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Dynamics of Utilization and Sustainable Production Potential of Narrow-barred Spanish Mackerel (*Scomberomorus commerson*) in the Waters of Tanjung Jabung Barat Regency, Jambi

Dinamika Pemanfaatan dan Potensi Produksi Lestari Ikan Tenggiri (Scomberomorus commerson) di Perairan Kabupaten Tanjung Jabung Barat, Jambi

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Abstract

Narrow-barred Spanish mackerel *(Scomberomorus commerson)* is a high-value large pelagic fish resource extensively exploited by fishers in Tanjung Jabung Barat waters, Jambi Province. This study aimed to analyze the Maximum Sustainable Yield (MSY) and utilization rate of mackerel based on production and fishing effort data from 2019 to 2023. The Schaefer surplus production model was applied with fishing effort standardization using the Fishing Power Index (FPI). Fishing gears operating in the area included a lift net (bagan perahu), hand line, group purse seine, one boat purse seine, bottom long line, and troll line. Group purse seine was selected as the standard gear with a CPUE of 525.83 kg/unit. The MSY was estimated at 60,753.94 kg year^{-1} with an optimum fishing effort (Eopt) of 208.98 standardized units. The Total Allowable Catch (TAC) was 48,603.15 kg year^{-1} (80% MSY). The average utilization rate over the study period was 22.76%, and the average effort rate was 12.58%. All utilization and effort rates were below 60%, indicating underfishing. This condition suggests there is still potential for sustainable increases in fishing effort in these waters.

Keywords: Mackerel, Fishing Power Index, MSY

Abstrak

Ikan tenggiri *(Scomberomorus commerson)* merupakan salah satu sumber daya ikan pelagis besar bernilai ekonomis tinggi yang banyak dimanfaatkan oleh nelayan di perairan Tanjung Jabung Barat, Provinsi Jambi. Penelitian ini bertujuan menganalisis potensi lestari (Maximum Sustainable Yield/MSY) dan tingkat pemanfaatan ikan tenggiri berdasarkan data produksi dan upaya penangkapan tahun 2019–2023. Metode yang digunakan adalah model surplus produksi Schaefer dengan standarisasi upaya penangkapan menggunakan Fishing Power Index (FPI). Alat tangkap yang beroperasi meliputi bagan perahu, pancing ulur, group purse seine, one boat purse seine, rawai dasar, dan pancing tonda. Alat tangkap standar adalah group purse seine dengan CPUE 525,83 kg/unit. Nilai MSY yang diperoleh sebesar 60.753,94 kg/tahun dengan upaya penangkapan optimum (Eopt) sebesar 208,98 unit standar. Jumlah Tangkapan yang Diperbolehkan (JTB) sebesar 48.603,15 kg/tahun (80% MSY). Rata-rata tingkat

pemanfaatan selama periode penelitian adalah 22,76% dan rata-rata tingkat pengupayaan sebesar 12,58%. Seluruh nilai tingkat pemanfaatan dan pengupayaan berada di bawah 60%, sehingga status pemanfaatan ikan tenggiri tergolong rendah (*underfishing*). Kondisi ini mengindikasikan masih terdapat peluang peningkatan upaya penangkapan secara berkelanjutan di perairan tersebut.

Kata kunci: Ikan tenggiri, Fishing Power Index, MSY

1. Introduction

Narrow-barred Spanish mackerel (*Scomberomorus commerson*) belongs to the family Scombridae and is a large pelagic fish with high economic value in both local and international markets. This species is carnivorous, highly active, and widely distributed throughout the tropical and subtropical waters of the Indo-Pacific region, including Indonesian waters (Noegroho & Hidayat, 2014; Pane et al., 2020). In Indonesia, narrow-barred Spanish mackerel is one of the leading pelagic fishery commodities, with its catch continuing to increase in response to growing market demand. The waters of Tanjung Jabung Barat are one of the major marine fishing grounds in Jambi Province, with considerable potential for pelagic fish resources, including narrow-barred Spanish mackerel. Fishers in this area employ various fishing gears to target this species, including group purse seines, one-boat purse seines, boat lift nets, hand lines, bottom longlines, and trolling lines. The diversity of fishing gears necessitates standardizing fishing effort before calculating catch per unit effort (CPUE) as an index of relative stock abundance (Yunita et al., 2023).

