 157,874 | 167,308 |

There are differences in fishing productivity between handline, trolling line, purse seine, and pole and line. it is necessary to standardize productivity, in order to calculate the Fishing Power Index (FPI), which can be seen in Table 5.

Table 5

Productivity and Fishing Power Index (FPI) on *Katsuwonus pelamis*

| Year | Productivity (Ton trip$^{-1}$) | | | |
|---|---|---|---|---|
| | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* |
| 2008 | 0.3923 | 0.0228 | 0.0024 | 0.1028 |
| 2009 | 0.4275 | 0.0242 | 0.0030 | 0.1404 |
| 2010 | 0.2351 | 0.0277 | 0.0049 | 0.1326 |
| 2011 | 0.3264 | 0.0330 | 0.0021 | 0.8127 |
| 2012 | 0.2931 | 0.0363 | 0.0187 | 0.1702 |
| 2013 | 0.8218 | 0.0121 | 0.0280 | 0.1056 |
| 2014 | 0.3795 | 0.0754 | 0.0203 | 0.1809 |
| 2015 | 0.4233 | 0.0328 | 0.0484 | 0.1023 |
| 2016 | 0.4347 | 0.0348 | 0.0225 | 0.1258 |
| 2017 | 0.4752 | 0.0470 | 0.0272 | 0.1555 |
| 2018 | 0.4302 | 0.0434 | 0.0327 | 0.1493 |
| Average | 0.4217 | 0.0354 | 0.0191 | 0.1980 |
| Index | Purse seiner | Trolling liner | Handliner | Pole and liner |
| CPUE | 0.4217 | 0.0354 | 0.0191 | 0.1980 |
| FPI | 1 | 0.084 | 0.045 | 0.47 |

Based on Table 5, the purse seine is used as a standard fishing gear, because its productivity is greater than for other fishing gear. Furthermore, the standardization process is performed by multiplying the FPI with the effort numbers (trips) of each fishing gear to get a standard effort. The results that can be seen in Table 6.

The CPUE linear equation relationship derived from the effort and yield data (shown in Table 6) shows CPUE yearly fluctuations (Figure 6).

Table 6

Standardization of catching efforts for *Katsuwonus pelamis*

| Year | Purse seiner | Trolling liner | Hand liner | Pole and liner | Standard total effort | CPUE (Ton trip$^{-1}$) |
|---|---|---|---|---|---|---|
| 2008 | 23.419 | 35.935 | 5.593 | 74.053 | 139.000 | 0.2552 |
| 2009 | 21.373 | 32.962 | 11.252 | 57.901 | 123.488 | 0.2971 |
| 2010 | 43.622 | 39.854 | 14.103 | 66.189 | 163.768 | 0.2662 |
| 2011 | 35.888 | 36.378 | 8.670 | 11.855 | 92.790 | 0.5060 |
| 2012 | 42.027 | 36.355 | 10.258 | 46.145 | 134.784 | 0.3636 |
| 2013 | 32.010 | 45.023 | 8.459 | 102.065 | 187.557 | 0.3250 |
| 2014 | 39.017 | 17.579 | 13.300 | 43.468 | 113.364 | 0.4701 |
| 2015 | 34.787 | 41.984 | 3.866 | 88.180 | 168.818 | 0.3226 |
| 2016 | 41.596 | 41.757 | 9.280 | 77.798 | 170.431 | 0.3570 |
| 2017 | 38.453 | 32.467 | 8.687 | 69.622 | 149.229 | 0.4337 |
| 2018 | 48.078 | 37.611 | 7.151 | 78.557 | 171.397 | 0.4099 |

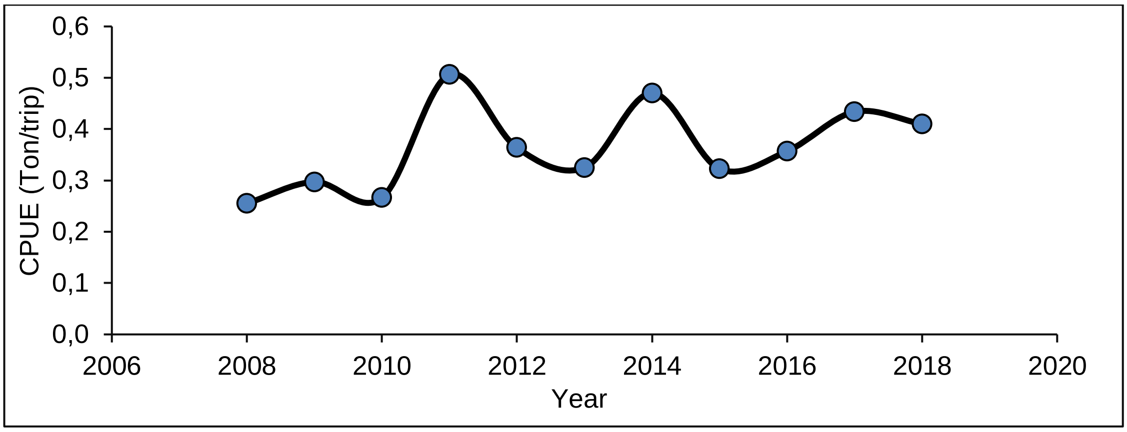


Figure 6. *Katsuwonus pelamis* CPUE fluctuations in the Banda Sea.

From Figure 6, it can be concluded that in 2011 there was the highest CPUE peak. The phenomenon of fluctuations in CPUE is strongly influenced by; (1) the size and number of vessels in operation, (2) type and size of fishing gear, (3) Illegal level, Unreported and Unregulated (IUU) fishing, (4) HR capabilities on board, (5) fishing ground location, (6) the number of fish captures landed (yield), (7) natural conditions during fishing operations and (8) the discipline of the fishing fleet with respect to the specified fishing ground (not fishing in waters that are not in accordance with the permit) (Aritonang et al 2021).

The relationship between CPUE and effort (Figure 7) shows that the estimation parameters for *K. pelamis*, the intercept (a) = 0.5731 and the slope (b) = -0.000001, form a Linear Schaefer equation CPUE = -0.000001x + 0.5731. This relationship can be interpreted that x supplementary units of effort (trips) per year will reduce the CPUE value by 0.000001 tons per year. The linear equation has a value of $R^2$= 0.24, which means that the effort's influence on the CPUE is of 24%. Thus, the value of $R^2$ (representing the influence of the variables used in this model) is statistically considered not strong enough.

MSY and EMSY calculation data for *K. pelamis* in the Banda Sea using the Schaefer Linear method are presented in Table 7. The results of biological analysis using the Schaefer Linear model approach can produce an MSY value of 57,837 tonnes with a standard effort/EMSY of 202,473 trips.

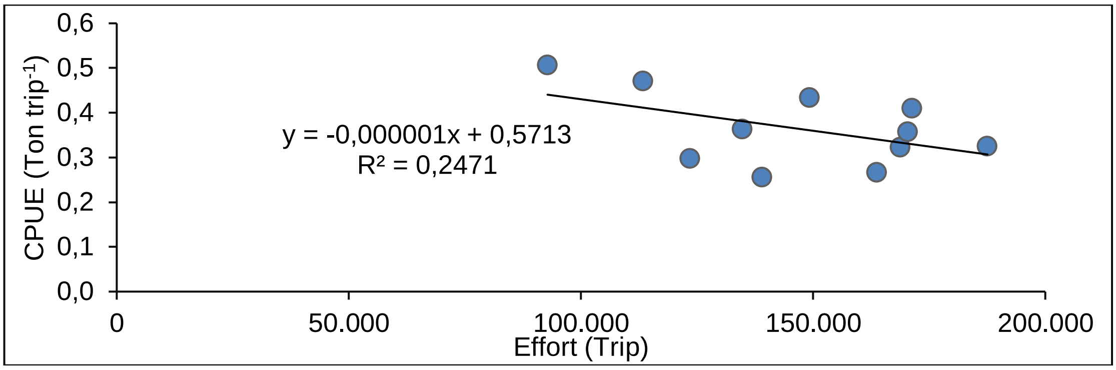


Figure 7. Linear equation of CPUE and effort *Katsuwonus pelamis*.

Table 7

MSY and EMSY estimation of *Katsuwonus pelamis* based on Schaefer linear model

| *Year* | *Catch number (Ton)* | *Total effort standard* | *CPUE (Schaefer)* |
|---|---|---|---|
| *I* | *Yi* | *X* | *Y* |
| 2008 | 35.477.7 | 139.000 | 0.2552 |
| 2009 | 36.686.7 | 123.488 | 0.2971 |
| 2010 | 43.597.1 | 163.768 | 0.2662 |
| 2011 | 46.954.8 | 92.790 | 0.5060 |
| 2012 | 49.002.4 | 134.784 | 0.3636 |
| 2013 | 60.965.5 | 187.557 | 0.3250 |
| 2014 | 53.294.3 | 113.364 | 0.4701 |
| 2015 | 54.454.8 | 168.818 | 0.3226 |
| 2016 | 60.844.5 | 170.431 | 0.3570 |
| 2017 | 64.719.4 | 149.229 | 0.4337 |
| 2018 | 70.251.2 | 171.397 | 0.4099 |
| Amount | 576.248.3662 | 1.614.628 | 4.0064 |
| Average value | 52.386.22 | 146.784 | 0.3642 |
| | Intercept a | | 0.57131 |
| | Slope b | | -0.000001 |
| | MSY Schaefer; -a^2/4b | | 57,837 |
| | E MSY Schaefer: -a/2b | | 202,473 |
| | Total Allowable Catch (TAC) 80% MSY | | 46,269.77 |

Based on the calculation of the linear model, biological overfishing has occurred in *K. pelamis* in the Banda Sea, which is indicated by the actual catch having passed MSY. This is evidenced by the actual catch in 2018 which reached 70,251.2 tons, exceeding the Total Allowable Catch (TAC) potential of 80% of the MSY value of 46,269.77 tons. The MSY *K. pelamis* curve can be seen in Figure 8.

