



Bioindicator Stock Status of Skipjack Tuna, *Katsuwonus pelamis* (Linnaeus, 1758) From Purse Seine Fishery In Western Part of Sumatra

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Abstract

Stock biological indicators such as size structure, length-weight relationship, and length-at-first-capture/Lc) are critical elements for conducting the species-specific stock assessment, especially skipjack tuna (*Katsuwonus pelamis*). However, this kind of research is primarily concentrated in the southern part of Java, Bali, and Nusa Tenggara. While, the stock condition in the western part of Sumatra, which is regarded as one of the major tuna purse seine fisheries, still barely examined. This study intended to give an insight into the current stock indicators from a biological (length and weight) perspective. All size data were acquired from Kutaraja, Aceh, and Sibolga, North Sumatra, as part of the scientific port sampling program, courtesy of the Research Institute for Tuna Fisheries, from January 2016 to December 2020. The result showed that the skipjack stock's health is heading unsustainable, primarily caused by improper use of fishing gear, which caused most of the skipjack tuna caught were indicatively at immature state. Although the growth pattern signified a positive allometric, continuous intense fishing on juveniles would make the stock collapse at some point in the future. Thus, further management actions should be taken imminently to prevent any stock from declining.

Keywords: Catch-at Size, Growth Pattern, Length-Weight Relationship, Tuna

Abstrak

Indikator biologis stok seperti struktur ukuran, hubungan panjang-berat, dan panjang pertama kali tertangkap/Lc) merupakan elemen kunci untuk kajian stok berbasis spesies, terutama pada cakalang (*Katsuwonus pelamis*). Namun, penelitian semacam ini sebagian besar terkonsentrasi di wilayah selatan Jawa, Bali dan Nusa Tenggara. Sementara itu, kondisi stok di bagian barat Sumatera yang dianggap sebagai salah satu pusat perikanan pukat cincin tuna hampir tidak diperhatikan. Studi ini dimaksudkan untuk memberikan gambaran terkait indikator stok dari perspektif biologis (panjang dan berat). Keseluruhan data ukuran diperoleh dari Kutaraja, Aceh, dan Sibolga, Sumatera Utara, sebagai bagian dari program pendataan harian di lokasi pendaratan utama tuna dan sejenisnya, seizin Loka Riset Perikanan Tuna, dari Januari 2016 hingga Desember 2020. Hasil penelitian menunjukkan bahwa kesehatan stok cakalang bergerak menuju ke arah yang tidak lestari. Hal ini sebagian besar disebabkan oleh penggunaan alat tangkap yang tidak tepat, yang menyebabkan sebagian besar ikan cakalang yang tertangkap terindikasi dalam keadaan belum matang gonad/dewasa. Meskipun pola pertumbuhannya bersifat alometrik positif, namun penangkapan yuwana yang intens dan terus menerus akan membuat stok menurun secara cepat. Oleh karena itu, tindakan pengelolaan harus segera diambil untuk mencegah penurunan stok di masa yang akan datang.

Kata kunci: Hubungan Panjang-Bobot, Pola Pertumbuhan, Ukuran saat Tertangkap.

1. Introduction

Skipjack tuna is regarded as one of the highest economic fisheries products from coastal states/countries along the Indian Ocean, particularly Indonesia. Total catch estimation, derived from the southern and western parts of Indonesia (Fisheries Management Area/FMA 572 & 573), has continued rising since the

introduction of the fish aggregating device (FAD) in the early 1980s (Wudianto et al., 2019). From an average of 11,000 tons annually in the 1970s to almost double (~21,000 tons/year) in the next decade (IOTC, 2020). The purse seine fleet dominated the catch (Atmaja et al., 2016; Nugroho & Atmaja, 2013). Its annual production is around 40,000 tons or close to half of skipjack tuna caught in the Indian Ocean (IOTC, 2020).

Among landing sites in the western region of Sumatra, oceanic fishing port (PPS) Sibolga, North Sumatra, and archipelagic fishing port (PPN) Kutaraja, Aceh have the largest concentration of purse seine fleets in the region (Atmaja et al., 2016; Hariati & Amri, 2011; Salmarika & Wisudo, 2019) beside PPS. Nizam Zachman, Jakarta. The total catch of tuna and skipjack from both areas to national fishery production, particularly the Fisheries Management Area (WPP) 572, is about 15%. The purse seine fleet contributes more than half (Direktorat Jenderal Perikanan Tangkap, 2017).

