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

by Cek Turnitin

Submission date: 11-Jun-2023 08:33PM (UTC+0800)
Submission ID: 2113557026
File name: 2023.1605-1617.pdf (455.46K)
Word count: 6113
Character count: 29610

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

[1]Maman Hermawan, [1]Jerry Hutajulu, [1]Syarif Syamsuddin, [1]Danu Sudrajat, [1]Yusrizal, [1]Erick Nugraha, [1]Aman Saputra, [2]Ratna Suharti, [2]Mira Maulita, [2]Firman Setiawan

[1] Faculty of Fishing Technology, Jakarta Technical University of Fisheries, South Jakarta, Indonesia; [2] Faculty of Fishery Resources Management, Jakarta Technical University of Fisheries, South Jakarta, Indonesia. Corresponding author: M. Maulita, maulita.stp@gmail.com

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 tuna (*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 2[illegible] May 2019 in the Banda Sea. Data collection was carried out at several sampling points as shown in Figure 1.

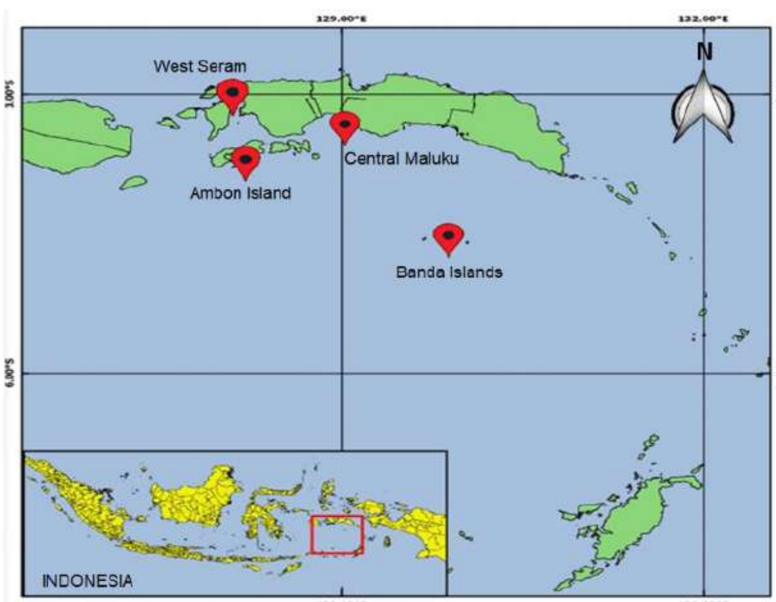

Figure 1. Map of research locations.

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:

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 of 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 = 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.

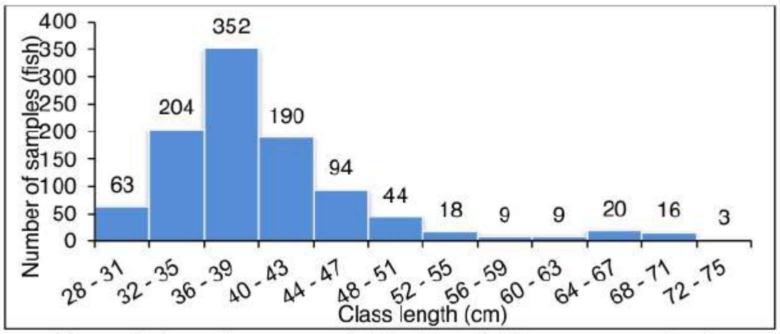

Figure 2. Long frequency distribution of *Katsuwonus pelamis.*

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.