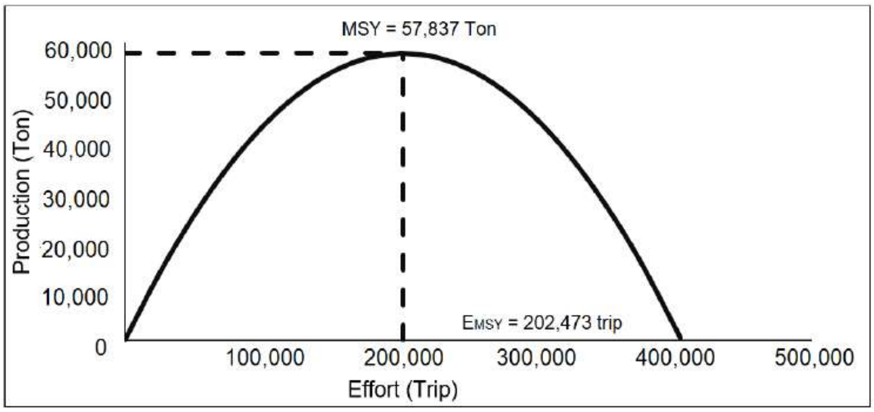


Figure 8. Stock balance curve (MSY) for *Katsuwonus pelamis.*

**Conclusions**. Biological aspects of *K. pelamis* in the Banda Sea show a positive allometric growth pattern. *K. pelamis* risks to be caught before spawning (Lc < Lm), resulting in an imbalance in natural stocks, since the fish caught have not yet spawned, therefore the recruitment can be disrupted. The fishery *K. pelamis* fisheries increase their production, with a low level of gear selectivity, so that there is a need for regulation of fishing gear and supervision. *K. pelamis* resources exploitation exceeds the maximum point of sustainable production and also the MEY, so that the profit decreases, as shown by the actual effort and production values.

**Conflict of interest**. The authors declare no conflict of interest.

**References**


Adnyani L. P., Nurmawati, Anggriani I., 2019 [Analysis of potential and utilization level of fish resources in Balikpapan waters. East Kalimantan]. Gorontalo Fisheries Journal 2(2):55-68. [In Indonesian].

Afifi M. A. M., El-Sadek A., El-Haddad K. M., 2022 First record of skipjack tuna (*Katsuwonus pelamis*) from Dahab in the Gulf of Aqaba. Red Sea. Egypt. Egyptian Journal of Aquatic Biology & Fisheries 26(3):699–710.

Afriliani W., Anna Z., Handaka A. A., Khan A. M. A., 2020 Typology of skipjack (*Katsuwonus pelamis*) fisheries at Nizam Zachman Oceanic Fishing Port. Jakarta. Indonesia. Asian Journal of Fisheries and Aquatic Research 7(2):39-50.

Andamari R., Hutapea J. R., Prisantoso B. I., 2012 [Reproduction aspects of the yellowfin tuna (*Thunnus albacares*)]. Journal of Tropical Marine Science and Technology 4(1):89-96. [In Indonesian].

Aritonang S. I. S., Jabbar M. A., Suharti R., Rahardjo P., Suyasa I. N., Zulkifli D., Sabariyah N., Bramana A., 2021 Fishing Season and Abundance of Scad Mackerel (*Decapterus russelli*) in Java Sea. Indonesian Fisheries Research Journal 27(4):179-186. [in Indonesian].

Bintoro G., Yulianto E. S., Lelono T. D., Prasetyo D. T., Rahman M. A., Sari W. K., 2022 Utilization status and bioeconomic performance of skipjack tuna (*Katsuwonus pelamis*) fishery in the south coast of Malang waters. East Java. Indonesia. IOP Conference Series: Earth and Environmental Science 1033:1-10.

Chakma S., Saha S., Hasan Md. N., Rahman Md. A., Akter M., Hoque Md. S., Ullah Md. R., Sujan K. M., Shahriar A., 2020 Effect of frozen storage on the biochemical. microbial and sensory attributes of Skipjack Tuna (*Katsuwonus pelamis*) fish loins. Journal of Applied Biology & Biotechnology 8(4):58-64.

Chodrijah U., 2011 [Several aspects of reproductive biology of yellowfin tuna *(Thunnus albacares)* from Banda Sea waters]. Proceedings of the 8th National Fish Seminar, pp. 401-409. [In Indonesian].

Chodrijah U., Nugraha B., 2013 [Size distribution of longline tuna catches and catching areas in Banda Sea Waters]. Indonesian Fisheries Research Journal 19(1):9-16. [In Indonesian].

Diningrum T. D. B., Triyono H., Jabbar M. A., 2019 [Biological aspects of skipjack tuna in southeast Celebes]. Journal of Fisheries and Maritime Extension 13(2):139-147. [In Indonesian].

Effendie M. I., 1979 [Fisheries biology method]. Dewi Sri Foundation, Bogor, 112 p. [In Indonesian].

Genti J. G., Marsoedi, Afandhi A., 2016 The utilization of skipjack tuna *Katsuwonus pelamis* (Linnaeus. 1758) availability for sustainable fisheries management in Prigi, East Java. Indonesian Journal of Environment and Sustainable Development 7(2):122-127.

Hidayat T., Chodrijah U., Noegroho T., 2014 [Characteristics of trolling fisheries in the Banda Sea]. Indonesian Fisheries Research Journal 20(1):43-51. [In Indonesian].

Hutajulu H., Imran Z., Budiharsono S., Kusumastanto T., 2019 Economic structure analysis in the development of skipjack tuna *(Katsuwonus pelamis)* fisheries industry in Jayapura City, Papua, Indonesia. AACL Bioflux 12(5):1726-1737

Hutomo M., Moosa M. K., 2005 Indonesian marine and coastal biodiversity: Present status. Indian Journal of Marine Sciences 34(1):88-97.
Jaleel A., Smith H. D., 2022 The Maldives tuna fishery: An example of best practice. Ocean Yearbook Online 36(1):314-345.
Jamal M., Sondita M. F. A., Haluan J., Wiryawan B., 2011 [Utilization of Skipjack Biological Data *(Katsuwonus pelamis)* in the Framework of Responsible Fisheries Management in the Waters of Bone Bay]. Journal of Indonesian Nature 14(1):107-113. [In Indonesian].
Jatmiko I., Hartaty H., Bahtiar A., 2015 [Reproductive biology of skipjack fish *(Katsuwonus pelamis)* in the Eastern Indian Ocean]. Bawal 7(2):87-94. [In Indonesian].
Karman A., Martasuganda S., Sondita M. F. A., Baskoro M. S., 2016 [Biological base of skipjack as the foundation for sustainable fisheries management in the North Maluku Province]. Journal of Tropical Marine Science and Technology 8(1):159-173. [In Indonesian].
Lintang C. J., Labaro I. L., Telleng A. T., 2012 [Study of the fishing season for tuna using handline fishing gear in the Maluku Sea]. Journal of Capture Fisheries Science and Technology 1(1):6-9. [In Indonesian].
Mahmud, Sinrang A. D. B., Massiseng A. N. A., 2021 Prospects of fisheries industry development in indonesia through online publication media. International Journal of Applied Biology 5(2):117-129.
Manik N., 2007 [Several aspects of the biology of skipjack tuna (*Katsuwonus pelamis*) in the waters around South Seram Island and Nusa Laut Island]. Oceanology and Limnology in Indonesia 33:17-25. [In Indonesian].
Manurung V. T., 2016 [Performance and Institutional Credit for Small-Scale Tuna Fishing Business in Eastern Indonesia]. The Agro-Economy Research Forum 16(2):60-74. [In Indonesian].
Mardlijah S., Pane A. R. P., Panggabean A. S., 2021 The stock status of skipjack tuna (*Katsuwonus pelamis*) in Tomini Bay and Its Surrounding Areas. Indonesia. IOP Conference Series: Earth and Environmental Science 934:1-9.
Mukhsin R., Mappigau P., Tenriawaru A. N., 2017 [The effect of entrepreneur’s orientation on the survival of small and medium enterprises of the fishery processing groups in Makassar City]. Journal of Analysis 6(2):188–193. [In Indonesian].
Noija D., Martasuganda S., Murdiyanto B., Taurusman A. A., 2014 [Potential and level of utilization of demersal fish resources in the waters of Ambon Island, Maluku Province]. Journal of Fisheries and Marine Technology 5(1):55-64. [In Indonesian].
Norungee D., Kawol D., 2011 Macroscopic study on some aspects of the reproductive biology of skipjack tuna (*Katsuwonus pelamis*) in the Western Indian Ocean. Indian Ocean Tuna Commission, 13th Working Party on Tropical Tunas, Maldives, 10 p.
Nugraha E., Yudho G. S., Jaenudin A., Yusrizal, Kusmedy B., Kusnidar A., Husen E. S., 2020 Relationship between length and weight of skipjack tuna (*Katsuwonus pelamis*) purse seine catching in the Maluku Sea. Indonesia. AACL Bioflux 13(1):330-345.
Ollé J., Vilà-Valls L., Alvarado-Bremer J., Cerdenares G., Duong T. Y., Hajjej G., Lino P. G., Muñoz-Lechuga R., Sow F. N., Diaha N. C., Araguas R. M., Sanz N., Viñas J., 2022 Population genetics meets phylogenetics: new insights into the relationships among members of the genus *Euthynnus (family Scombridae).* Hydrobiologia 849:47–62.
Paulangan Y. P., Rumbiak K., Barapadang B., 2020 Fishing season and participatory mapping of the fishing ground of target fish in Depapre Bay. Jayapura Regency. Papua Indonesia. IOP Conference Series: Earth and Environmental Science 584:1-8.
Satrioajie W. N., Suyadi, Syahailatua A., Wouthuyzen S., 2018 The importance of the Banda Sea for tuna conservation area: A review of studies on the biology and the ecology of tuna. IOP Conference Series: Earth and Environmental Science. 184:1-11.
Senen B., Sulistiono S., Ismudi M., 2011 [Biological aspects of the flying catfish (*Decapterus macrosoma*) in Banda Neira waters. Maluku. Indonesia]. Agricultural Journal UMMI 1:35-40. [In Indonesian].
Simbolon D., Wiryawan B., Wahyuningrum P. I., Wahyudi H., 2011 [Utilization level and seasonal patterns of fishing for lemuru in the Bali Strait waters. Bulletin PSP 19(3):293-307. [In Indonesian].