Although skipjack tuna is thought to be highly resistant to overfishing due to their fast growth rate and year-round spawning (Dueri et al., 2012), the total catches have been significantly increased (~30%) from the 2018-2020 catch limit as per IOTC (Indian Ocean Tuna Commission) Resolution 16/02. Most of this raise was from purse seine fishery (IOTC-WPTT23, 2021). The latest study confirmed that the exploitation rate of skipjack tuna is already at the optimum level (Rochman et al., 2015). Therefore, there is an urgent need for constraining the catches to maintain the current stock condition above the target reference point ($SB_{current} > SB_{40\%SB0}$). Since skipjack management is under regional authorities, Indonesia should monitor and provide a periodical update on its stock condition, as an obligation to be a member of the regional fisheries management organization (RFMO).

However, such research, e.g., length-weight relationships and size distribution, are

more concentrated in the southern part of Java, Bali, and Nusa Tenggara (Nurdin & Panggabean, 2018; Rochman et al., 2015; Zedta et al., 2017). The stock condition in the western part of Sumatra, which is regarded as one of the significant tuna purse seine fisheries, is barely examined. This study aimed to provide information and fill the research's gap about several biological parameters as a reference of skipjack's stock indicator in the western part of Sumatra waters through robust scientific port sampling data. The result is purposely intended as a base for future stock assessment in the future.

2. Materials and Methods

2.1 Study site

The primary data source was generated from the scientific port sampling program based at PPS Kutaraja, Aceh, and PPN Sibolga, North Sumatra (Figure 1) from 2016 to 2020 (excl. 2018) courtesy of the Research Institute for Tuna Fisheries (RITF). The two locations were chosen for various reasons. One of them is the biggest landing site for the purse seine fleet in Sumatra's western part.

2.2 Sampling

Length and weight sampling were conducted using a stratified random sampling method. At which least one fish was sampled in every container/basket. The length of fish is measured from the tip of the upper jaw to the fork length (FL) with a precision of 0.1 cm, while the

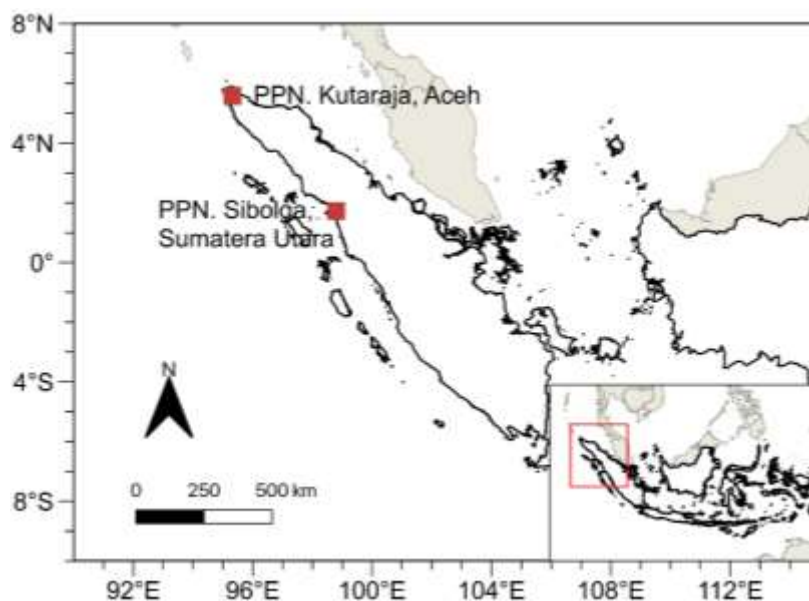


Figure 1. Map of the study site.

Table 1. Summary of length and weight observations of skipjack tuna from 2016-2020 in Kutaraja, Aceh, and Sibolga, North Sumatra.

Year	Kutaraja					Sibolga					Total Samples (N)	Mean Length (cm FL)	Mean Weight (gr)
	N	Length (cm FL)		Weight (gr)		N	Length (cm FL)		Weight (gr)				
		Min	Max	Min	Max		Min	Max	Min	Max			
2016	3,369	12	64	30	5,500	6,688	20	61	109	4,997	10,057	33.97	779.83
2017	na	na	na	na	na	12,462	18	63	33	5,500	12,469	35.85	944.48
2018	na	na	na	na	na	na	na	na	na	na	na	na	na
2019	658	19	63	98	4,718	4,888	17	59	33	4,920	5,552	33.98	821.49
2020	2,523	19	53	32	2,865	6,135	18	60	20	4,573	8,664	33.75	764.86

*) refers to the absence of data collection due to financial constraints.

weight refers to whole weight (WHO) with an accuracy of 1 gram. The number of skipjack samples successfully identified and measured as many as 36,723 specimens.