Effective and sustainable fisheries resource management requires reliable scientific information on fish stock status and exploitation levels. The Schaefer surplus production model is widely used to estimate sustainable fishery potential because of its holistic approach, which uses time-series data on catch and fishing effort (Suwardi et al., 2023). The model assumes the fish population is at equilibrium and allows direct estimation of Maximum Sustainable Yield (MSY) and the optimum fishing effort (Eopt) via a linear regression of CPUE on fishing effort. The Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia No. 19 of 2022 stipulates that the Total Allowable Catch (TAC) should be set at 80% of the Maximum Sustainable Yield (MSY) as a reference for sustainable fisheries management. Previous studies on narrow-barred Spanish mackerel stocks in Indonesian waters have demonstrated that excessive fishing pressure can result in substantial declines in fish production, as observed at the Sungai Rengas Fishing Port in West Kalimantan (Suwardi et al., 2023).

To date, adequate scientific information on the stock status and sustainable potential of narrow-barred Spanish mackerel in Tanjung Jabung Barat waters remains lacking. Therefore, this study aims to: (1) estimate the Maximum Sustainable Yield (MSY) and optimum fishing effort (Eopt) of narrow-barred Spanish mackerel; (2) determine the Total Allowable Catch (TAC) based on the prevailing fisheries regulations; and (3) evaluate the levels of resource utilization and fishing effort for narrow-barred Spanish mackerel in the waters of Tanjung Jabung Barat as a basis for recommending sustainable fisheries management strategies.

2. Material and Method

2.1. Time and Place

This study was conducted using secondary data on the catch production and fishing effort of narrow-barred Spanish mackerel obtained from the Fisheries Port and the Marine and Fisheries Office of Jambi Province, covering the period from 2019 to 2023.

2.2. Methods

The Stock assessment was performed using the Schaefer surplus production model through the following analytical procedures:

2.2.1. Standardization of Fishing Effort

Since fishers used multiple fishing gears to catch narrow-barred Spanish mackerel, fishing effort was standardized using the Fishing Power Index (FPI) method. The FPI value for each fishing gear was calculated by dividing its catch per unit effort (CPUE) by the CPUE of the standard fishing gear, which was selected based on having the highest CPUE (Listiani et al., 2017): FPIi = CPUEi / CPUEstd.

The standardized fishing effort for each fishing gear was calculated by multiplying the Fishing Power Index (FPI) by its corresponding actual fishing effort. The total standardized annual fishing effort was obtained by summing the standardized annual fishing effort for all gear types.

2.2.2. CPUE Analysis

Catch per unit effort (CPUE) was calculated as the ratio of catch (kg) to the total standardized fishing effort per year: $CPUE = C / E$

2.2.3. Schaefer Surplus Production Model

The relationship between catch per unit effort (CPUE) (Y) and standardized fishing effort (X) was analyzed using simple linear regression (Suwardi et al., 2023): $CPUE = a + b \cdot E$

The MSY and Eopt were derived from the regression equation as follows: $Eopt = -a /(2b)$; $MSY = -a^2 / (4b)$

The Total Allowable Catch (TAC) was determined as 80% of the Maximum Sustainable Yield (MSY) in accordance with the Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia No. 19 of 2022.