Sparre P., Ursine E., Venema S. C., 1989 Introduction to tropical fish stock assessment Part 1. Manual, FAO Fisheries Technical paper. No. 306.1 Rome, FAO p. 337.
Sparre P., Venema S. C., 1999 Introduction to tropical fish stock assessment. Part 1. FAO Fishing Technology Paper No.306/1.Rev.2. Rome, FAO, 407 p.
Sugara A., Nolisa A., Anggoro A., Suci A. N. N., Suhendri R., 2022 [Diversity Species Identification of fish catched by fishermen Tapak Paderi Bengkulu City]. Samakia: Journal of Fisheries Science 13(1):1-7. [In Indonesian].
Tadjuddah M., Anadi L., Mustafa A., Arami H., Abdullah, Kamri S., Wianti N. I., 2017 Growth pattern and size structure of skipjack tuna caught in Banda Sea. Indonesia. AACL Bioflux 10(2):227-233.
Tangke U., 2014 [Estimation of pelagic fishing area based on sea surface temperature and chlorophyll-a approaches in the Maluku Sea]. Scientific Journal of Agribusiness and Fisheries (AGRIKAN UMMU-Ternate) 7(1):74–81. [In Indonesian].
Udupa K. S., 1986 Statistical method of estimating the size at first maturity offishes. Fishbyte 4(2):8-10.
Widodo A. A., Nugraha B., 2009 [Kendari-based tuna fishery. Southeast Sulawesi]. BAWAL 299–307. [In Indonesian].
Yaskun M., Sugiarto E., 2017 [Analysis of the potential of marine fisheries products on the welfare of fishermen and the community in Lamongan Regency]. EKBIS Journal 17(1):867-875. [In Indonesian].

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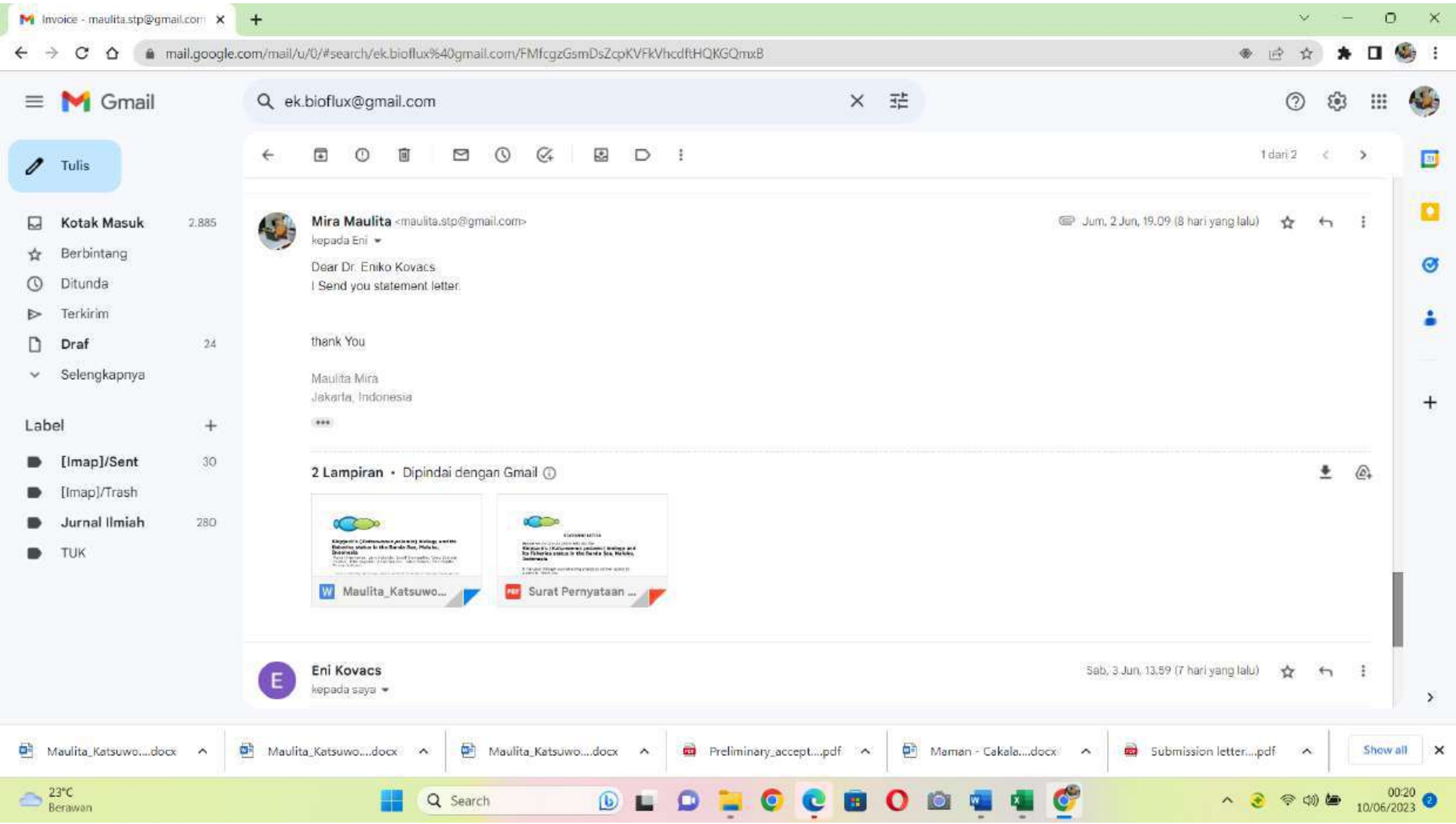
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**STATEMENT LETTER**

Hereby we declare our article with the title:

**Skipjack's (*Katsuwonus pelamis*) biology and its fisheries status in the Banda Sea, Maluku, Indonesia**

It has gone through several editing processes and we agreed to publish it. Thank you.

Author,

Maman Hermawan Ratna Suharti Danu Sudrajat Yusrizal

Firman Setiawan Jerry Hutajulu Syarif Syamsuddin

Erick Nugraha Mira Maulita (Corresponding author) Aman Saputra

Date: June 02, 2023

# Skipjack's (*Katsuwonus pelamis*) biology and its fisheries status in the Banda Sea, Maluku, Indonesia

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**Abstract**. *Katsuwonus pelamis* fish is a marine biological resource that has a quite high economic value in Indonesia. A potential fishing ground for large pelagic fish in eastern Indonesia is the Banda Sea. This study aimed to examine the aspects of biology and the management of *K. pelamis* exploitation in the Maluku region. The research was conducted in Maluku province for 90 days starting from March 4th to May 25th 2019. The method used was the purposive sampling and the data collected were primary data and secondary data. *K. pelamis* in the Banda Sea had a maximum sustainable yield (MSY) value of 57,837 tons with a fishing effort of 202,473 trips and the maximum economic yield (MEY) value was at 48,866 tons for a fishing effort of 122,732 trips. The study provided data on the frequency distribution of *K. pelamis* with the shortest fork length (FL) being 28.5 cm and the longest being 77.3 cm. The calculation of the growth pattern of large pelagic fish was carried out using the $t_{test}$ ($t_{count}$=0.05 tab) at a 95% confidence interval (α=0.05). The growth pattern obtained for *K. pelamis* was positive allometric. The sex ratio obtained was 1 male:1 female. The level of gonadal maturity was dominated by GML II (39%). *K. pelamis* caught with the purse seine have the first caught size (Lc=40.12 cm) > size at first maturity (Lm=44.81 cm). The actual catch of 70,251 tons showed that the species utilization has exceeded the maximum value of sustainable potential and, economically, the catch of *K. pelamis* has passed the MEY condition. The *K. pelamis* fisheries increase their production, with a low level of gear selectivity, so that there is a need for regulation of fishing gear and supervision.
**Key Words**: sex ratio, fork length, total weight, gonadal maturity level.

**Introduction**. Indonesian waters are considered to have living fish resources with the highest level of biodiversity (Sugara et al 2022; Yaskun & Sugiarto 2017; Hutomo & Moosa 2005). These resources cover at least 37% of the world's fish species (Mahmud et al 2021; Adnyani et al 2019). The resources of Skipjack (*Katsuwonus pelamis*) are grouped into large pelagic fish resources, including tuna (*Thunnus* sp.) and mackerel (*Euthynnus affinis*) (Jakson et al 2014; Bintoro et al 2022; Lintang et al 2012). *K. pelamis* are fishery products of interest for the general consumers and of a high economic value (Hutajulu et al 2019; Afriliani et al 2020; Genti et al 2016). Waters in eastern Indonesia are known as centers of *K. pelamis* production (Manurung 2016). One of the waters that has become a potential fishing ground for large pelagic fish in Eastern Indonesia is the Banda Sea (Hidayat et al 2014). The Banda Sea is the waters of the Eastern Indonesian Region which is included in the waters of the West Pacific Ocean and is bordered by the Indian Ocean (Chodrijah & Nugraha 2013). The Banda Sea became a potential fishing area for *K. pelamis* in Maluku Province (Tadjuddah et al 2017; Satrioajie et al 2018) throughout the year (Tangke et al 2014).

