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Growth and Exploitation Status of Skipjack Tuna (Katsuwonus pelamis) in Waters Around Manokwari

Pertumbuhan dan Status Pemanfaatan dari Cakalang (*Katsuwonus pelamis*) di Perairan Sekitar Manokwari

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ABSTRAK

Ikan cakalang (*Katsuwonus pelamis*) merupakan ikan yang mempunyai nilai ekonomi tinggi dan peluang permintaan pasar lokal maupun ekspor. Pengumpulan data dilaksanakan pada bulan April-Agustus 2021 dengan mengumpulkan data hasil tangkapan dari nelayan di beberapa titik pendaratan ikan di Manokwari. Ikan cakalang tangkapan dari nelayan di tangkap di Perairan sekitar Manokwari. Tujuan dari penelitian ini adalah untuk mengetahui distribusi ukuran, hubungan panjang dan berat, model pertumbuhan, laju mortalitas dan pemanfaatan ikan cakalang di Perairan sekitar Manokwari. Ukuran ikan cakalang yang diperoleh berkisar antara 260 mm dan 760 mm, dengan ukuran rata-rata berkisar antara 540 mm dan 595 mm. Hubungan antara panjang total dengan berat tubuh ikan cakalang mengikuti persamaan Log W = 0,00006 + 2,7702 Log L, dimana nilai b sebesar 2,7702 menunjukkan bahwa pola pertumbuhan ikan cakalang (*K. pelamis*) bersifat alometrik negatif. Model pertumbuhan menggunakan model von Bertalanffy, ditemukan panjang asimtot ($L\infty$) sebesar 792,75 mm, laju pertumbuhan (K) sebesar 0,75/tahun dan umur teoritis (t0) sebesar -0,0254 tahun. Mortalitas total (Z) sebesar 1,32/tahun. Mortalitas alami (M) sebesar 0,61/tahun. Mortalitas akibat penangkapan (F) sebesar 0,71/tahun. Laju eksploitasi sebesar 0,54/tahun menunjukkan bahwa laju eksploitasi ikan cakalang di perairan sekitar Manokwari sudah sedikit melebihi laju pemanfaatan optimum. Nilai spawning potential ratio (SPR) sebesar 16%, sudah lebih rendah dari batas titik acuan (20%).

Kata kunci: hubungan panjang berat; Ikan cakalang; model pertumbuhan; Tingkat Pemanfaatan; Manokwari

ABSTRACT

Skipjack tuna (*Katsuwonus pelamis*) has high economic value and opportunities for local and export market demand. The present study aims to investigate growth and exploitation status of the resource. Data collection was carried out in April-August 2021 by collecting catch data from fishermen at four fish landing sites in Manokwari. Skipjack tuna caught from the fishermen were caught in the waters around Manokwari. The size of skipjack tuna measured ranged between 260 mm and 760 mm, with an average monthly size ranging between 540 mm and 595 mm. The relationship between total length and body weight of skipjack tuna followed the equation W = 0.00006L2.7702, where the b value of 2.7702 indicates that the growth pattern of skipjack tuna (*K. pelamis*) is negative allometric. The growth model using the von Bertalanffy model, found asymptote length (L∞) of 792.75 mm, growth rate (K) of 0.75 year-1 and theoretical age (t0) of -0.0254 years. The total mortality (Z) was 1.32 yr^{-1}. Natural mortality (M) was 0.61 yr^{-1}. The mortality due to capture (F) was 0.71 yr^{-1}. The exploitation rate of 0.54 indicated that the exploitation rate of skipjack tuna in the waters around Manokwari has slightly exceeded the optimum utilization rate. The spawning potential ratio (SPR) value was 16%, which was less than the lower reference point (20%).