2.2.4. The Resource Utilization Level and the Fishing Effort Level

The level of resource utilization (TP) and the fishing effort level (TPU) were calculated as the ratio of the observed (actual) values to their respective optimum values (Noegroho & Hidayat, 2014):

$$TP = (Ci / MSY) \times 100\% \quad ; \quad TPU = (Ei / Eopt) \times 100\%$$

The categories of resource utilization level were based on the Decree of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia (Kepmen KP) No. 19 of 2022, namely: low (<60%), developing (60–80%), fully exploited (80–100%), and overfished (>100%).

3. Result and Discussion

3.1. Standardization of Fishing Effort

Based on production and fishing effort data collected during the 2019–2023 period, six fishing gear types were used to catch narrow-barred Spanish mackerel in the waters of Tanjung Jabung Barat Regency, namely boat lift nets, handlines, group purse seines, one-boat purse seines, bottom longlines, and trolling lines. The CPUE and Fishing Power Index (FPI) values for each fishing gear are presented in Table 1.

Table 1. Fishing Power Index (FPI) Values of Fishing Gear Used for Narrow-Barred Spanish Mackerel (Scomberomorus commerson) in the Waters of Tanjung Jabung Barat Regency, 2019–2023

No	Fishing Gear	Production (kg)	Effort (unit)	CPUE (kg/unit)	FPI
1	Boat lift net	12.200	40	305,00	0,5800
2	Handline	20	2	10,00	0,0190
3	Group Purse Seine*	6.310	12	525,83	1,0000
4	One Boat Purse Seine	48.920	216	226,48	0,4307
5	Bottom longline	200	2	100,00	0,1902
6	Troll line	1.495	26	57,50	0,1094

Note: * = Standard fishing gear (FPI = 1.00)

As shown in Table 1, the group purse seine exhibited the highest CPUE (525.83 kg/unit) and was therefore selected as the standard fishing gear (FPI = 1.00). Boat lift nets ranked second with an FPI of 0.58, followed by one-boat purse seines (0.43), bottom longlines (0.19), trolling lines (0.11), and handlines (0.02). The substantial variation in FPI values among fishing gear types indicates significant differences in fishing efficiency. As active fishing gear, the group purse seine can encircle schools of fish over a relatively large area, resulting in considerably higher catch efficiency than passive gears such as handlines. This finding is consistent with the study by Listiani et al. (2017), which reported that purse seines are consistently selected as the standard fishing gear due to their superior efficiency in pelagic fisheries. The selection of the group purse seine as the standard gear in the present study is also consistent with the approach adopted in similar studies conducted in the Sunda Strait and Bali Strait (Listiani et al., 2017).

3.2. Standardized Catch Production and Fishing Effort

Following the standardization process, annual data on catch production, standardized fishing effort, and CPUE of narrow-barred Spanish mackerel for the 2019–2023 period were obtained, as presented in Figure 1. The total catch production during the study period was 69,145 kg, with a cumulative standardized fishing effort of 131.50 units. The highest catch production was recorded in 2022 (30,886 kg), while the lowest was in 2021 (3,432 kg). Figure 1 shows that fluctuations in catch production were not consistent with the pattern of standardized fishing effort throughout the study period. Catch production increased sharply in 2022 before declining again in 2023, while standardized fishing effort also peaked in 2022 and subsequently decreased. The substantial decline in catch production observed in 2021 (3,432 kg), despite a recorded standardized fishing effort of 7.17 units, was likely associated with seasonal variability and natural fluctuations in the abundance of narrow-barred Spanish mackerel. This species is a pelagic fish whose distribution and migration are strongly influenced by sea surface temperature, ocean currents, and prey availability (Noegroho & Hidayat, 2014). A similar pattern was reported by Suwardi et

al. (2023) at Sungai Rengas Fishing Port, West Kalimantan, where the production of narrow-barred Spanish mackerel declined from 113.826 ton in 2018 to 66.318 ton in 2021, which was attributed to changes in oceanographic conditions and increasing fishing pressure.