*K. pelamis* is a type of fish that belongs to the Scrombidae family (Afifi et al 2022; Mardlijah et al 2021; Chakma et al 2020). The Scrombidae family basically occurs in marine waters and is classified as pelagic fish (Ollé et al 2022; Paulangan et al 2020). Based on

their size, tuna is divided into two groups: *Thunnus* species are grouped into large tuna and *K. pelamis* species are classified as small tuna (Nugraha et al 2020; Chodrijah 2011). Exploitation of this resource is carried out by various forms of fishing activities, including purse seine, pole and line and handline (Jaleel & Smith 2022; Mardlijah et al 2021; Widodo & Nugraha 2009). Due to the magnitude of the potential and to the condition of the available large pelagic fish resources, it is necessary to study the status of large pelagic fisheries, especially those targeting *K. pelamis* in the Banda Sea.

This study aimed to examine several aspects of *K. pelamis* including: a) biological aspects, in particular the length-weight relationship, b) fisheries characteristics, including production trends, fishing effort, fishing grounds, fishing season, fishing gear and CPUE and c) the management of the *K. pelamis* populations ant their exploitation, which includes the calculation of the catch rate, maximum sustainable yield, maximum economic yield, and the number of allowed catches in the Maluku region.

## Material and Method

***Research sites***. The research was conducted for 90 days, from 4 March to 25 May 2019 in the Banda Sea. Data collection was carried out at several sampling points as shown in Figure 1.

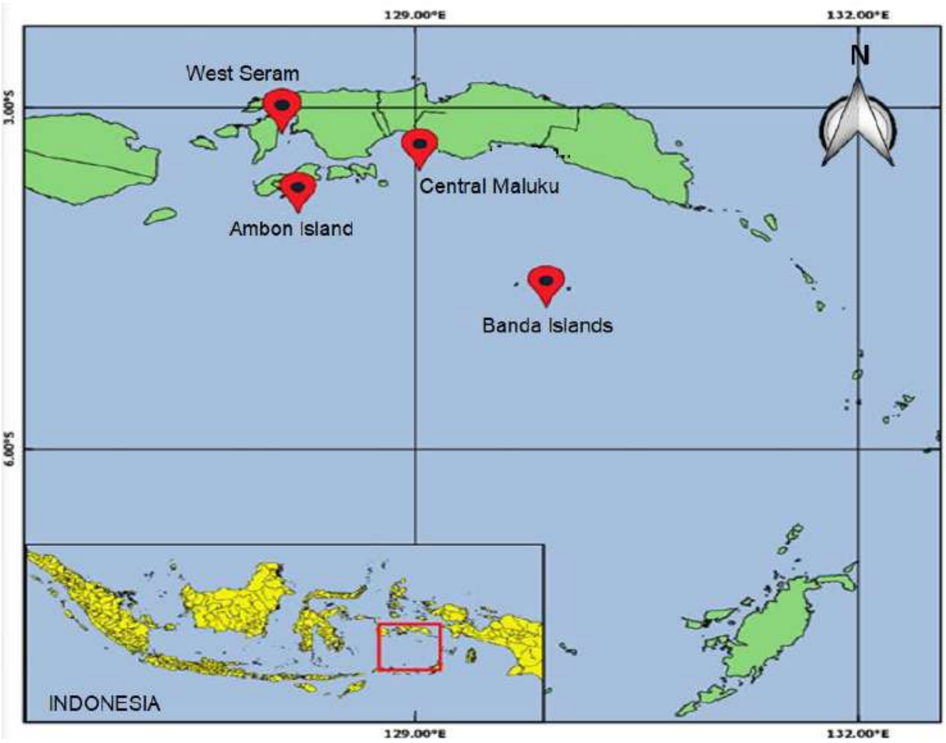

Figure 1. Map of research locations.

The tools and materials used in this study are as follows: ruler, tape measure, digital scales, camera, stationery, identification label, and several samples of *K. pelamis.*

***Data retrieval method***. In this study a survey method was used, namely by observing fish samples in the field. Determination of locations and fishing gear was carried out by purposive sampling, namely by collecting data deliberately according to the desired conditions (Mukhsin et al 2017), while the determination of respondents was carried out by accidental sampling. Data collection for *K. pelamis* sampling was carried out using the simple random sampling method, by measuring the fork length, total weight, sex and gonadal maturity level of 10% of the total catch. Secondary data were periodic data (time series) of catches and fishing effort for 5 to 10 years.

***Length frequency distribution***. Frequency distribution was obtained by determining the class interval, median class and frequency in each length group. The length frequency distribution that has been determined with the same class intervals can then be put in a diagram to show the results.

***Length-weight relationship***. The model used in estimating the relationship between length and weight is an exponential relationship with the following equation (Andamari et al 2012):

$$W = aL^b$$

Where:
W - weight of fish (g);
L - standard fish fork length (cm);
A - the constant number or intercept of the regression calculation;
B - exponent or tangential angle.

To determine the value of a and b, a linear regression analysis is needed by considering the logarithm of the formula above. The linear equation becomes:

$$Ln\ W = Ln\ a + b\ Ln\ L$$

Then a simple linear equation can be made:

$$Y = a + bX$$

Where:
Y - dependent variable;
X - free change;
a' - antilog intercept;
b - slope (slope).

The b values, b<3, b=3 and b>3, according to Effendie (1979), discriminate among the allometric type, as follows:

1) If b<3, then the increase in length is faster than the increase in weight; it is called negative allometric
2) If b>3, then the weight gain is faster than the increase in length; it is called positive allometric
3) If b=3, then the increase in length and weight gain are balanced, which is called isometric

***Sex ratio***. Comparison of the sex of the biota was carried out by visual observation of a number of male and female individuals obtained as samples at the study site. The sex ratio is calculated using the formula (Diningrum et al 2019):

$$X(\%) = \frac{X}{(X+Y)} \times 100$$

$$Y(\%) = \frac{Y}{(X+Y)} \times 100$$

Where:
X - number of male fish;
Y - number of female fish.

After the sex ratio in percentage is obtained, comparisons are carried out to find out whether there is a significant difference between the male and female population, by using the '$X^2$' (chi square) test, with the formula (according to Effendie 1979):

$$X^2 = \frac{(fo-fh)^2}{fh}$$

Where:
$X^2$ - chi square;

$f_0$ - observed biota frequency;
$f_h$ - expected biota frequency.

The $X^2_{count}$ value is obtained from this calculation, then the value is compared with the table of $X^2_{table}$ value, with a 95% confidence level and the degrees of freedom (db) = 1, with the hypothesis:
$H_0$ = no significant difference between the number of male and female fish
$H_1$ = there is a significant difference between the number of male and female fish
If, $X^2_{count} < X^2_{table}$ = $H_0$ is accepted, $H_1$ is rejected
$X^2_{count} > X^2_{table}$ = $H_0$ is rejected, $H_1$ is accepted

***Gonad Maturity Level (GML)***. GML was determined by visual observation of the gonadal morphology. Furthermore, the observed characteristics are adjusted to the characteristics of the level of maturity.

***Size at first maturity (Lm)***. The value of Lm can be estimated by the Soerman-Karber formula proposed by Udupa (1986), as follows:

$$m = xk + \frac{d}{2} - (X \sum Pi)$$

$$M = \text{antilog } (m \pm 1{,}96 \sqrt{x^2 \Sigma \frac{pi*qi}{n_i - 1}})$$

Where:
m - logarithm of the length class at first maturity;
d - difference in the logarithm of the increase in the median length;
k - number of length classes;
xk - logarithm of the median length, where the fish is 100% at gonadal maturity (or where $p_i = 1$);
$p_i$ - proportion of mature fish in the $i^{th}$ length class, related to the number of fish in the length interval i;
$n_i$ - number of fish in the $i^{th}$ class of length;
$q_i$ - 1 – $p_i$;
M - length of fish at first maturity equal to the anti-log m (if $\propto = 0.05$, then the confidence interval of m is 95%).

***First caught size (Lc)***. The size of Lc is estimated by the method of Sparre & Venema (1999):

$$SL = \frac{1}{a + \exp\ (a - bL)}$$

The Lc value is obtained by plotting the cumulative frequency percentage of fish caught with a standard length, where the intersection point between the 50% cumulative frequency curve is the length of 50% of the catch. The Lc value can be calculated through the formula (Sparre et al 1989):

$$Lc = \frac{-a}{b}$$

***Catch Per Unit Effort (CPUE)***. Catch data and fishing effort obtained are then tabulated to determine the CPUE. The fishing effort can be in the form of operating days or months of operation, the number of fishing trips or the number of fleets conducting fishing operations. In this study the fishing effort (effort) used is the number of trips. The formula that can be used to determine the CPUE value is as follows (Noija et al 2014):

$$CPUE_i = \frac{Catch_i}{Effort_i}$$

Where:
$CPUE_i$ - catch per unit of fishing effort in year i (tonnes/unit);
$Catch_i$ - catch in year i (tons);
$Effort_I$ - fishing effort in year i (trip).