The length-weight relationship almost follows the cubic law (Pauly, 1983). With the notion of differences among fishes, hence to analyze the relationship for each species using the following equations:

$$W = aL^b \dots \dots \dots 1)$$

Keterangan:

- W = weight (g)
- L = length (cm FL)
- a and b = constant

2.3 Statistical analysis

Student's t-test was performed to check whether $b=3$ or $b \neq 3$ using R software version 4.0, with an initial hypothesis $H_0: \beta=3$

(isometric) and $H_1: \beta \neq 3$ (allometric). The t-statistic is calculated as $t = (b - 3) / S_b$, where

$$S_b = \text{standard error from 'b'}; S_b = \sqrt{\left(\frac{1}{n-2}\right) *}$$

$$\left[\left(\frac{S_y}{S_x}\right)^2 - b^2\right]. S_y \text{ and } S_x \text{ standard errors from } y$$

and x. significance of t-value was calculated at 1% and 5% range with a degree of freedom n^2 (Sawant et al., 2013). The interaction between average length to years of observation is also evaluated as a parameter of stock dynamics.

3. Results and Discussions

During five years of observation, there were 36,723 length and weight data have been collected, with over 80% of data was collected from Sibolga, North Sumatra, while the rest (6,550 specimens) was collected form Kutaraja, Aceh. Some outliers (e.g., extreme values) were excluded for smoother analysis. The average

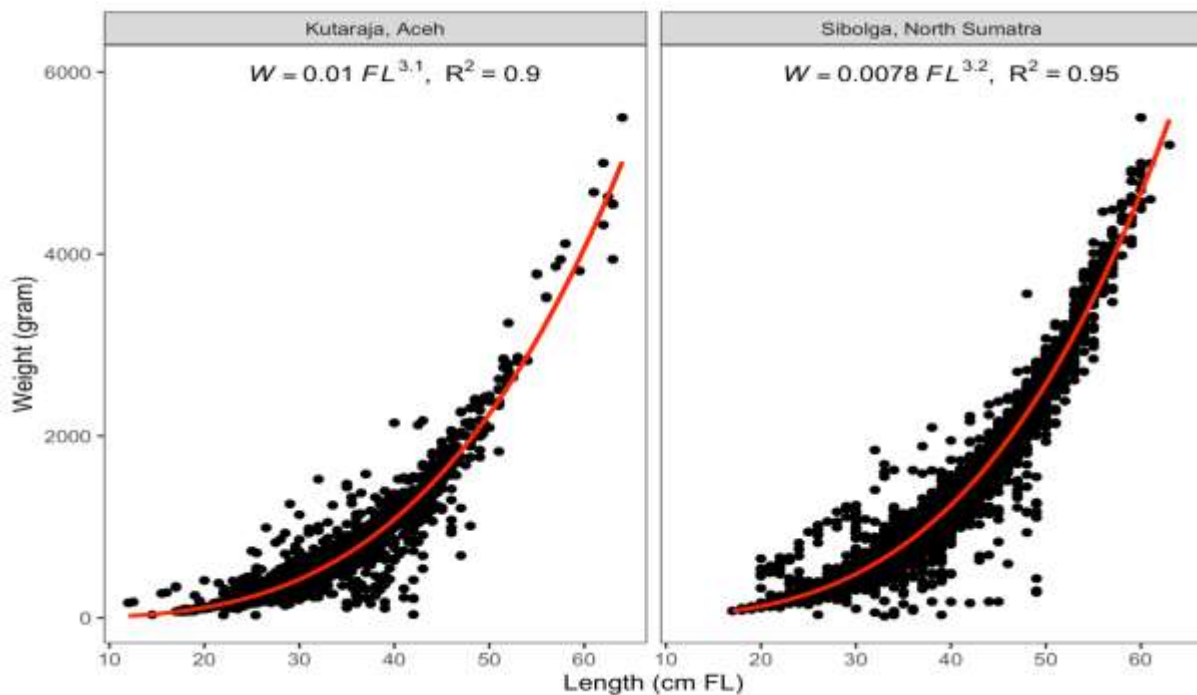


Figure 2. Length and weight relationship of skipjack tuna from Kutaraja, Aceh and Sibolga, North Sumatra 2016-2020