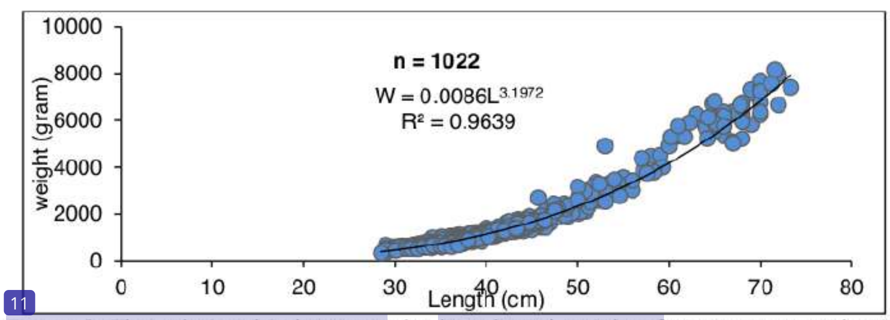

Figure 3. The relationship between the length and weight of *Katsuwonus pelamis.*

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.

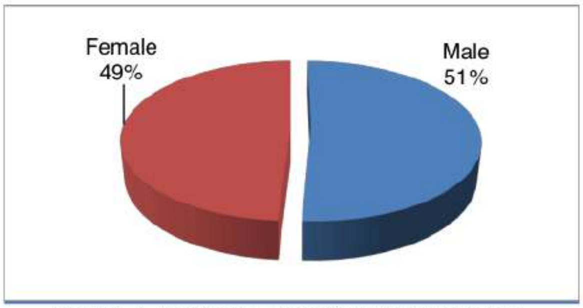

Figure 4. Sex ratio of *Katsuwonus pelamis.*

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 of *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.

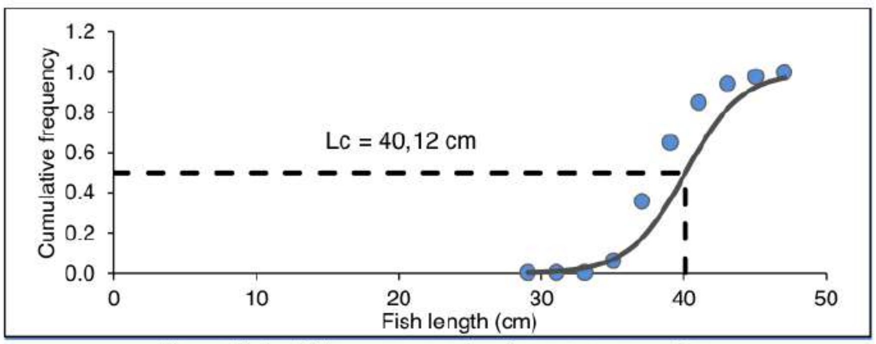

Figure 5. Lc *Katsuwonus pelamis* on a purse seine.

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.

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 4

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

Year	Production (T)					Trips			
	Purse seiner	Trolling liner	Hand liner	Pole and liner	Total	Purse seiner	Trolling liner	Hand liner	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

Table 5

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

Year	Productivity (Ton trip^{-1})			
	Purse seiner	Trolling liner	Hand liner	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).

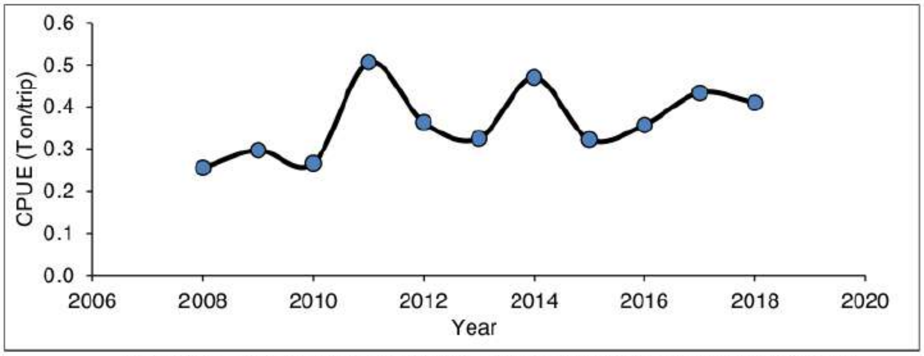

Figure 6. *Katsuwonus pelamis* CPUE fluctuations in the Banda Sea.