**Results and discussion**

***Length frequency distribution of K. pelamis***. Based on the results of observations of 1022 samples of *K. pelamis*, length frequency distribution data was obtained, with the shortest size being 28.5 cm and the longest being 77.3 cm. The distribution of fish length during the observation is presented in Figure 2.

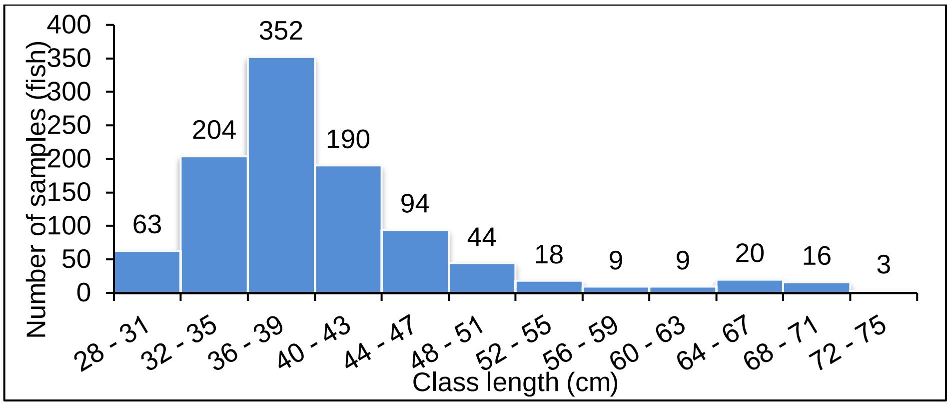

Figure 2. Long frequency distribution of *Katsuwonus pelamis.*

Overall, the mode of the sample was found in the class of 36–39.9 cm, due to the use of Fish Aggregating Devices (FADs) which causes the capture of many specimens with small or immature gonads.

***Length-weight relationship in K. pelamis***. The relationship between length and weight obtained is presented in Figure 3, according to the characteristics of the fish growth pattern.

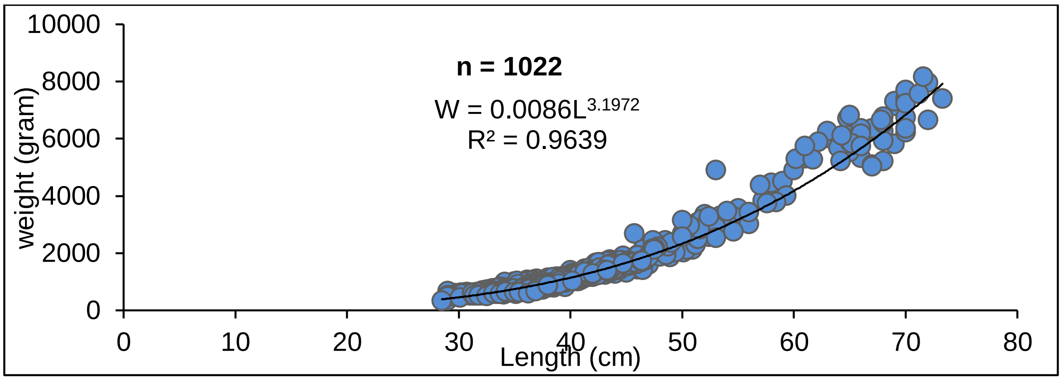

Figure 3. The relationship between the length and weight of *Katsuwonus pelamis.*

From the length-weight relationship it resulted that the length-weight relationship of *K. pelamis* is $W = 0.0086L^{3.1972}$, with a value of b = 3.1972. Then from a t test performed on the value of b, at a 95% confidence interval, it resulted $t_{count} > t_{table}$ ($t_{count} = 10.1975$; $t_{table} = 1.962$), which means that the increase rates in length and weight were significantly different or the increase in length is not proportional to the increase in weight. The value b = 3.1972 it showed a positive allometric growth pattern, where the weight gain is faster than the increase in length.

Calculation of the growth pattern of *K. pelamis* using the $t_{test}$ ($t_{count} = 0.05$) at a 95% confidence interval (α=0.05) showed that by producing a coefficient of determination

(R) of 0.9818 shows a correlation coefficient (r) close to 1. This also shows that the increase in length will affect weight gain by showing that the correlation or relationship between length and fish weight is close and positive.

***Sex ratio of K. pelamis***. The observed sample of 100 *K. pelamis*, of which 51 male fish (51%) and 49 female fish (49%), had a sex ratio of 1:1. According to Senen et al (2011), a balanced sex ratio also indicates that one male fish will fertilize one female fish. The number of female fish is a determinant of the sustainability of a population because during the mating season there will be a high competition, so that the natural mortality of males is higher. The sex ratio of *K. pelamis* is presented in Figure 4.

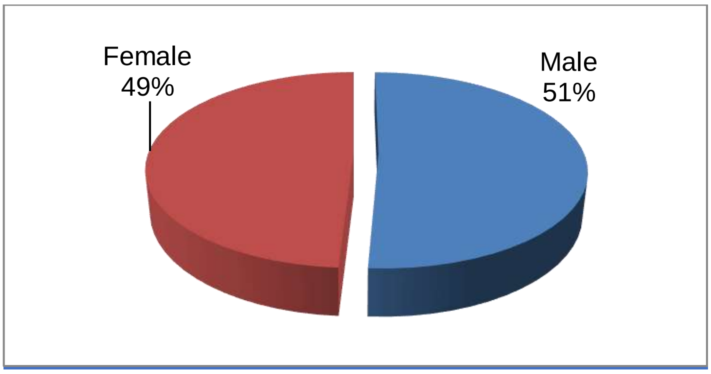


Figure 4. Sex ratio of *Katsuwonus pelamis.*

To find out the accuracy of whether the comparison is balanced or not, it is necessary to calculate the sex ratio using the chi-square test presented in Table 1.

Table 1

*Sex ratio Katsuwonus pelamis*

| *Sex* | *N* | $t_{count}$ | $t_{table}$ |
|---|---|---|---|
| Male<br>Female | 51<br>49 | 0.040 | 3.84 |

The results of the chi-square test are $t_{count}$=0.040 and $t_{table}$=3.84, so that $t_{count} < t_{table}$ and $H_0$ is accepted, which means there is no real difference between the male and female populations of *K. pelamis.*

***Gonad maturity level of K. pelamis***. The level of maturity of the male gonads can be seen from the size and color of the gonads, while in the female gonads it can be seen from the gonads' size and color and from the presence or absence of eggs in the gonads. The results of gonadal observations can be seen in Table 2.

Table 2

Percentage of gonad maturity level of *Katsuwonus pelamis*

| *Sex* | *Amount (N)* | *GML (%)* | | | |
|---|---|---|---|---|---|
| | | *I* | *II* | *III* | *IV* |
| Male | 51 | 41.18 | 31.37 | 19.61 | 7.84 |
| Female | 49 | 26.53 | 46.94 | 18.37 | 8.16 |
| Combined | 100 | 34 | 39 | 19 | 8 |

For male fish, the number of mature gonads was 27.45% and 72.55% were immature. For female fish, the number of mature gonads was 26.53% and 83.47% were immature. Overall (males and females), the number of mature fish was 27% and 73%

were immature. This indicates that more fish are caught before the gonads maturity, suggesting that the fish have not yet had time to spawn, which affects the recruitment in the fishing area.

***Length at first maturity (Lm)***. From the observations on the level of gonad maturity and length size distribution against 100 *K. pelamis*, it resulted that the length at first maturity of the gonads was 44.81 cm. By using a 95% confidence level, the confidence interval for size prediction at maturity of gonads is 43.39-46.28 cm. For comparison, the Lm of *K. pelamis* recorded at other locations are presented in Table 3.

Table 3

Lm of *Katsuwonus pelamis* at other locations

| *Lm value (FL)(cm)* | *Research location* | *Source* |
|---|---|---|
| 42.8 | South Seram island waters | Manik (2007) |
| 42.9 | Eastern Indian Ocean Waters | Jatmiko et al (2015) |
| 43 | West and South waters of North Maluku | Karman et al (2016) |
| 43 | West Indian Ocean Waters | Norungee & Kawol (2011) |
| 46.5 | Bay of Bone, South Sulawesi | Jamal et al (2011) |

***Length at first capture (Lc)***. Calculation of Lc is done by using data on the length distribution and the number of fish in the purse seine. Based on observation of 226 fish caught by purse seine, it was found that the length of the first caught was 40.12 cm. Lc of *K. pelamis* is presented in Figure 5.

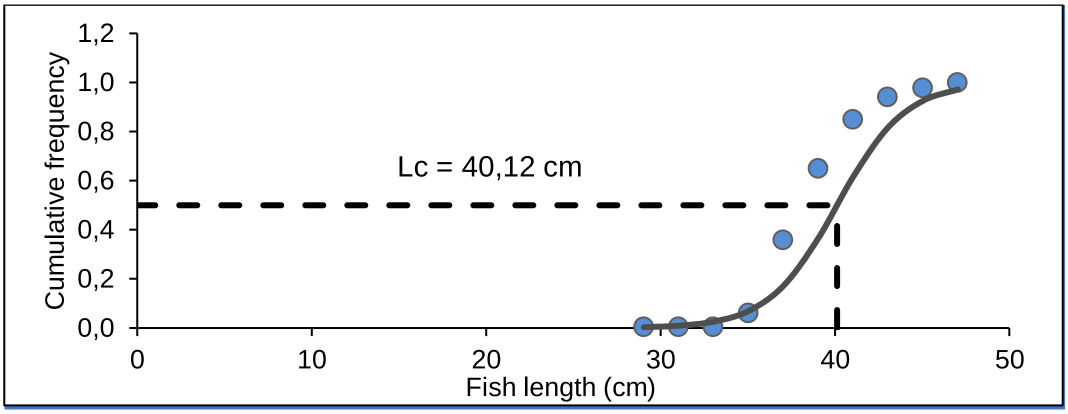


Figure 5. Lc *Katsuwonus pelamis* on a purse seine.