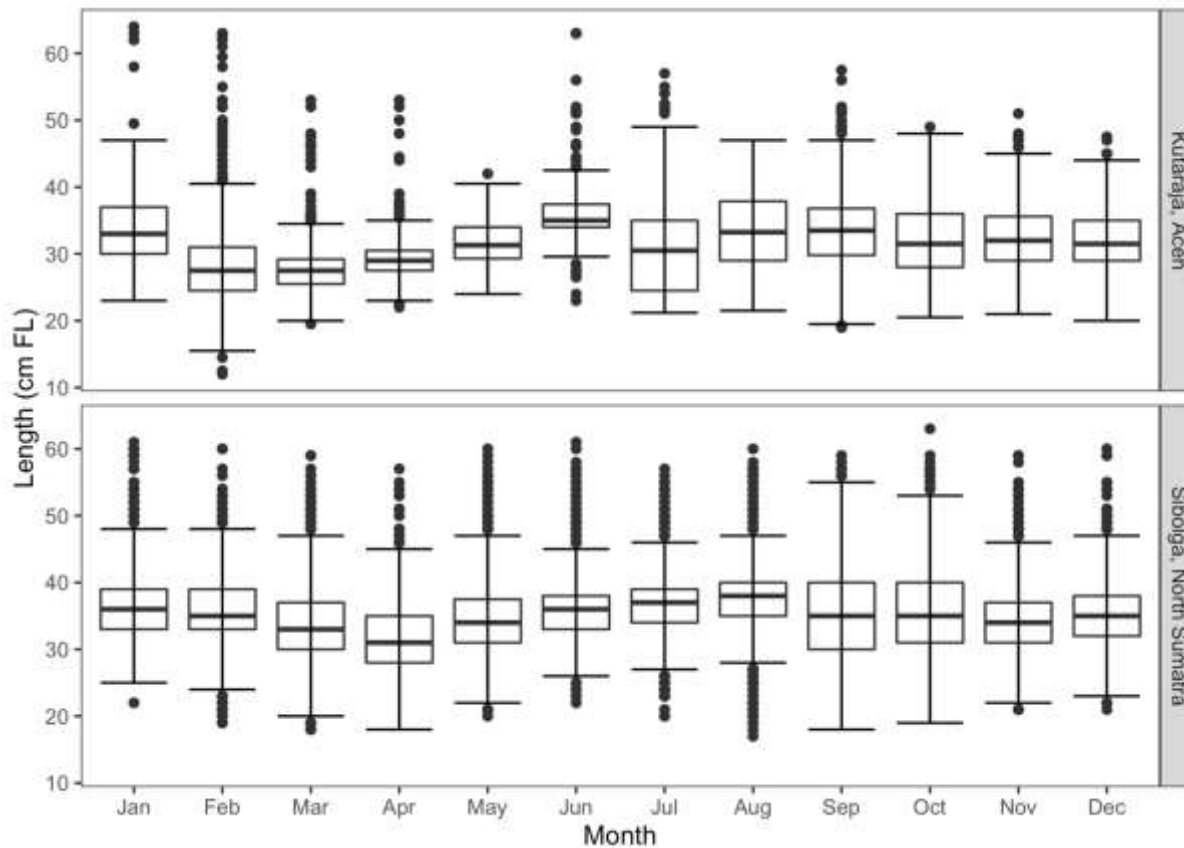


Figure 3. Length distribution of skipjack tuna from Kutaraja, Aceh and Sibolga, North Sumatra 2016-2020.

monthly collection from both locations was 182 ± 0.006 and 580 ± 0.003 , respectively. Due to financial constraints, there were no samples in 2017 (Kutaraja) and 2018 for both areas. There was no slight drop in performance related to the Covid-19 pandemic. In contrast, there was a 20% increase compared to the previous year's observation (Table 1).

3.1 Length and weight relationship

Regression analysis for the length-weight relationship of skipjack tuna from Kutaraja, Aceh, and Sibolga, North Sumatra, showed a relatively similar trend, which can be determined through the following equations: $W = 0.0100 * FL^{3.1}$ and $W = 0.0078 * FL^{3.2}$, respectively (Figure 2). The regression coefficient (R^2) for all relationships was above 0.9, and the model was fit well, where the length variable could explain more than 90% of the weight. Furthermore, Student's t-test results revealed both skipjack tuna exhibit an allometric growth pattern ($p < 0.05$) with an exponent parameter (b) between 3.09-3.15 and 3.24-3.25, respectively, within a 95% confidence interval.