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) (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.

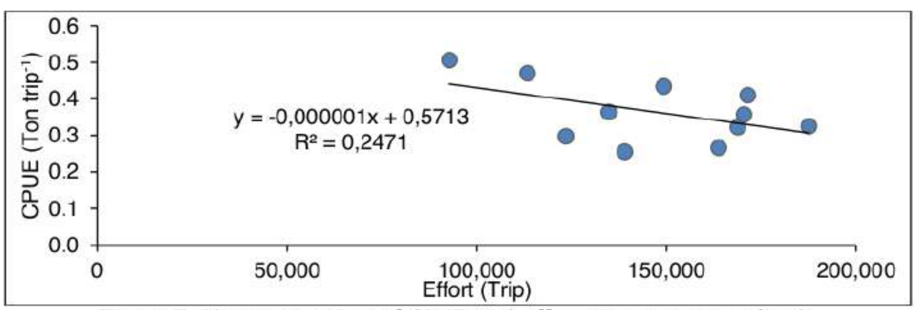

Figure 7. Linear equation of CPUE and effort *Katsuwonus pelamis*.

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.

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

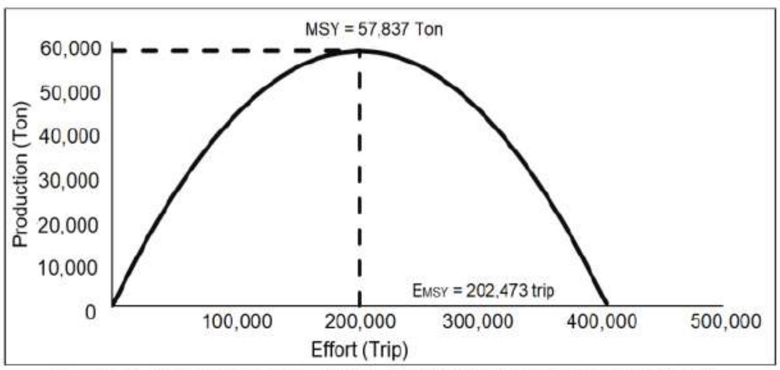

Figure 8. Stock balance curve (MSY) for *Katsuwonus pelamis.*

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. *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 18 so 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].

Received: 16 March 2023. Accepted: 19 May 2023. Published online: 03 June 2023.
Authors:
Maman Hermawan, Jakarta Technical University of Fisheries, Faculty of Fishing Technology, AUP Street No.1, Pasarminggu 12520, South Jakarta, Indonesia, e-mail: mhermawan60@gmail.com
Jerry Hutajulu, Jakarta Technical University of Fisheries, Faculty of Fishing Technology, AUP Street No.1, Pasarminggu 12520, South Jakarta, Indonesia, e-mail: jerryhutajulu15@gmail.com
Syarif Syamsuddin, Jakarta Technical University of Fisheries, Faculty of Fishing Technology, AUP Street No.1, Pasarminggu 12520, South Jakarta, Indonesia, e-mail: tigershark007@gmail.com
Yusrizal, Jakarta Technical University of Fisheries, Faculty of Fishing Technology, AUP Street No.1, Pasarminggu 12520, South Jakarta, Indonesia, e-mail: buyung_trc@yahoo.com
Danu Sudrajat, Jakarta Technical University of Fisheries, Faculty of Fishing Technology, AUP Street No.1, Pasarminggu 12520, South Jakarta, Indonesia, e-mail: sudrajatwrb1@gmail.com
Aman Saputra, Jakarta Technical University of Fisheries, Faculty of Fishing Technology, AUP Street No.1, Pasarminggu 12520, South Jakarta, Indonesia, e-mail: amansaputra@yahoo.com
Erick Nugraha, Jakarta Technical University of Fisheries, Faculty of Fishing Technology, AUP Street No.1, Pasarminggu 12520, South Jakarta, Indonesia, e-mail: nugraha_eriq1@yahoo.co.id
Ratna Suharti, Jakarta Technical University of Fisheries, Faculty of Aquatic Resources Management, AUP Street No.1, Pasarminggu 12520, South Jakarta, Indonesia, e-mail: r_suharti@yahoo.com
Firman Setiawan, Jakarta Technical University of Fisheries, Faculty of Aquatic Resources Management, AUP Street No.1, Pasarminggu 12520, South Jakarta, Indonesia, e-mail: firmansetiawan001@gmail.com