Then a comparison was made between the values of Lm and Lc, showing that for the fish caught by the purse seine has a value Lc<Lm and it was captured before spawning, which is thought to cause a significant decrease in the population of *K. pelamis.*

***Catch per Unit Effort (CPUE) and Maximum Sustainable Yield (MSY)***. Production and fishing efforts of *K. pelamis* in the Banda Sea are carried out using 4 types of fishing gear including handline, troll line, purse seine and pole and line. Production and effort of catching *K. pelamis* can be seen in Table 4.

Table 4

Production and catching efforts of *Katsuwonus pelamis* in the Banda Sea

| Year | Production (T) | | | | | Trips | | | |
|---|---|---|---|---|---|---|---|---|---|
| | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* | *Total* | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* |
| 2008 | 9,186.63 | 9,775.52 | 301.40 | 16,214.11 | 35,477.65 | 23,419 | 427,899 | 123,472 | 157,717 |
| 2009 | 9,137.30 | 9,491.48 | 745.91 | 17,312.00 | 36,686.68 | 21,373 | 392,497 | 248,406 | 123,316 |
| 2010 | 10,253.94 | 13,137.78 | 1,516.36 | 18,689.02 | 43,597.11 | 43,622 | 474,562 | 311,339 | 140,968 |
| 2011 | 11,712.66 | 14,313.94 | 408.27 | 20,519.92 | 46,954.79 | 35,888 | 433,171 | 191,396 | 25,248 |
| 2012 | 12,318.24 | 15,724.01 | 4,232.45 | 16,727.68 | 49,002.38 | 42,027 | 432,897 | 226,447 | 98,277 |
| 2013 | 26,305.18 | 6,484.45 | 5,226.45 | 22,949.42 | 60,965.51 | 32,010 | 536,119 | 186,753 | 217,374 |
| 2014 | 14,806.04 | 15,786.37 | 5,952.18 | 16,749.75 | 53,294.35 | 39,017 | 209,321 | 293,614 | 92,577 |
| 2015 | 14,726.79 | 16,392.38 | 4,127.07 | 19,208.60 | 54,454.84 | 34,787 | 499,933 | 85,352 | 187,803 |
| 2016 | 18,079.96 | 17,311.33 | 4,616.49 | 20,836.71 | 60,844.49 | 41,596 | 497,222 | 204,868 | 165,692 |
| 2017 | 18,272.12 | 18,172.17 | 5,210.66 | 23,064.41 | 64,719.36 | 38,453 | 386,606 | 191,767 | 148,278 |
| 2018 | 20,681.51 | 19,426.73 | 5,158.88 | 24,984.11 | 70,251.22 | 48,078 | 447,850 | 157,874 | 167,308 |

There are differences in fishing productivity between handline, trolling line, purse seine, and pole and line. it is necessary to standardize productivity, in order to calculate the Fishing Power Index (FPI), which can be seen in Table 5.

Table 5

Productivity and Fishing Power Index (FPI) on *Katsuwonus pelamis*

| Year | *Productivity (Ton trip$^{-1}$)* | | | |
|---|---|---|---|---|
| | *Purse seiner* | *Trolling liner* | *Handliner* | *Pole and liner* |
| 2008 | 0.3923 | 0.0228 | 0.0024 | 0.1028 |
| 2009 | 0.4275 | 0.0242 | 0.0030 | 0.1404 |
| 2010 | 0.2351 | 0.0277 | 0.0049 | 0.1326 |
| 2011 | 0.3264 | 0.0330 | 0.0021 | 0.8127 |
| 2012 | 0.2931 | 0.0363 | 0.0187 | 0.1702 |
| 2013 | 0.8218 | 0.0121 | 0.0280 | 0.1056 |
| 2014 | 0.3795 | 0.0754 | 0.0203 | 0.1809 |
| 2015 | 0.4233 | 0.0328 | 0.0484 | 0.1023 |
| 2016 | 0.4347 | 0.0348 | 0.0225 | 0.1258 |
| 2017 | 0.4752 | 0.0470 | 0.0272 | 0.1555 |
| 2018 | 0.4302 | 0.0434 | 0.0327 | 0.1493 |
| Average | 0.4217 | 0.0354 | 0.0191 | 0.1980 |
| Index | Purse seiner | Trolling liner | Handliner | Pole and liner |
| CPUE | 0.4217 | 0.0354 | 0.0191 | 0.1980 |
| FPI | 1 | 0.084 | 0.045 | 0.47 |

Based on Table 5, the purse seine is used as a standard fishing gear, because its productivity is greater than for other fishing gear. Furthermore, the standardization process is performed by multiplying the FPI with the effort numbers (trips) of each fishing gear to get a standard effort. The results that can be seen in Table 6.

The CPUE linear equation relationship derived from the effort and yield data (shown in Table 6) shows CPUE yearly fluctuations (Figure 6).

Table 6

Standardization of catching efforts for *Katsuwonus pelamis*

| *Year* | *Purse seiner* | *Trolling liner* | *Hand liner* | *Pole and liner* | *Standard total effort* | *CPUE (Ton trip$^{-1}$)* |
|---|---|---|---|---|---|---|
| 2008 | 23.419 | 35.935 | 5.593 | 74.053 | 139.000 | 0.2552 |
| 2009 | 21.373 | 32.962 | 11.252 | 57.901 | 123.488 | 0.2971 |
| 2010 | 43.622 | 39.854 | 14.103 | 66.189 | 163.768 | 0.2662 |
| 2011 | 35.888 | 36.378 | 8.670 | 11.855 | 92.790 | 0.5060 |
| 2012 | 42.027 | 36.355 | 10.258 | 46.145 | 134.784 | 0.3636 |
| 2013 | 32.010 | 45.023 | 8.459 | 102.065 | 187.557 | 0.3250 |
| 2014 | 39.017 | 17.579 | 13.300 | 43.468 | 113.364 | 0.4701 |
| 2015 | 34.787 | 41.984 | 3.866 | 88.180 | 168.818 | 0.3226 |
| 2016 | 41.596 | 41.757 | 9.280 | 77.798 | 170.431 | 0.3570 |
| 2017 | 38.453 | 32.467 | 8.687 | 69.622 | 149.229 | 0.4337 |
| 2018 | 48.078 | 37.611 | 7.151 | 78.557 | 171.397 | 0.4099 |

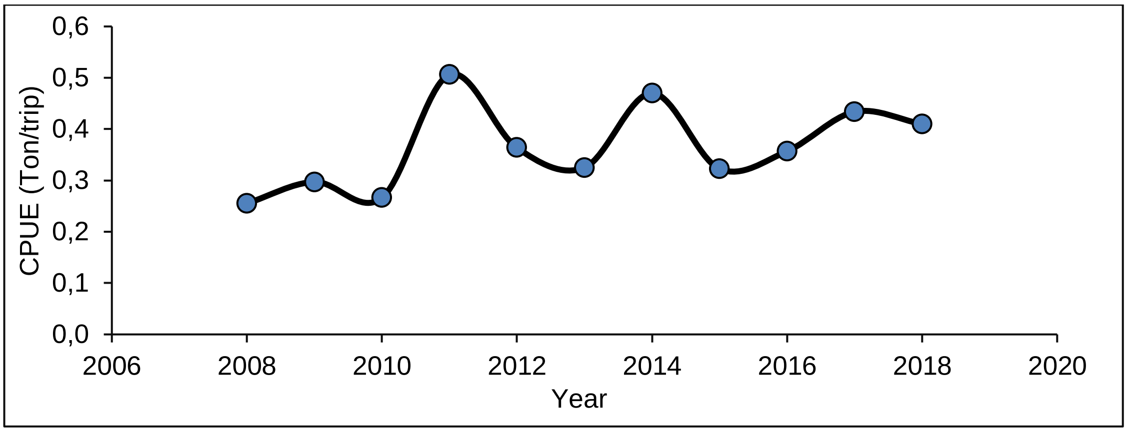


Figure 6. *Katsuwonus pelamis* CPUE fluctuations in the Banda Sea.

From Figure 6, it can be concluded that in 2011 there was the highest CPUE peak. The phenomenon of fluctuations in CPUE is strongly influenced by; (1) the size and number of vessels in operation, (2) type and size of fishing gear, (3) Illegal level, Unreported and Unregulated (IUU) fishing, (4) HR capabilities on board, (5) fishing ground location, (6) the number of fish captures landed (yield), (7) natural conditions during fishing operations and (8) the discipline of the fishing fleet with respect to the specified fishing ground (not fishing in waters that are not in accordance with the permit) (Aritonang et al 2021).

The relationship between CPUE and effort (Figure 7) shows that the estimation parameters for *K. pelamis*, the intercept (a) = 0.5731 and the slope (b) = -0.000001, form a Linear Schaefer equation CPUE = -0.000001x + 0.5731. This relationship can be interpreted that x supplementary units of effort (trips) per year will reduce the CPUE value by 0.000001 tons per year. The linear equation has a value of $R^2$= 0.24, which means that the effort's influence on the CPUE is of 24%. Thus, the value of $R^2$ (representing the influence of the variables used in this model) is statistically considered not strong enough.

MSY and EMSY calculation data for *K. pelamis* in the Banda Sea using the Schaefer Linear method are presented in Table 7. The results of biological analysis using the Schaefer Linear model approach can produce an MSY value of 57,837 tonnes with a standard effort/EMSY of 202,473 trips.