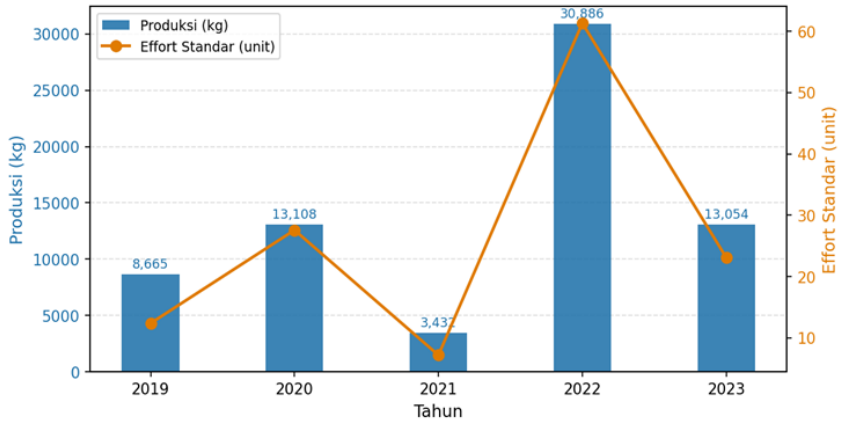

Figure 1. Annual catch production and standardized fishing effort of narrow-barred Spanish mackerel in the waters of Tanjung Jabung Barat Regency, 2019–2023.

3.3. Catch Per Unit Effort (CPUE)

The standardized CPUE of narrow-barred Spanish mackerel is presented in Figure 2. The CPUE fluctuated throughout the study period, with the highest value recorded in 2019 (700.77 kg/unit) and the lowest in 2020 (475.49 kg/unit).

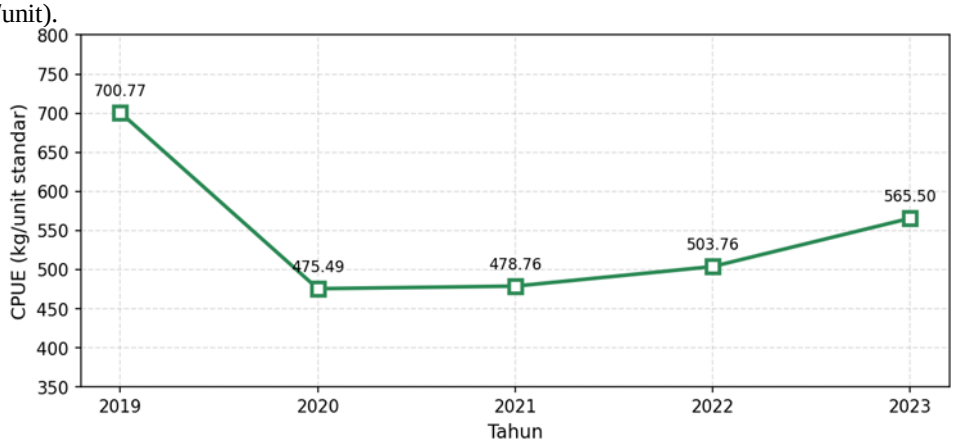

Figure 2. Fluctuations in the standardized catch per unit effort (CPUE) of the narrow-barred Spanish in the waters of Tanjung Jabung Barat Regency, 2019–2023

Figure 2 shows that the standardized CPUE did not exhibit a consistent decline despite increases in fishing effort over several years of the study period. Overall, CPUE fluctuated without a distinct pattern, a characteristic commonly observed in tropical pelagic fisheries, where environmental conditions and seasonal variability strongly influence catch rates. In the Schaefer surplus production model, CPUE is used as an index of relative stock abundance, with a decline in CPUE accompanied by increasing fishing effort indicating a reduction in stock biomass (Suwardi et al., 2023; Noegroho & Hidayat, 2014). However, this pattern was not evident in the present study, suggesting that the stock has not yet experienced significant fishing pressure. This interpretation is supported by the low coefficient of determination (R^2 = 0.098) for the CPUE–effort regression, indicating that fishing effort explained only 9.8% of the variation in CPUE. Environmental factors, including fishing season, sea surface temperature, and local oceanographic dynamics, are therefore likely to be the dominant drivers of CPUE fluctuations in the waters of Tanjung Jabung Barat Regency. These findings are consistent with those reported by Pane et al. (2020), who demonstrated that seasonal conditions strongly influence the abundance of narrow-barred Spanish mackerel in the Arafura Sea.