Keywords: Growth model, LWR, Manokwari, Skipjack Tuna, utilization rate,

INTRODUCTION

The waters around Manokwari which are directly related to or become part of the western Pacific Ocean are very important in the context of the management and utilization of fishery resources, especially fish resources that are highly migratory such as skipjack tuna. Within the Pacific waters it has been identified as spawning ground areas for skipjack tuna **(**Kiyofuji and Ochi, 2016). Utilization of fish resources, especially in the fisheries management area (WPP) 717 is still not optimal (Sala, 2017). However, its utilization has been widely carried out, especially skipjack tuna (*Katsuwonus pelamis*) in Manokwari production in 2016 of 5,163.60 tons (BPS Kab. Manokwari, 2020) and waters around West Papua in 2019 of 22,152 tons (KKP, 2022). So far, the types of fisheries that exploit resources are generally small-scale, so that the fishing fleet is concentrated in coastal waters.

Skipjack tuna is a fish that has high economic value and the opportunity for market demand is widely open. This encourages increased skipjack utilization so that it may brought about negative impact on the condition of the population. Research on skipjack tuna in the waters around Papua is still limited. For example, Sala (2017) found that based on an analysis of relative abundance based on data on fishing effort and skipjack catches around the waters in Papua's bird's head, there was a downward trend in skipjack tuna populations until the early 2000s due to high exploitation using purse seine and pole and line fishing gears. The results of research from Sala and Manuhutu (2020) based on 2013 data, showed that skipjack catches by fishermen in the waters around Manokwari were dominated by small fish, which could be an indication of growth overfishing.

Sustainable management of fish resources does not prohibit fishing activities that are economic in nature but recommends that the level of utilization does not exceed the carrying capacity of the aquatic environment or the ability of fish resources to recover. Excessive utilization of fish resources will threaten the sustainability of fish resources, so that it can cause a decrease in fish populations. For this reason, there needs for a management measures for skipjack tuna capture (Jamal *et al.*, 2011).

Several factors that directly affect population size are the births, growth and mortality. The present study is focused on a few aspects related to the dynamics of the population of skipjack, namely to investigate the size structure of the fish, growth patterns and models, mortality and exploitation status of skipjack tuna stocks in the waters around Manokwari.

RESEARCH METHODS

Data Collection

This research was conducted in April-August 2021 in the waters around Manokwari. Sampling was carried out at 4 fishing landing sites, namely the Sanggeng Fish Landing Base (PPI), Borobudur Market, Pasirido, and Sowi 4 (Figure 1).

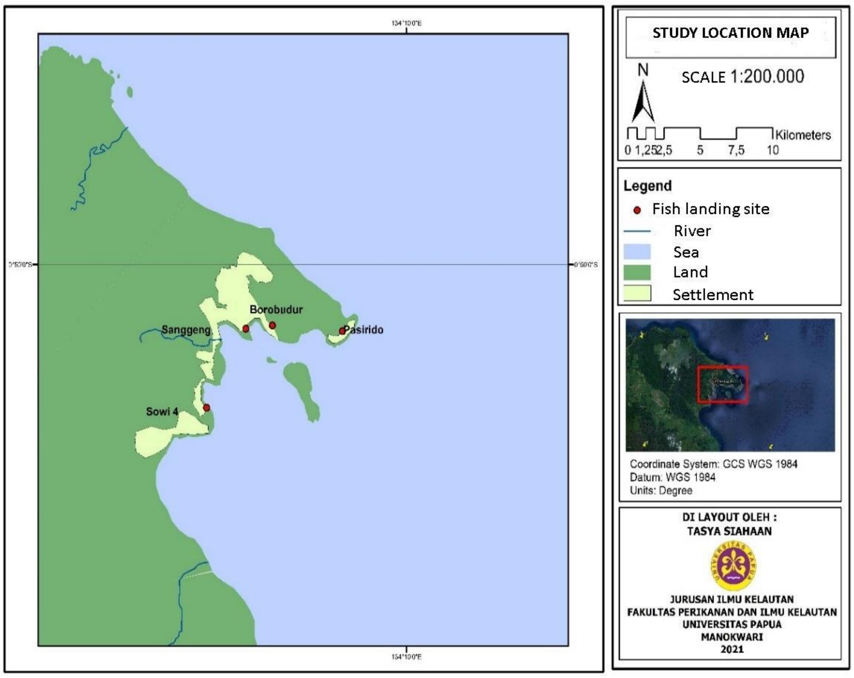

Figure 1. Map of research location

Collection of skipjack sample data was carried out using a fisher-based survey approach. The number of samples taken was a minimum of 30% of the population at each fish landing site, for 7 days at each month. Data collection was conducted for five months (April to August). Each individual sample of skipjack was measured the total length using a 0.5 mm accuracy meter and the weight using digital scale with an accuracy of 1 g.