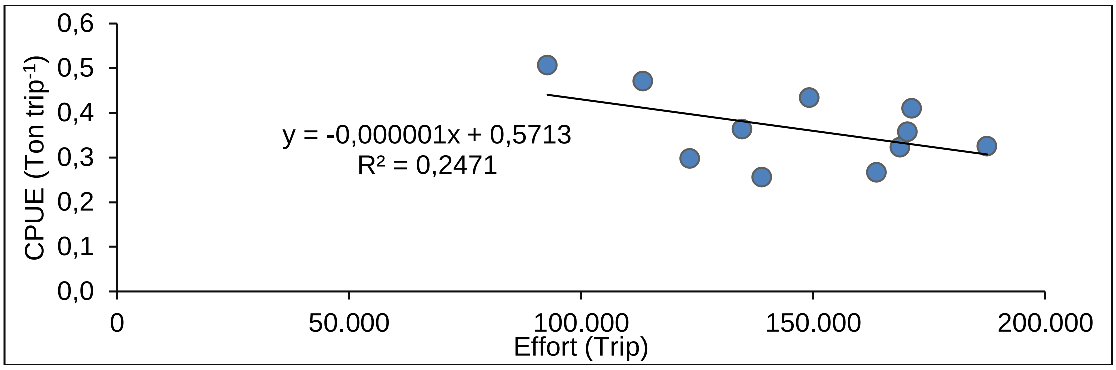

Figure 7. Linear equation of CPUE and effort *Katsuwonus pelamis*.

Table 7

MSY and EMSY estimation of *Katsuwonus pelamis* based on Schaefer linear model

| *Year* | *Catch number (Ton)* | *Total effort standard* | *CPUE (Schaefer)* |
|---|---|---|---|
| *I* | *Yi* | *X* | *Y* |
| 2008 | 35.477.7 | 139.000 | 0.2552 |
| 2009 | 36.686.7 | 123.488 | 0.2971 |
| 2010 | 43.597.1 | 163.768 | 0.2662 |
| 2011 | 46.954.8 | 92.790 | 0.5060 |
| 2012 | 49.002.4 | 134.784 | 0.3636 |
| 2013 | 60.965.5 | 187.557 | 0.3250 |
| 2014 | 53.294.3 | 113.364 | 0.4701 |
| 2015 | 54.454.8 | 168.818 | 0.3226 |
| 2016 | 60.844.5 | 170.431 | 0.3570 |
| 2017 | 64.719.4 | 149.229 | 0.4337 |
| 2018 | 70.251.2 | 171.397 | 0.4099 |
| Amount | 576.248.3662 | 1.614.628 | 4.0064 |
| Average value | 52.386.22 | 146.784 | 0.3642 |
| | Intercept a | | 0.57131 |
| | Slope b | | -0.000001 |
| | MSY Schaefer; -a^2/4b | | 57,837 |
| | E MSY Schaefer: -a/2b | | 202,473 |
| | Total Allowable Catch (TAC) 80% MSY | | 46,269.77 |

Based on the calculation of the linear model, biological overfishing has occurred in *K. pelamis* in the Banda Sea, which is indicated by the actual catch having passed MSY. This is evidenced by the actual catch in 2018 which reached 70,251.2 tons, exceeding the Total Allowable Catch (TAC) potential of 80% of the MSY value of 46,269.77 tons. The MSY *K. pelamis* curve can be seen in Figure 8.

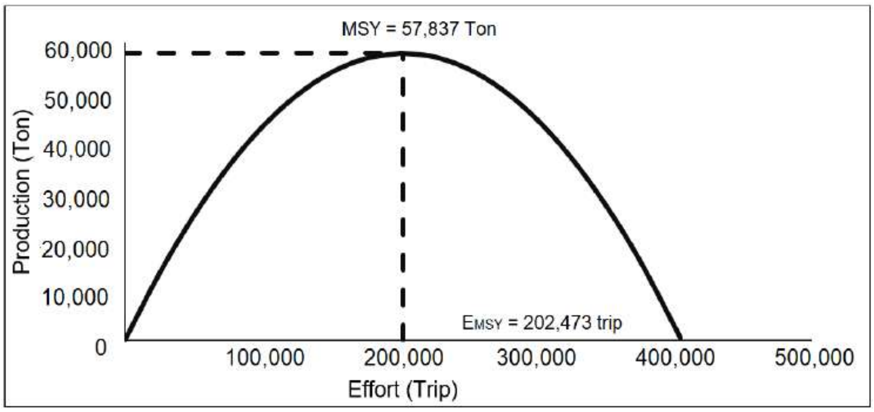

Figure 8. Stock balance curve (MSY) for *Katsuwonus pelamis.*

**Conclusions**. Biological aspects of *K. pelamis* in the Banda Sea show a positive allometric growth pattern. *K. pelamis* risks to be caught before spawning (Lc < Lm), resulting in an imbalance in natural stocks, since the fish caught have not yet spawned, therefore the recruitment can be disrupted. The fishery *K. pelamis* fisheries increase their production, with a low level of gear selectivity, so that there is a need for regulation of fishing gear and supervision. *K. pelamis* resources exploitation exceeds the maximum point of sustainable production and also the MEY, so that the profit decreases, as shown by the actual effort and production values.

**Conflict of interest**. The authors declare no conflict of interest.

**References**


Adnyani L. P., Nurmawati, Anggriani I., 2019 [Analysis of potential and utilization level of fish resources in Balikpapan waters. East Kalimantan]. Gorontalo Fisheries Journal 2(2):55-68. [In Indonesian].

Afifi M. A. M., El-Sadek A., El-Haddad K. M., 2022 First record of skipjack tuna (*Katsuwonus pelamis*) from Dahab in the Gulf of Aqaba. Red Sea. Egypt. Egyptian Journal of Aquatic Biology & Fisheries 26(3):699–710.

Afriliani W., Anna Z., Handaka A. A., Khan A. M. A., 2020 Typology of skipjack (*Katsuwonus pelamis*) fisheries at Nizam Zachman Oceanic Fishing Port. Jakarta. Indonesia. Asian Journal of Fisheries and Aquatic Research 7(2):39-50.

Andamari R., Hutapea J. R., Prisantoso B. I., 2012 [Reproduction aspects of the yellowfin tuna (*Thunnus albacares*)]. Journal of Tropical Marine Science and Technology 4(1):89-96. [In Indonesian].

Aritonang S. I. S., Jabbar M. A., Suharti R., Rahardjo P., Suyasa I. N., Zulkifli D., Sabariyah N., Bramana A., 2021 Fishing Season and Abundance of Scad Mackerel (*Decapterus russelli*) in Java Sea. Indonesian Fisheries Research Journal 27(4):179-186. [in Indonesian].

Bintoro G., Yulianto E. S., Lelono T. D., Prasetyo D. T., Rahman M. A., Sari W. K., 2022 Utilization status and bioeconomic performance of skipjack tuna (*Katsuwonus pelamis*) fishery in the south coast of Malang waters. East Java. Indonesia. IOP Conference Series: Earth and Environmental Science 1033:1-10.

Chakma S., Saha S., Hasan Md. N., Rahman Md. A., Akter M., Hoque Md. S., Ullah Md. R., Sujan K. M., Shahriar A., 2020 Effect of frozen storage on the biochemical. microbial and sensory attributes of Skipjack Tuna (*Katsuwonus pelamis*) fish loins. Journal of Applied Biology & Biotechnology 8(4):58-64.

Chodrijah U., 2011 [Several aspects of reproductive biology of yellowfin tuna *(Thunnus albacares)* from Banda Sea waters]. Proceedings of the 8th National Fish Seminar, pp. 401-409. [In Indonesian].

Chodrijah U., Nugraha B., 2013 [Size distribution of longline tuna catches and catching areas in Banda Sea Waters]. Indonesian Fisheries Research Journal 19(1):9-16. [In Indonesian].

Diningrum T. D. B., Triyono H., Jabbar M. A., 2019 [Biological aspects of skipjack tuna in southeast Celebes]. Journal of Fisheries and Maritime Extension 13(2):139-147. [In Indonesian].

Effendie M. I., 1979 [Fisheries biology method]. Dewi Sri Foundation, Bogor, 112 p. [In Indonesian].

Genti J. G., Marsoedi, Afandhi A., 2016 The utilization of skipjack tuna *Katsuwonus pelamis* (Linnaeus. 1758) availability for sustainable fisheries management in Prigi, East Java. Indonesian Journal of Environment and Sustainable Development 7(2):122-127.

Hidayat T., Chodrijah U., Noegroho T., 2014 [Characteristics of trolling fisheries in the Banda Sea]. Indonesian Fisheries Research Journal 20(1):43-51. [In Indonesian].

