

Preliminary study of population parameters and spawning potential ratio (SPR) of skipjack tuna (*Katsuwonus pelamis*) in Indonesia

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Cover letter (purpose, expectation, conclusion, and recommendation)

This study aimed to estimate key biological and population parameters of skipjack tuna, including growth parameters, mortality rates, exploitation rate, and spawning potential ratio (SPR), using length-based stock assessment approaches. These parameters provide important information for evaluating the population dynamics of skipjack tuna in the Indian Ocean. Length-based methods are particularly useful for fisheries where detailed age-composition or long-term catch-at-age data are limited, as they allow population characteristics and stock status to be assessed from length-frequency data. The results are expected to provide scientific information to support fisheries stock assessment and the development of appropriate fisheries management measures in the Indian Ocean.

Abstract

This study estimated the population parameters, mortality rates, exploitation rate, and spawning potential ratio (SPR) of skipjack tuna (*Katsuwonus pelamis*) landed at 13 fishing ports along the Indian Ocean side of Indonesia from 2018 to 2021. A total of 126,994 fish were measured across seven fishing gear types, dominated by handlines (53.0%), purse seines (26.6%), and trolling lines (14.1%). Growth parameters were estimated at an asymptotic fork length (L_{∞}) of 78.48 cm, a growth coefficient (K) of 0.64 year⁻¹, and t_0 of 0.54 years. Total mortality (Z), natural mortality (M), and fishing mortality (F) were 3.38 year⁻¹, 1.034 year⁻¹, and 2.35 year⁻¹ respectively, resulting in an exploitation rate (E) of 0.6956. Length-based SPR (LB-SPR) analysis revealed relative fishing mortality (F/M) at approximately twice the natural mortality (2.01–2.08). The estimated model SPR values remained around 18–20% (0.18–0.20) of unfished levels, with length at 50% selectivity (SL_{50}) estimated between 30.85 cm and 31.73 cm. These findings provide essential biological evidence to support skipjack tuna assessment and fisheries management in Indonesia.

Keywords: skipjack tuna, population parameters, spawning potential ratio.

Introduction

Skipjack tuna (*Katsuwonus pelamis*) is one of the most important tropical tuna species in the Indian Ocean and supports fisheries, food supply, employment, and livelihoods of coastal communities. In Indonesia, skipjack tuna is exploited by a range of fishing gears operating in coastal and oceanic waters. The species is therefore an important component of Indonesian fisheries, particularly for communities that depend on tuna fisheries for income and food security. At the regional level, skipjack tuna is also one of the three tropical tuna species under the mandate of the Indian Ocean Tuna Commission (IOTC) (IOTC, 2025).

Information on population dynamics is essential for understanding the status and exploitation characteristics of fish stocks. Growth, mortality, and exploitation parameters provide important information for evaluating how a fish population responds to fishing pressure and for developing appropriate fisheries-management measures. In particular, the asymptotic length (L_{∞}) and growth coefficient (K) describe the growth characteristics of a population, while total mortality (Z), natural mortality (M), fishing mortality (F), and exploitation rate (E) provide information on the relative contribution of natural and fishing-related mortality (Ghosh et al., 2012).

The spawning potential ratio (SPR) is another useful indicator for evaluating the reproductive capacity of an exploited fish population. SPR represents the spawning potential of a fished population relative to the spawning potential that would be expected in the absence of fishing. Length-based SPR methods are particularly useful where detailed age-structured data, reproductive information, or long-term tagging data are unavailable. The LB-SPR approach uses the length composition of catches together with life-history parameters to estimate relative fishing mortality, selectivity-at-length, and SPR (Hordyk et al., 2015).

The information on population parameters and spawning potential of skipjack tuna based on length-frequency observations from multiple fishing ports remains important for understanding exploitation patterns. Therefore, this study aimed to estimate the population parameters, mortality rates, exploitation rate, and spawning potential ratio of skipjack tuna (*K. pelamis*) landed at fishing ports on the Indian Ocean side of Indonesia during 2018–2021

using length-based approaches. The results are intended to provide biological information that can support fisheries assessment and management of skipjack tuna.

Methods

Data collection

Data were collected from January 2018 to December 2021 at 13 fishing ports located on the Indian Ocean side of Indonesia (Figure 1). Data collection was conducted by fisheries enumerators at the landing sites. The enumerators recorded information on fishing activities and biological characteristics of the catch, including catch, fishing effort, species composition, and fork length (FL).