3.2 Length distribution

In general, the catch of skipjack tuna from Sibolga has a more considerable size range (30-40 cm FL) and mean (35.15 ± 0.03 cm FL) compared to Kutaraja, which 20-40 cm FL; 31.81 ± 0.07 cm FL, respectively. Over time, the mean size trend revealed that the recent catch from Kutaraja was slightly decreased compared to two previous years, while Sibolga was relatively stable over four years (Figure 3). Since both locations' average catch sizes were lower than a length at 50% mature (Lm_{50}) reference (Hartaty & Arnenda, 2019), the stock's health was not in an ideal condition. Almost all caught in the period of 2016-2020 were fell under the value of Lm_{50} . Although it is commonly found in most net-based gears, it should be concerned for future stock projection and sustainability.

During March-August, the monthly median length indicates a slight movement towards a larger size, stabilized starting in the second semester. These trends happened in both observation areas (Figure 4). However, in a

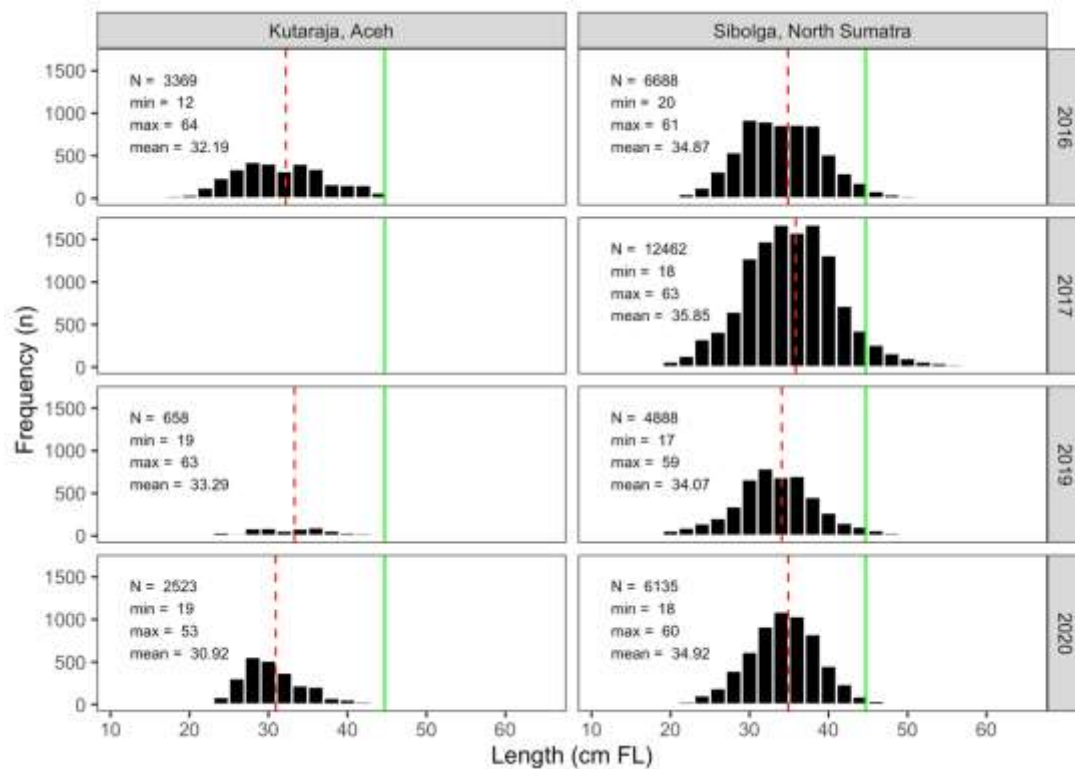


Figure 4. Monthly median length movement of skipjack tuna from Kutaraja, Aceh, and Sibolga, North Sumatra 2016-2020.

more general view, the deviations were not that dissimilar, between 30-40 cmFL.