How to cite this article:
Hermawan M., Hutajulu J., Syamsuddin S., Yusrizal, Saputra A., Sudrajat D., Nugraha E., Suharti R., Maulita M., Setiawan F., 2023 Skipjack tuna's (*Katsuwonus pelamis*) biology and its fisheries status in the Banda Sea, Maluku, Indonesia. AACL Bioflux 16(3):1605-1617.

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

ORIGINALITY REPORT

14%	9%	10%	4%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Submitted to Padjadjaran University Student Paper	2%
2	Submitted to Universitas Airlangga Student Paper	1%
3	www.smujo.id Internet Source	1%
4	www.readkong.com Internet Source	<1%
5	www.researchgate.net Internet Source	<1%
6	www.seminarpasca-sttal.ac.id Internet Source	<1%
7	researchrepository.murdoch.edu.au Internet Source	<1%
8	A Rahmah, I Mardhatillah, A Damora, M Muhammad, N Nurfadillah. "Application of Surplus Production Model to the Yellowfin Tuna Thunnus albacares in the northern and	<1%

western parts of Aceh waters", IOP Conference Series: Earth and Environmental Science, 2021
Publication

9	Baihaqi, Mahiswara, T W Budiarti. "Characteristics of purse seine fisheries in the Sulawesi Sea (case study in Tumumpa fishing port)", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1 %
10	Patrick Omoregie Isibor, Bamidele Akinsanya, Temitope Sogbamu, Fatsuma Olaleru et al. "Nilonema gymnarchi (Nematoda: Philometridae) and trace metals in Gymnarchus niloticus of Epe lagoon in Lagos State, Nigeria", Heliyon, 2020 Publication	<1 %
11	Ridwan Sala, Tasya Magdalena Br Siahaan, Roni Bawole, Mudjirahayu Mudjirahayu, Mercy Patanda. "Growth and Exploitation Status of Skipjack Tuna (Katsuwonus pelamis) in Waters Around Manokwari", Jurnal Sumberdaya Akuatik Indopasifik, 2023 Publication	<1 %
12	Submitted to Universitas Hasanuddin Student Paper	<1 %
13	Moh. Rasyid Ridho, Enggar Patriono, Endri Junaidi, Muhammad Avesena, Anita Karolina,	<1 %

Vera Ardelia. "THREE SPOT GOURAMI (Trichogaster trichopterus) FOOD HABITS IN THE KOMERING RIVER'S DOWNSTREAM, SOUTH SUMATERA", BIOVALENTIA: Biological Research Journal, 2021
Publication

14	Submitted to Universiti Sains Malaysia Student Paper	<1 %
15	Najamuddin, Mahfud Palo, Andi Assir, Hardianti. "Analysis of sustainable biological aspects of Scottish seine net in the waters of Majene, Indonesia", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1 %
16	worldwidescience.org Internet Source	<1 %
17	citation.allacademic.com Internet Source	<1 %
18	www.agriculturejournals.cz Internet Source	<1 %
19	Suradi Wijaya Saputra, Anhar Solichin, Wiwiet Teguh Taufani. " Stock Analysis of (H.Milne Edwards, 1837) on the North Coast of Central Java, Indonesia ", IOP Conference Series: Earth and Environmental Science, 2018 Publication	<1 %