Hutajulu H., Imran Z., Budiharsono S., Kusumastanto T., 2019 Economic structure analysis in the development of skipjack tuna *(Katsuwonus pelamis)* fisheries industry in Jayapura City, Papua, Indonesia. AACL Bioflux 12(5):1726-1737

Hutomo M., Moosa M. K., 2005 Indonesian marine and coastal biodiversity: Present status. Indian Journal of Marine Sciences 34(1):88-97.
Jaleel A., Smith H. D., 2022 The Maldives tuna fishery: An example of best practice. Ocean Yearbook Online 36(1):314-345.
Jamal M., Sondita M. F. A., Haluan J., Wiryawan B., 2011 [Utilization of Skipjack Biological Data *(Katsuwonus pelamis)* in the Framework of Responsible Fisheries Management in the Waters of Bone Bay]. Journal of Indonesian Nature 14(1):107-113. [In Indonesian].
Jatmiko I., Hartaty H., Bahtiar A., 2015 [Reproductive biology of skipjack fish *(Katsuwonus pelamis)* in the Eastern Indian Ocean]. Bawal 7(2):87-94. [In Indonesian].
Karman A., Martasuganda S., Sondita M. F. A., Baskoro M. S., 2016 [Biological base of skipjack as the foundation for sustainable fisheries management in the North Maluku Province]. Journal of Tropical Marine Science and Technology 8(1):159-173. [In Indonesian].
Lintang C. J., Labaro I. L., Telleng A. T., 2012 [Study of the fishing season for tuna using handline fishing gear in the Maluku Sea]. Journal of Capture Fisheries Science and Technology 1(1):6-9. [In Indonesian].
Mahmud, Sinrang A. D. B., Massiseng A. N. A., 2021 Prospects of fisheries industry development in indonesia through online publication media. International Journal of Applied Biology 5(2):117-129.
Manik N., 2007 [Several aspects of the biology of skipjack tuna (*Katsuwonus pelamis*) in the waters around South Seram Island and Nusa Laut Island]. Oceanology and Limnology in Indonesia 33:17-25. [In Indonesian].
Manurung V. T., 2016 [Performance and Institutional Credit for Small-Scale Tuna Fishing Business in Eastern Indonesia]. The Agro-Economy Research Forum 16(2):60-74. [In Indonesian].
Mardlijah S., Pane A. R. P., Panggabean A. S., 2021 The stock status of skipjack tuna (*Katsuwonus pelamis*) in Tomini Bay and Its Surrounding Areas. Indonesia. IOP Conference Series: Earth and Environmental Science 934:1-9.
Mukhsin R., Mappigau P., Tenriawaru A. N., 2017 [The effect of entrepreneur's orientation on the survival of small and medium enterprises of the fishery processing groups in Makassar City]. Journal of Analysis 6(2):188–193. [In Indonesian].
Noija D., Martasuganda S., Murdiyanto B., Taurusman A. A., 2014 [Potential and level of utilization of demersal fish resources in the waters of Ambon Island, Maluku Province]. Journal of Fisheries and Marine Technology 5(1):55-64. [In Indonesian].
Norungee D., Kawol D., 2011 Macroscopic study on some aspects of the reproductive biology of skipjack tuna (*Katsuwonus pelamis*) in the Western Indian Ocean. Indian Ocean Tuna Commission, 13th Working Party on Tropical Tunas, Maldives, 10 p.
Nugraha E., Yudho G. S., Jaenudin A., Yusrizal, Kusmedy B., Kusnidar A., Husen E. S., 2020 Relationship between length and weight of skipjack tuna (*Katsuwonus pelamis*) purse seine catching in the Maluku Sea. Indonesia. AACL Bioflux 13(1):330-345.
Ollé J., Vilà-Valls L., Alvarado-Bremer J., Cerdenares G., Duong T. Y., Hajjej G., Lino P. G., Muñoz-Lechuga R., Sow F. N., Diaha N. C., Araguas R. M., Sanz N., Viñas J., 2022 Population genetics meets phylogenetics: new insights into the relationships among members of the genus *Euthynnus (family Scombridae).* Hydrobiologia 849:47–62.
Paulangan Y. P., Rumbiak K., Barapadang B., 2020 Fishing season and participatory mapping of the fishing ground of target fish in Depapre Bay. Jayapura Regency. Papua Indonesia. IOP Conference Series: Earth and Environmental Science 584:1-8.
Satrioajie W. N., Suyadi, Syahailatua A., Wouthuyzen S., 2018 The importance of the Banda Sea for tuna conservation area: A review of studies on the biology and the ecology of tuna. IOP Conference Series: Earth and Environmental Science. 184:1-11.
Senen B., Sulistiono S., Ismudi M., 2011 [Biological aspects of the flying catfish (*Decapterus macrosoma*) in Banda Neira waters. Maluku. Indonesia]. Agricultural Journal UMMI 1:35-40. [In Indonesian].
Simbolon D., Wiryawan B., Wahyuningrum P. I., Wahyudi H., 2011 [Utilization level and seasonal patterns of fishing for lemuru in the Bali Strait waters. Bulletin PSP 19(3):293-307. [In Indonesian].

Sparre P., Ursine E., Venema S. C., 1989 Introduction to tropical fish stock assessment Part 1. Manual, FAO Fisheries Technical paper. No. 306.1 Rome, FAO p. 337.
Sparre P., Venema S. C., 1999 Introduction to tropical fish stock assessment. Part 1. FAO Fishing Technology Paper No.306/1.Rev.2. Rome, FAO, 407 p.
Sugara A., Nolisa A., Anggoro A., Suci A. N. N., Suhendri R., 2022 [Diversity Species Identification of fish catched by fishermen Tapak Paderi Bengkulu City]. Samakia: Journal of Fisheries Science 13(1):1-7. [In Indonesian].
Tadjuddah M., Anadi L., Mustafa A., Arami H., Abdullah, Kamri S., Wianti N. I., 2017 Growth pattern and size structure of skipjack tuna caught in Banda Sea. Indonesia. AACL Bioflux 10(2):227-233.
Tangke U., 2014 [Estimation of pelagic fishing area based on sea surface temperature and chlorophyll-a approaches in the Maluku Sea]. Scientific Journal of Agribusiness and Fisheries (AGRIKAN UMMU-Ternate) 7(1):74–81. [In Indonesian].
Udupa K. S., 1986 Statistical method of estimating the size at first maturity offishes. Fishbyte 4(2):8-10.
Widodo A. A., Nugraha B., 2009 [Kendari-based tuna fishery. Southeast Sulawesi]. BAWAL 299–307. [In Indonesian].
Yaskun M., Sugiarto E., 2017 [Analysis of the potential of marine fisheries products on the welfare of fishermen and the community in Lamongan Regency]. EKBIS Journal 17(1):867-875. [In Indonesian].

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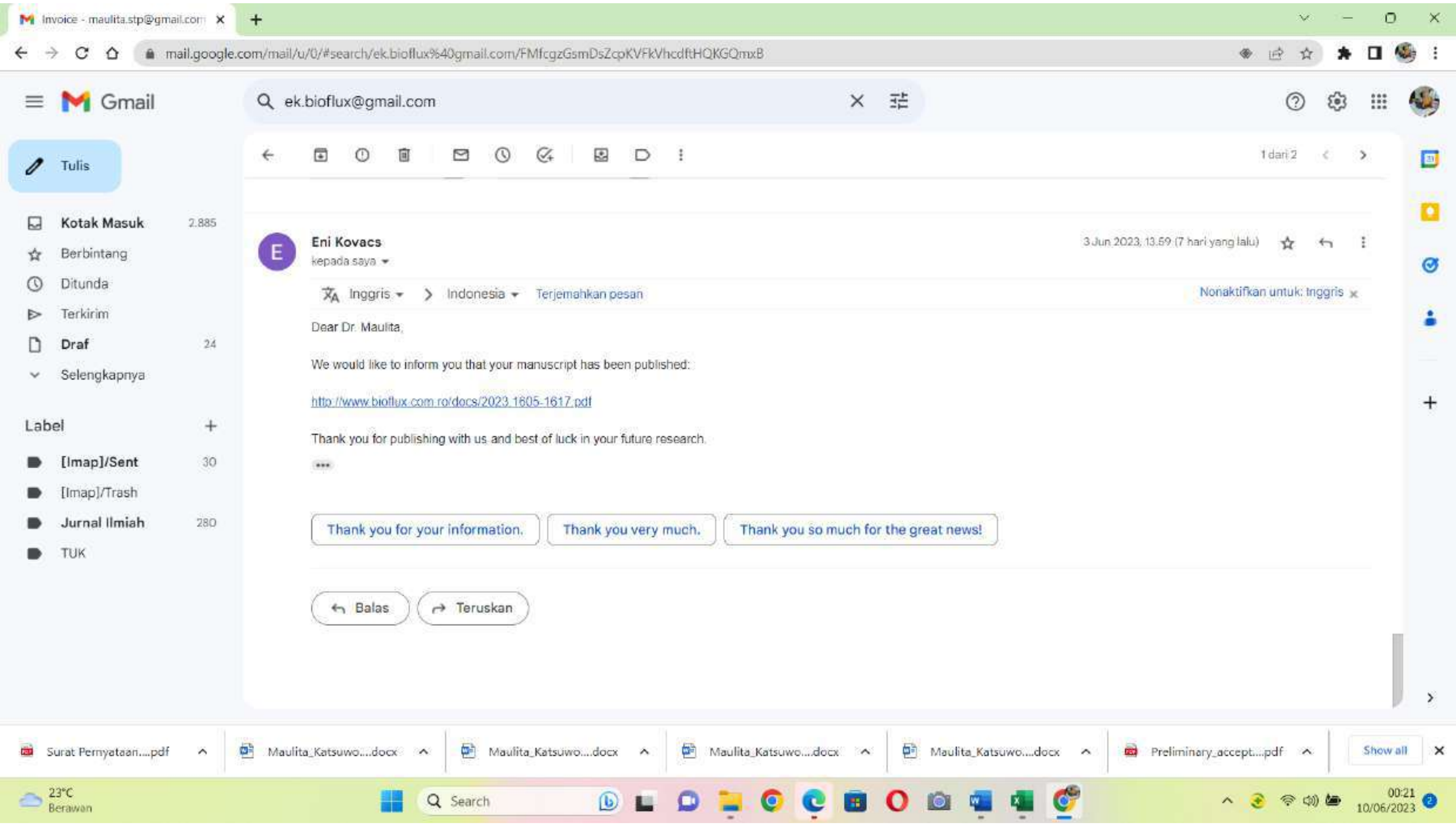
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