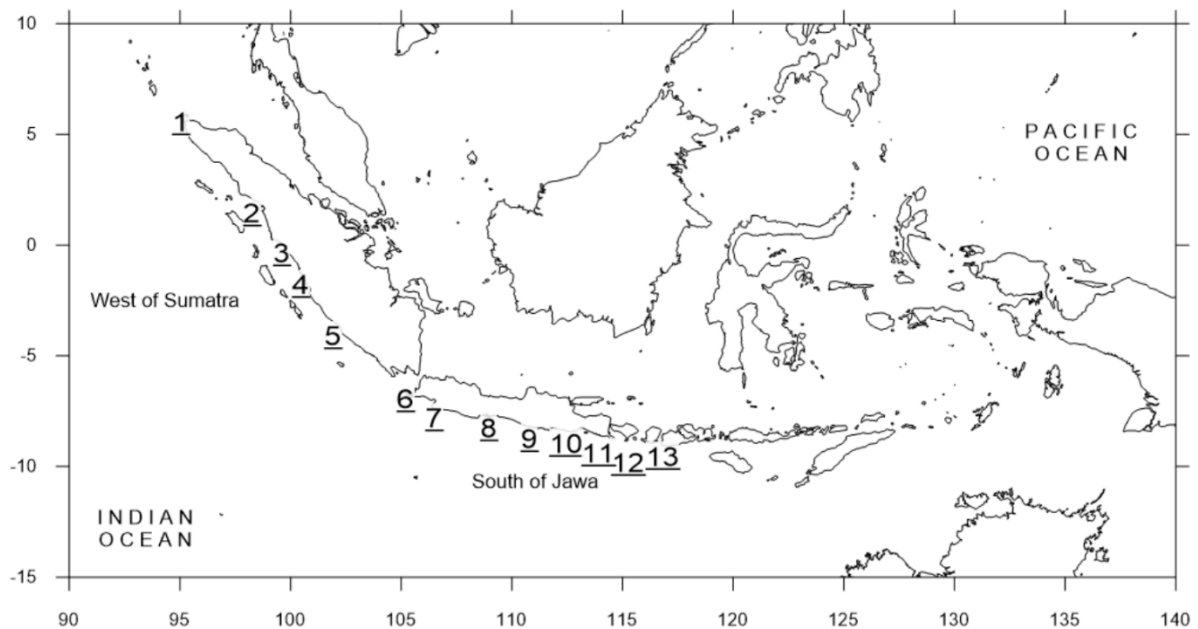


Figure 1. Data collection sites in 13 fishing ports in Indonesia: 1. Lampulo, 2. Sibolga, 3. Bungus, 4. Pasar Gaung, 5. Bengkulu, 6. Binuangeun, 7. Palabuhanratu, 8. Cilacap, 9. Pacitan, 10. Prigi, 11. Muncar, 12. Pengambangan, and 13. Labuhan Lombok.

Estimation of population parameters

Population parameters were estimated using a length-based approach. Growth was described using the von Bertalanffy growth function (VBGF) (Sparre & Venema, 1998):

$$L_t = L_{\infty}[1 - \exp\{-K(t - t_0)\}]$$

where L_t is the expected fork length at age t , L_∞ is the asymptotic length, K is the growth coefficient, and t_0 is the theoretical age when length is zero (Pauly, 1983).

Mortality and exploitation rate

Total mortality (Z) was estimated using a length-based mortality approach from the length-frequency data. Natural mortality (M) was estimated using the relationship which relates natural mortality to the von Bertalanffy growth parameters and mean environmental temperature.

Fishing mortality (F) was calculated from the relationship:

$$F = Z - M$$

The exploitation rate (E) was calculated as:

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

where Z is total mortality, M is natural mortality, and F is fishing mortality (Sparre et al., 1998).

Spawning potential ratio

The spawning potential ratio was estimated using the length-based spawning potential ratio (LB-SPR) approach. LB-SPR uses the observed length composition of the catch and life-history parameters to estimate the relative fishing mortality (F/M), selectivity-at-length, and SPR (Hordyk et al., 2015). The analysis was conducted separately for each year from 2018 to 2021.

The LB-SPR analysis produced estimates of:

- relative fishing mortality (F/M);
- length at 50% selectivity (SL_{50});
- length at 95% selectivity (SL_{95}); and

- spawning potential ratio (SPR).

Results

Fishing gears and length composition

A total of 126,994 skipjack tuna were measured during January 2018–December 2021 from 13 fishing ports on the Indian Ocean side of Indonesia. The fish were caught using seven fishing gears: handlines, purse seines, trolling lines, gillnets, lift nets, longlines, and pole-and-lines.