Estimated b values from both locations were higher than three as the threshold value, which indicated a positive allometry growth pattern (i.e., the incremental weight gain is more significant than its length). The similarities were likely caused by the indifferences in gear used, whereas Rahmah et al. (2021); Rizwan et al. (2014); Yusuf et al. (2020) all confirmed that fishers from Sibolga and Kutaraja use almost identical purse seine configurations (including its mesh size). Thus, it's generated in a reasonably consistent catch size across the year of observations due to selectivity constraint, as shown in Table 1. The results are also reportedly comparable with findings from south of Java, Bali, and Nusa Tenggara waters (Nurdin & Panggabean, 2018; Restiangsih & Amri, 2019; Satria & Kurnia, 2017). Since the condition factor is directly proportional to weight (Lima-Junior et al., 2002), the higher the weight given the same length information, the more significant their condition factor (Jisr et al., 2018). In other words, a positive allometry pattern could be a sign that the stock is still in good condition. Which is likely driven by a known high productivity area within the archipelagic waters (Nurdin et al., 2013, 2017), suitable for skipjack tuna's growth. In

addition, the length and weight relationship are essential for accessing total biomass by estimating mean weight by length classes and creating a raising factor to predict the whole size-frequency distribution for all fishes caught by the boat (Andrade & Campos, 2002). Furthermore, it is also possible to utilize the information to detect the discrepancy of particular fish in separated stocks King (2013).

The monthly median length distribution shifted positively from March to August in both locations. An indication of the occurrence of recruitment in the early months, as a direct effect of spawning season in the previous year (Restiangsih et al., 2020). Seasonal upwelling in the western part of Sumatra from October to March (Amri et al., 2013; Silubun et al., 2015) also attracts small fishes due to increased primary productivity. Therefore, the smaller size of skipjack tuna is often found in this particular period. A similar pattern also appeared in the southern (Zedta et al., 2017) and eastern part of Indonesian waters (Nugraha & Mardijah, 2017). However, it is still unclear how the mean length from Kutaraja was smaller than Sibolga when utilizing a similar configuration (Yusuf et al., 2020), probably due to the fishers in Kutaraja using the shorter version of the purse seine. In general, the average length size from all

locations was relatively smaller than those collected from Pacitan, East Java (Yusuf et al., 2019) and Manado, North Sulawesi (Kekenusa et al., 2012), even though using the same gear type. High fishing pressure, accompanied by non-selective gear (smaller mesh size), is touted to significantly affect the low selectivity of skipjack landed.

Most of the skipjack caught were immature or under their size at first maturity, 43.5-44.7 cm FL (Grande et al., 2014; Hartaty & Arnenda, 2019), allegedly closely related to the design of the gear. Most of the purse seiners in the western part of Sumatra are licensed to catch small pelagic fishes (PSPK) rather than large pelagic (PSPB) (unpublished data). However, an earlier study in Manado, North Sulawesi, showed no differences (Chodrijah & Setyadji, 2018). Thus, it negatively affected the large pelagic fishery because either PSPK or PSPB tend to have similar mesh sizes design. The effect, as illustrated above, almost all skipjack caught were still juveniles. Thus, low recruitment in the next year/season is expected, and if this is allowed to continue, it is feared that growth overfishing will occur, in which the fish never had a chance to grow and mature before it gets caught (Diekert, 2012).

In conclusion, based on some biological indicators, the skipjack stock's health in the western part of Sumatra is heading in an unsustainable direction. Because, although it still possesses a good condition factor, characterized by a high level of resilience (Dueri et al., 2012), and can quickly respond to increased fishing pressure by early maturation (Stergiou, 2002), if exploitation of smaller and immature skipjacks continues, there will be an imbalance between what is available (recruitment) and what can be exploited (spawning biomass) so the stock will likely collapse shortly. Anticipating such scenario, we recommend some management options, e.g., 1) hold any fishing activities between February and April where a lot of juvenile skipjacks are appearing, 2) applying a stricter inspection regarding the implementation of Ministerial Decree No. 71/PERMEN-KP/2016 about allowed mesh size measurement on purse seine fleet (above 2 inches), and 3) relocate or ban purse seine fleet from fishing in the territorial or archipelagic waters to protect the juvenile skipjack tuna's nursery and feeding ground.

4. Conclusions

Some biological indicators showed that the skipjack stock's health in the western part of Sumatra is heading towards an unsustainable

direction, indicated by the mean length of the fish caught was below its size at first maturity or mostly at an immature stage. Even though it has a good condition factor, an unequal proportion of new recruitment and what could be harvested could cause the stock collapse shortly. Mesh size limitation and time and area closure should be considered an option for further management action, accompanied by prolonged and continuous monitoring of the biological aspect of skipjack tuna in the future.

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