www.coursehero.com

20	Internet Source	<1 %
21	www.neliti.com Internet Source	<1 %
22	Prawira A.R.P. Tampubolon, Imanda Hikmat Pradana, Andri Warsa. "DETERMINING MONOFILAMENT GILLNET OPTIMUM MESH SIZE TO MITIGATE Amphilophus citrinellus POPULATION OUTBREAKS IN IR.H.DJUANDA RESERVOIR", Indonesian Fisheries Research Journal, 2015 Publication	<1 %
23	Sri Ayuni, Bambang Sumantri, Ellys Yuliarti. "Analysis of Allocation of Fulfillment, Use, and Factors Influencing the Need for Cassava Farming Funds", AGRITROPICA : Journal of Agricultural Sciences, 2022 Publication	<1 %
24	Suria M.M.. "Lactic acid bacteria waste infusion as a source of attraction and oviposition stimulation of gravid female Aedes albopictus mosquitoes", Tropical Biomedicine, 2022 Publication	<1 %
25	e.bangor.ac.uk Internet Source	<1 %

26	Ade Sunaryo. " Length-weight relationship and condition factor of Hamilton's thryssa fish ( ) from Pabean Bay, West Java, Indonesia ", E3S Web of Conferences, 2021 Publication	<1 %
27	Alvi Rahmah, Julyanur Sahputri, Mutia Ratna Aprilla, Makwiyah Chaliluddin, Afdhal Sayyid Elrahimi. " Study of determining the fishing season for tiger grouper ( ) landed at Kutaraja Fishing Port, Banda Aceh ", E3S Web of Conferences, 2022 Publication	<1 %
28	Chandan Debnath, Prasanta Mahanta. "Effects of different feeding regimens on co-rearing of Labeo gonius and L. rohita: Unveiling growth, survival, and condition in concrete tanks", Research Square Platform LLC, 2023 Publication	<1 %
29	G L Arnenda, F Rochman, A Wujdi, R Kurniawan, N I Wiratmini, I M S Wijana. "Reproductive biology of male Euthynnus affinis (Cantor, 1849) in Kedonganan Bali", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1 %
30	M F Talahatu, D Susiloningtyas, S Budiharsono, T Handayani. " The utilization	<1 %

status of Yellowfin Tuna in Morotai Island Regency ", IOP Conference Series: Earth and Environmental Science, 2020
Publication

31	Romi Novriadi, Indah Istiqomah, Alim Isnansetyo, Derek Balk, Melissa Jolly-Breithaupt, Simon Davies. "Corn fermented protein in production diets for pacific white legged shrimp Litopenaeus vannamei: Improved growth performance, health status and resistance to infection", Aquaculture Reports, 2023 Publication	<1 %
32	S Makmur, D Muthmainnah, Subagdja, D Arfiati, G Bintoro, A W Ekawati. "Reproductive biology of hampala barb (Hampala macrolepidota Kuhl & Van Hasselt 1823) in Ranau Lake, Indonesia", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1 %
33	S Wouthuyzen, F D Hukom, P Makatipu, D Pelasula. "Reef fish stocks assessment around the islands in the Banda Sea for supporting local community livelihood", IOP Conference Series: Earth and Environmental Science, 2018 Publication	<1 %
34	link.springer.com Internet Source	<1 %

35	mri.lipi.go.id Internet Source	<1%
36	repository.essex.ac.uk Internet Source	<1%
37	www.crfm.net Internet Source	<1%
38	B Nugraha, S W Utomo, I J P Dewi. "Management of sustainable fisheries and utilization status of red snapper (Lutjanus spp.) using handline landed in archipelagic fishing port of Brondong", IOP Conference Series: Earth and Environmental Science, 2021 Publication	<1%

Exclude quotes	On	Exclude matches	Off
Exclude bibliography	On		