Handlines contributed the largest proportion of the sampled fish, accounting for approximately 53.0% of the total observations. Purse seines were the second-largest contributor, accounting for 26.6%, followed by trolling lines with 14.1%. The remaining observations were obtained from gillnets, lift nets, longlines, and pole-and-lines.

The average fork length differed among fishing gears. The largest mean fork length was observed in fish caught by gillnets, at 45.1 cm. In contrast, the smallest mean fork lengths were recorded for fish caught by lift nets (33.0 cm) and purse seines (34.0 cm) (Figure 2).

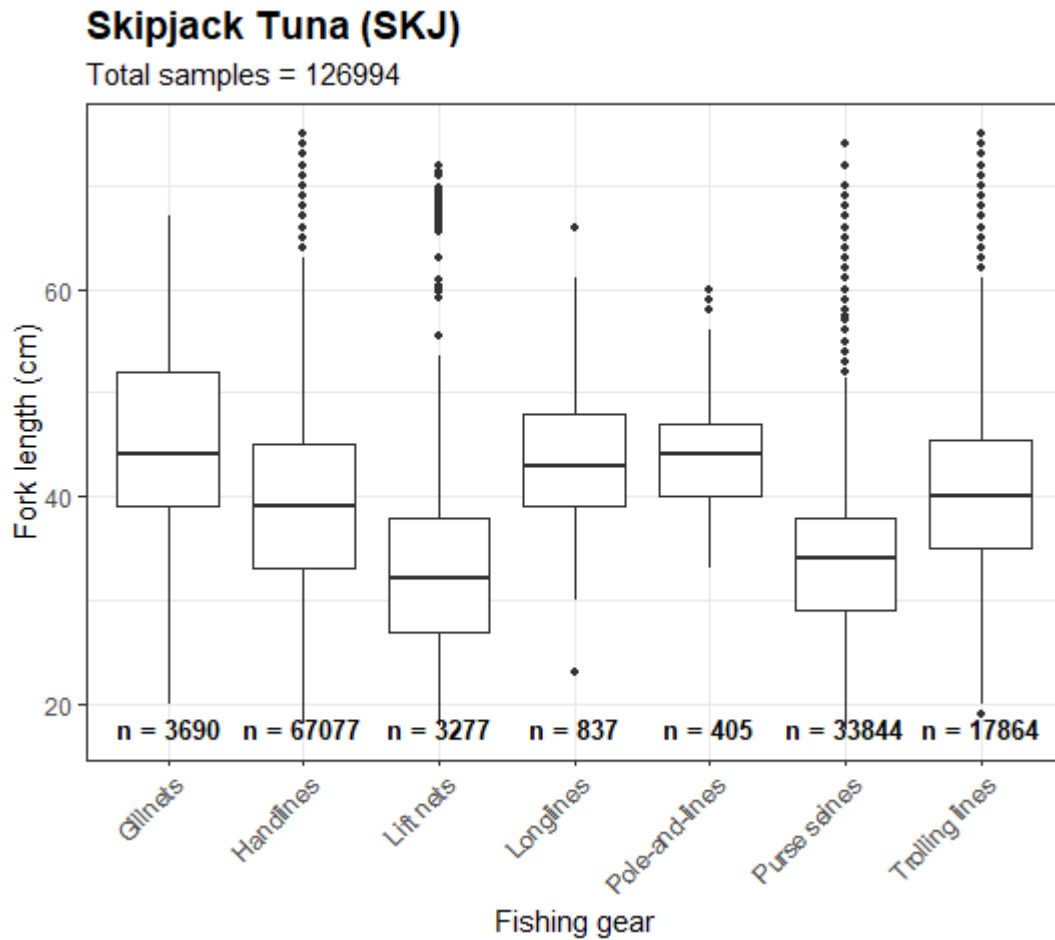


Figure 2. Length frequency of skipjack tuna (*K. pelamis*) from various gears in Indonesia.

Growth parameters

The length-based analysis estimated an asymptotic fork length (L_{∞}) of 78.48 cm, a growth coefficient (K) of 0.64 year⁻¹, and a theoretical age at zero length (t_0) of 0.54 years (Table 1).

The estimated L_{∞} indicates that the modeled population has an asymptotic fork length of approximately 78.5 cm (Figure 3). The relatively high K value indicates that skipjack tuna approaches its asymptotic size relatively rapidly. These parameters were subsequently used as inputs for the mortality and LB-SPR analyses.