Data Analyzes

a. Length and Weight Relationship (LWR)

The LWR was analyzed based on the following formula (Bal & Rao, 1984):

$$\mathbf{W = aL^b}$$

Description:
W = Fish weight (grams)
L = Total length of fish (mm)
a and b = Constants

The value of b was tested to determine whether the value of b obtained is significantly different from the value of 3 using a t-test (Weaver & Wuensch, 2013) as follows:

$$t = \frac{b-b*}{Sb}$$

Description:
Sb = Standard error of b
b = Regression coefficient (slope)
b* = set to 3

b. Growth

Growth model used to calculate the growth rate of skipjack tuna was based on the von Bertalanffy model with the following formula:

$$\mathbf{Lt =_{L} [1\text{-}exp^{-k(t-t0)}]}$$

Description :
Lt = Length of fish at age t
L_∞ = Asymptote length of fish
K = coefficient of growth rate
t_0 = Theoritical age when the length is zerro

Estimation of the value of t_o used Pauly's (1980) empirical formula as follows:

$$\mathbf{Log\ (-t_0\ ) = -0.3952 - 0.2752\ (Log\ L_{-}\ {}_{1.038}(Log\ K)}$$

c. Mortality

Calculation of the total mortality (Z) used catch curve converted to length method in the FISAT II program (Gayanilo *et al.*, 2006). Natural mortality (M) of skipjack tuna was estimated using empirical equation of Pauly (1980):

$$M = -0.0066 - 0.279 \text{ Log}L\infty + 0.6543 \text{ Log}K + 0.4634 \text{ Log}T$$

Description:
T = Average sea surface temperature of waters around Manokwari which was 30.4ºC (Sala and Manuhutu, 2020).

Fishing mortality (F) was estimated by using equation: **F = Z - M.**

d. Exploitation Rate

The exploitation rate (E) was estimated using Gulland (1971) equation as cite in Hidayat (2017), namely:

$$E = \frac{F}{Z}$$

If the value E = 0.5 or F = M indicates that E is optimum (E_{opt}) (Gulland 1971 *in* Pauly 1987).

e. Spawning Potential Ratio (SPR)

SPR was analyzed based on the length data of skipjack tuna measured during the study in 2021. Analysis was performed using the Barefoot Ecologist's Toolbox developed by Jeremy Prince which was accessible via http://barefootecologist.com.au/lbspr (Prince, 2003).

RESULTS AND DISCUSSION

Size Distribution of Skipjack Tuna

A total of 1000 individuals of skipjack tuna (*K. pelamis*) samples were taken randomly from fisher catches caught in the waters around Manokwari from April to August 2021. Based on the measurement results on the samples, a frequency distribution diagram of the total length of skipjack (*K. pelamis*) was made during observations which is shown in Figure 2. The results of the analysis showed that skipjack tuna caught in the waters around Manokwari dominantly varied in size, ranging from a minimum size of 260 mm and a maximum size of 760 mm with the highest frequency from April to August in the range of 540-595 mm. The size composition of skipjack is different from composition of skipjack in May-August 2013 which is dominated by relatively small size (< 30 cm) (Sala and Manuhutu, 2020). Hidayat (2017) reported that in the waters of the West Pacific, the composition of skipjack size dominated by large size (> 50 kg) in November-December-January.