3.4. Maximum Sustainable Yield (MSY) and TAC Analysis Using the Schaefer Model

Linear regression analysis between CPUE and standardized fishing effort produced the following equation: CPUE = 581.44 − 1.39E (R^2 = 0.098). The estimated Maximum Sustainable Yield (MSY), Effort Optimum (Eopt), and Total Allowable Catch (TAC) are presented in Figure 3 and Table 2.

Figure 3 illustrates the Schaefer surplus production curve for narrow-barred Spanish mackerel in the waters of Tanjung Jabung Barat Regency. The peak of the curve occurred at an Effort optimum (Eopt) of 208.98 standardized units, corresponding to an estimated Maximum Sustainable Yield (MSY) of 60,753.94 kg $year^{-1}$. All

observed catch data (red points) were located well below the MSY curve, indicating that the current level of exploitation remains substantially below the estimated sustainable production potential. The Total Allowable Catch (TAC), established at 80% of the MSY in accordance with the Indonesian Ministerial Decree of Marine Affairs and Fisheries No. 19/2022, was estimated at 48,603.15 kg year^{-1}. The estimated MSY in the present study is lower than that reported for narrow-barred Spanish mackerel in the waters of Indramayu (approximately 643.26 t year^{-1}) (Hakim et al., 2014), but higher than estimates reported for several other fishing grounds in Indonesia. Such differences are expected due to variations in ecosystem productivity and in the spatial scale of fisheries management. The regression intercept (a = 581.44) represents the potential CPUE under an unexploited (virgin stock) condition, whereas the regression slope (b = −1.39) describes the rate of CPUE decline with increasing fishing effort. The negative but relatively small slope coefficient suggests that the narrow-barred Spanish mackerel stock in these waters retains relatively high intrinsic productivity and has not yet been subjected to excessive fishing pressure (Suwardi et al., 2023).

Table 2. Results of the Schaefer surplus production model analysis for narrow-barred Spanish mackerel in the waters of Tanjung Jabung Barat Regency

Parameter	Value	Unit
Regression intercept (a)	581,44	–
Regression slope (b)	−1,39	–
Coefficient of determination (R^2)	0,098	–
Effort Optimum (Eopt)	208,98	standardized units
MSY (Cmsy)	60.753,94	kg/year
TAC (80% MSY)	48.603,15	kg/year

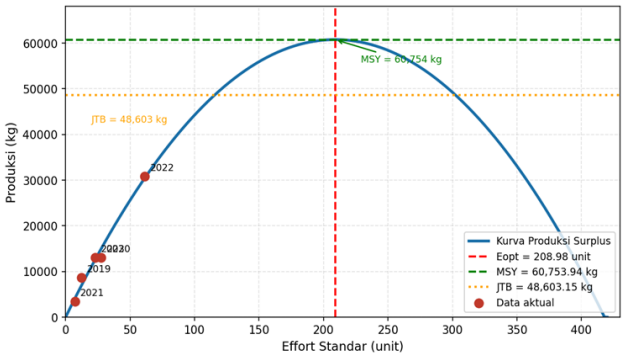

Figure 3. Maximum Sustainable Yield (MSY) curve for narrow-barred Spanish mackerel in the waters of Tanjung Jabung Barat Regency