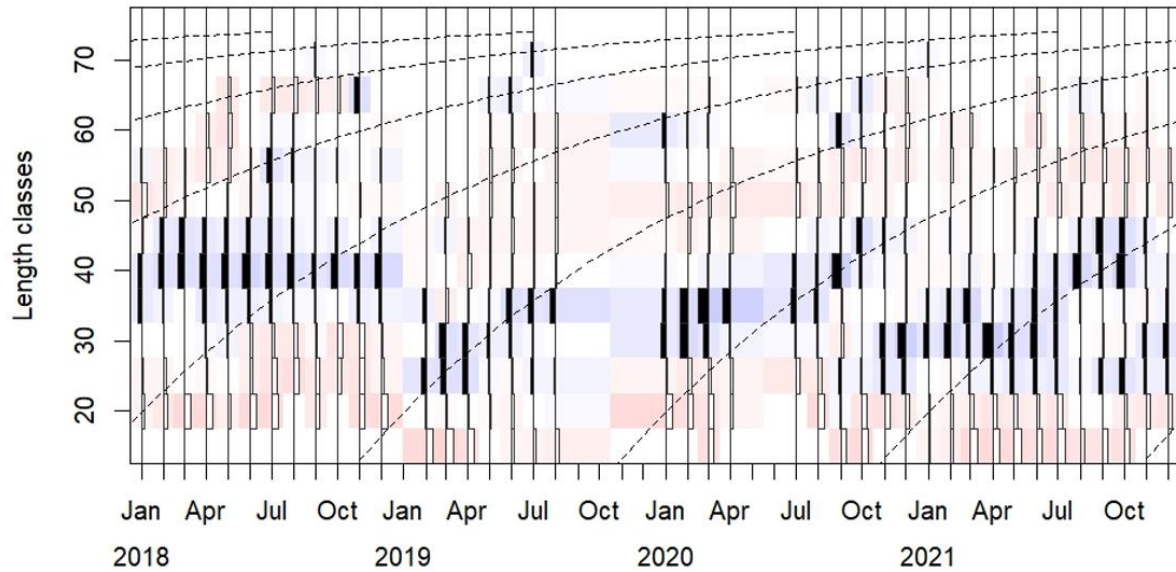


Figure 3. Monthly length frequency and Von Bertalanffy Growth Curve of skipjack tuna (*K. pelamis*) in Indonesia.

Mortality and exploitation

The estimated total mortality coefficient (Z) was 3.38 year^{-1} (Figure 4). Natural mortality estimated using the Pauly method was 1.034 year^{-1} , while fishing mortality was estimated at 2.35 year^{-1} . The resulting exploitation rate was 0.69 (Table 1):

$$E = \frac{2.35}{3.38} = 0.69$$

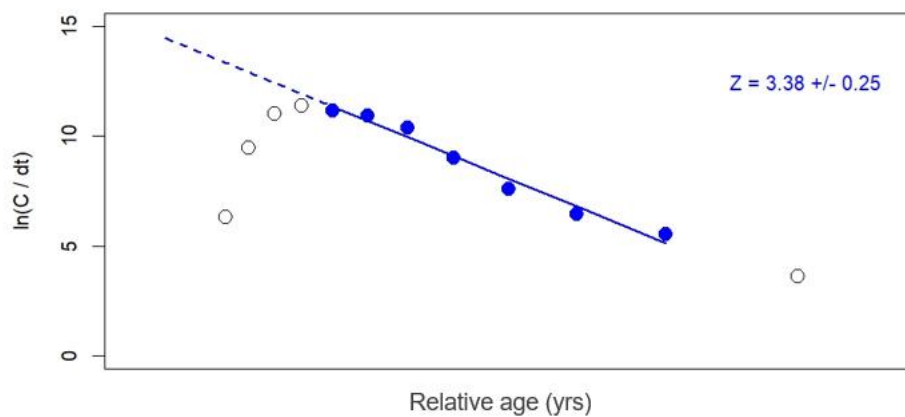


Figure 4. Length converted catch-curve (LCCC) for skipjack tuna (*K. pelamis*) in Indonesia.

Spawning potential ratio and selectivity

The LB-SPR analysis produced annual estimates of relative fishing mortality, selectivity-at-length, and spawning potential ratio for 2018–2021 (Table 1).

The reported SPR values were 0.33, 0.07, 0.20, and 0.15 for 2018, 2019, 2020, and 2021, respectively. The corresponding estimated SPR values from Ests(SPR) were 0.20, 0.18, 0.18, and 0.18, respectively. Thus, the estimated SPR values from the model output were relatively consistent after 2019, remaining around 0.18.