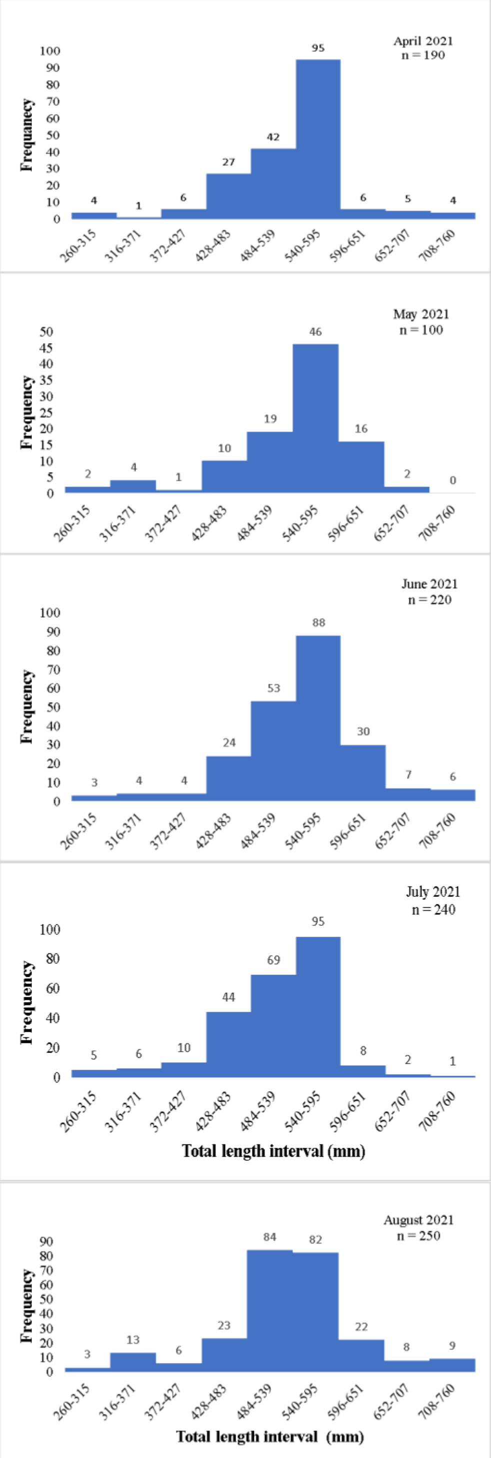

Figure 2. Frequency distribution of skipjack lengths

Based on several research results in different locations, it shows that first maturity length (Lm) of skipjack tuna at sizes > 400 mm and there are differences in size in different waters (Fishbase.se, 2021). Yonvitner *et al*. (2021) report the Lm of 413 mm for skipjack measured in Cilacap fishing port. The difference in the size at first maturity is influenced by food availability, water temperature, and growth rate (Satria and Kurnia, 2017). Catching adult populations also has an impact on reducing adult size because of the recovery of skipjack is the relatively slow (Hallier and Founteneun, 2015).

Table 1. Average total length of skipjack caught in the waters around Manokwari in 2021

Month	n	Average Total Length ± SD (mm)
April	190	531.8 ± 71.4
May	100	537.5 ±77.1
June	220	545.1 ± 79.1
July	240	515.9 ± 69.6
August	250	530.9 ± 81.8

Length Weight Relationship (LWR)

Regression analysis between the length and weight of skipjack tuna caught in the waters around Manokwari base on data from April to August 2021 was found that the relationship following equation W = $0.00006L^{2.77}$ with a coefficient of determination (R^2) of = 0.8683. Statistical t-test analysis at a 95% confidence interval found t-value of 6.73) > t-table of 1.96. This test explained that the growth pattern of skipjack tuna (*K. pelamis*) is negative allometric, i.e. length gain is more dominant than weight gain (Figure 3). The same growth pattern is also resported in Lappa waters, Sinjai district (Jamal *et al.*, 2011). However, there is a different growth pattern of skipjack tuna in Pelabuhan Ratu waters which has a positive allometric which means that weight growth is more dominant than length growth (Nurdin and Panggabean, 2017).