3.5. Exploitation and Fishing Effort Levels

The exploitation level (EL) and fishing effort level (FEL) of narrow-barred Spanish mackerel in the waters of Tanjung Jabung Barat Regency during the 2019–2023 period are presented in Table 3. Both the exploitation level (EL) and fishing effort level (FEL) remained well below the 60% threshold throughout the study period. The highest EL was recorded in 2022 at 50.84%, while the lowest occurred in 2021 at 5.65%, with an average of 22.76%. Similarly, the highest FEL was observed in 2022 at 29.34%, whereas the lowest was recorded in 2021 at 3.43%, with an average of 12.58%. According to the classification established by the Indonesian Ministerial Decree of Marine Affairs and Fisheries No. 19/2022, all years of the study fall within the underfishing category (EL and FEL < 60%). These findings indicate that the narrow-barred Spanish mackerel stock in the waters of Tanjung Jabung Barat Regency has not yet been exploited to its optimum sustainable level.

Table 3. Exploitation and fishing effort levels of narrow-barred Spanish mackerel in the waters of Tanjung Jabung Barat Regency, 2019–2023

Year	Catch Production (kg)	Cmsy (kg)	Exploitation Level (%)	Effort Std (unit)	Eopt (unit)	Fishing Effort Level (%)
2019	8.665	60.753,94	14,26	12,37	208,98	5,92
2020	13.108	60.753,94	21,58	27,57	208,98	13,19
2021	3.432	60.753,94	5,65	7,17	208,98	3,43
2022	30.886	60.753,94	50,84	61,31	208,98	29,34
2023	13.054	60.753,94	21,49	23,08	208,98	11,05
Average	13.829	–	22,76	26,30	–	12,59

Note: EL = Exploitation Level; FEL = Fishing Effort Level; MSY = 60,753.94 kg year^{-1}; Eopt = 208,98 unit

The relatively low exploitation level observed in this study may be attributed to several factors, including (1) the limited number of fishing vessels and fishing gear operating in the area, (2) the low frequency of fishing trips

due to financial and technological constraints faced by fishers, and (3) the seasonal migratory behavior of narrow-barred Spanish mackerel, resulting in its irregular availability throughout the year (Noegroho & Hidayat, 2014; Silma et al., 2025). These findings are consistent with those of Silma et al. (2025), who investigated the population dynamics of narrow-barred Spanish mackerel at Sukadana Coastal Fishing Port, West Kalimantan, and reported an exploitation rate (E = 0.32/year), indicating an underfished stock. In contrast, Suwardi et al. (2023) reported that the narrow-barred Spanish mackerel fishery at Sungai Rengas Fishing Port experienced considerably higher fishing pressure than that observed in the waters of Tanjung Jabung Barat Regency. This difference in exploitation status likely reflects variations in fishing intensity and local stock conditions between the two fishing grounds.

The marked increase in the exploitation level in 2022 (50.84%) corresponded to the substantial increase in catch production during the same year (30,886 kg). Although this value was the highest recorded during the study period, it remained well below the threshold generally associated with intensive exploitation (80–100%). This finding suggests that fishing effort could still be increased without compromising stock sustainability, provided that the annual catch remains below the Total Allowable Catch (TAC) of 48,603.15 kg year^{-1}. Nevertheless, continuous monitoring is recommended because future increases in fleet size and fishing intensity may alter the exploitation status of the stock (Pane et al., 2020)

4. Conclusions

Based on the Schaefer surplus production model applied to the narrow-barred Spanish mackerel fishery in the waters of Tanjung Jabung Barat Regency during the 2019–2023 period, the estimated Maximum Sustainable Yield (MSY) was 60,753.94 kg year^{-1}, with an optimum fishing effort (Eopt) of 208.98 standardized units. The estimated Total Allowable Catch (TAC), set at 80% of the MSY, was 48,603.15 kg year^{-1}. The average exploitation level and fishing effort level during the study period were 22.76% and 12.58%, respectively. Both values remained below the 60% threshold, indicating that the fishery is currently in an underfishing condition.

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