The estimated F/M values from Ests(FM) were 2.01, 2.08, 2.03, and 2.03 for 2018–2021, respectively. These values indicate that relative fishing mortality was estimated at approximately twice the natural mortality during the four-year period.

The estimated length at 50% selectivity (SL_{50}) from Ests(SL_{50}) ranged from 30.85 to 31.73 cm, while the estimated length at 95% selectivity (SL_{95}) ranged from 38.62 to 39.81 cm (Figure 5).

The relatively stable Ests(SPR) values suggest that the estimated spawning potential remained at approximately 18–20% of the unfished level during 2018–2021 under the assumptions of the LB-SPR model. The SL_{50} estimates also showed relatively little annual variation, decreasing from 31.73 cm in 2018 to 30.85 cm in 2021. Similarly, SL_{95} decreased from 39.81 to 38.62 cm.

Table 1. LB-SPR results for skipjack tuna (*K. pelamis*) in Indonesia from 2018–2021.

LB-SPR parameter	2018	2019	2020	2021
SPR	0.33	0.07	0.20	0.15
FM	1.32	3.26	1.54	2.05
SL_{50} (cm)	37.92	27.28	29.90	29.89
Ests(SL_{50}) (cm)	31.73	31.15	30.95	30.85
Ests(SL_{95}) (cm)	39.81	39.06	38.73	38.62
Ests(FM)	2.01	2.08	2.03	2.03
Ests(SPR)	0.20	0.18	0.18	0.18

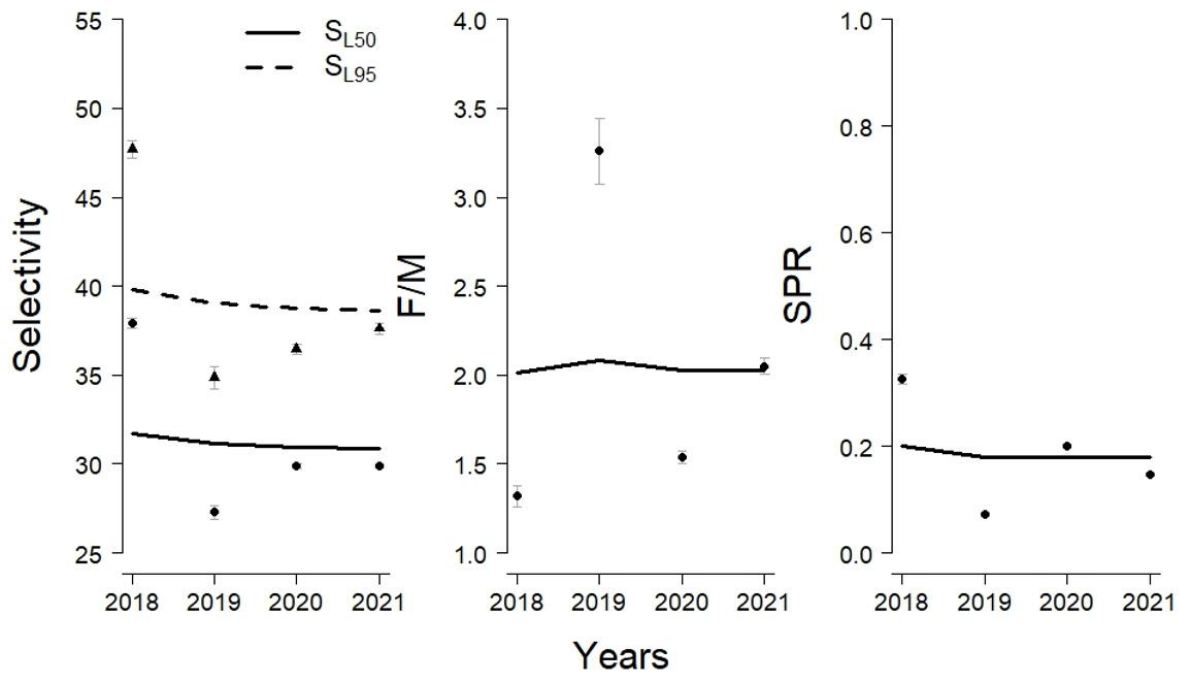


Figure 5. Yearly selectivity, F/M ratio and Spawning Potential Ratio (SPR) of skipjack tuna (*K. pelamis*) in Indonesia from 2018-2021.

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