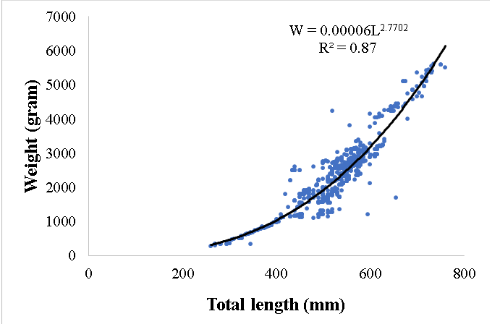

Figure 3. The relationship between length and weight of skipjack tuna

The difference in growth pattern is influenced by biological and ecological factors of each waters in which the fish live. In general, the growth pattern depends on physiological and environmental conditions such as temperature, pH, geographic location and sampling technique as well as biological conditions such as gonadal development and food availability (Froese, 2006). Also, the difference in the value of b is influenced by differences in seasons and levels of gonad maturity and fishing activity, because fishing activities are quite influential on the life and growth of fish populations. In addition, differences in the number and variation of fish sizes were observed (Satria *et al.*, 2017).

Growth Model of Skipjack Tuna

The growth model of skipjack tuna (*K. pelamis*) caught in the waters around Manokwari was estimated using the Von Bertalanffy growth model in the FISAT II application. The results of analysis showed the value of growth rate (K) of 0.75 yr^{-1}, the asymptote length ($L\infty$) of 792.75 mm. Estimation of the theoretical age t_0 found the value of -0.0254 years. Then, the growth model follows equation $Lt = [792.75\ (1-e^{-0.75(t+0.0254)})$. Graphically, the growth model of skipjack caught in the waters around Manokwari is shown in Figure 4.

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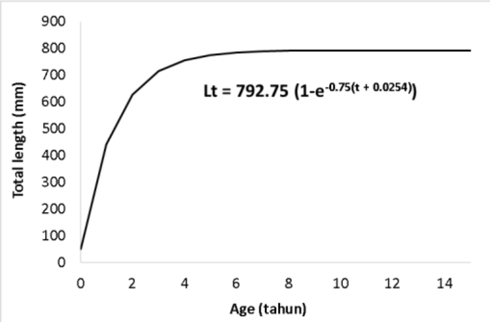

Figure 4. Growth curve of skipjack taken from water around Manokwari

Fish growth is influenced by various factors, such as water quality and food availability. Ideally, skipjack tuna caught in Indonesian waters at sea surface temperature of 28ºC-29ºC (Simbolon and Limbong, 2012), chlorophyll-*a* of 0.3 mg.m^{-3} (Azmi, 2015), dissolved oxygen of 2.45 ml.l^{-1} (Sharp, 1978), and salinity 33-35%. The growth coefficient of skipjack tuna is different from that reported by Sala and Manuhutu (2020), namely the value (K) of 0.42 yr^{-1}, asymptote length (L∞) of 75.3 cm and reported by Hidayat *et al.* (2017), found K of 0.41 yr^{-1}, L∞ of 101.85 cm for skipjack in the waters of the Western Pacific.

According to Toatubun *et al.* (2015) the length of skipjack tuna at the age of one year is approximately 37 cm, in the second year it can reach 46 cm, the third year is 55 cm, the fourth year is 64 cm, the fifth year is 72 cm, even skipjack can reach one meter at the age of more than 7 years. According to Collette and Nauen (1983) the maximum age of skipjack tuna in waters is 12 years. Jamal *et al.* (2011) reported skipjack tuna found in the Bone Bay area reaches its maximum length at the age of 7 years. Differences in growth parameter values are influenced by environmental factors of each waters such as food availability, water temperature, dissolved oxygen, fish size and gonadal maturity (Hernandez & Seijo, 2003; Day & Rowe, 2002). Also, fishing pressures can also bring about a slow growth of fish (Edeline, *et al.*, 2007).

Mortality and Stock Status

The total mortality rate (Z) obtained from the data analysis was 1.32 yr^{-1}. Estimation of the natural mortality rate of skipjack tuna based on Pauly's empirical equation found the value of 0.61yr^{-1}. Hence, the value of the fishing mortality rate (F) was 0.71 yr^{-1}. The mortality rate of skipjack tuna in the waters around Manokwari is dominated by fishing mortality. The exploitation rate (E) of skipjack was 0.54. Gulland (1983) suggests that optimum exploitation is when fishing mortality equals to natural mortality or when E equals to 0.5. Since E was larger than 0.5, it suggests that there was tendency of overexploitation of skipjack stock in the water around Manokwari. The biological parameters of skipjack tuna used as inputs in the SPR analysis are presented in Table 2.

Table 2. The value of the biological parameters used in the LB-SPR analysis

Parameter	Value	Source
M/K	0.813	Present study
L∞ (mm)	792.75	Present study
Lm50 (mm)	413.00	Yonvitner *et al.* (2021)
Lm95 (mm)	522.40	Fishbase.se

According to Hordyk *et al* (2015) a small M/K value indicates the population is dominated by large fish. Therefore, the M/K value of 0.81 obtained from this study can be interpreted as the stock condition that is dominated by large fish, because the average skipjack caught is more than 500 mm in size. This is supported by selectivity and maturity curves which show that the size of the caught fish is larger than the size of the first spawning fish (Figure 5).

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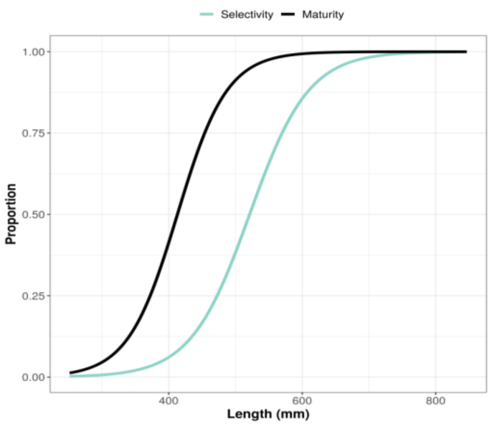

Figure 5. Selectivity and maturity curves of skipjack tuna caught in the waters around Manokwari

The results of the SPR analysis obtained an estimated SPR value of 16%, lower than the reference limit (20%), as shown in Figure 6. The SPR value can be an illustration of the number of eggs (spawn) produced relative to conditions where there is no exploitation activity, if the utilization rate continues in the long term (Powers, 2022).

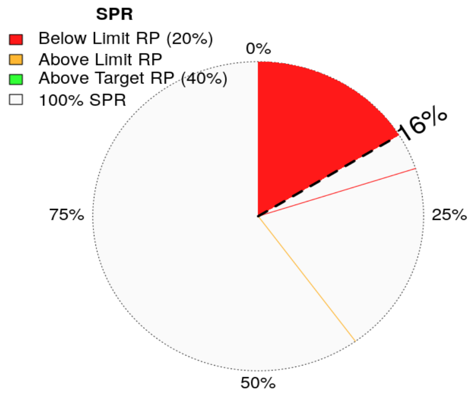

Figure 6. Estimated spawning potential ratio (SPR) of skipjack stock caught in the waters around Manokwari water

The results of the utilization rate analysis which show a value higher than the optimum utilization level and an SPR value lower than the reference level limit of 20% are indication of overfishing and low reproductive potential of skipjack tuna resources. Therefore, efforts are needed to control fishing effort and increase the selectivity of fishing gear so that skipjack tuna resources are maintained, especially to avoid recruitment overfishing in which the fisheries caught more fish that are ready to spawn (spawning stock) or gonadal mature fish.

CONCLUSION

1. The total length of skipjack tuna (Katsuwonus pelamis) in the waters around Manokwari varies, ranging in size from 260 mm to 760 mm with an average of 540-595 mm.
2. The relationship between length and weight of skipjack tuna caught in the waters around Manokwari followed the equation $W = 0.00006L^{2.77}$.
3. The growth model of skipjack tuna followed the growth equation $Lt = 792.75\ (1\text{-}e^{-0.75(t + 0.0254)})$.
4. The utilization rate of skipjack tuna in the waters around Manokwari was 0.54, which was higher than the optimum utilization rate. The estimated SPR was 16% which was below the lower limit of reference point.

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