Stock assessment of yellowtail fusilier in Karimunjawa Islands, Indonesia

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Abstract. This study analyzed the population parameters of yellowtail fusilier (*Caesio cuning*) in Karimunjawa waters to inform strategies for sustainable management. Sampling was carried out over 13 months (July 2024-July 2025) at major fish trading centers on Karimunjawa and Kemujan Islands. A total of 1,583 individuals were measured for total length (TL, cm) and body weight (W, g) to estimate growth parameters, exploitation rates, and recruitment patterns. The results showed a negative allometric length–weight relationship. The length at first capture (Lc50%) was 19.8 cm TL, the growth coefficient (K) was 0.86 per year, and the exploitation rate (E) was 0.61, exceeding the optimal limit (E = 0.5). These values indicate overexploitation. Recruitment analysis revealed a continuous year-round pattern, with a peak between May and June. Overall, the findings confirm that the *C. cuning* population in Karimunjawa Islands is experiencing high fishing pressure.
Key Words: *Caesio cuning,* Karimunjawa Islands, exploitation rate, length-weight relationship, Lc50%.

Introduction. The yellowtail fusilier (*Caesio cuning* (Bloch, 1791)) is a member of the family Caesionidae that live in coral reefs in coastal waters around the Indo-West Pacific region, including the Karimunjawa Islands. As a planktonivore (primarily zooplanktivorous), its main diet consists of pelagic zooplankton such as copepods, pteropods, salps, doliolids, chaetognaths, and other planktonic organisms. *C. cuning* feeds on zooplankton, allowing it to play an important role in transferring energy from plankton (lower trophic levels) to higher trophic levels in the food chain (Carpenter 1988; Kuiter & Tonozuka 2001; Friedlander & DeMartini 2002; Allen & Erdmann 2012; Ayodya et al 2021).

The yellowtail fusilier is a primary target species for fishermen in the Karimunjawa Islands (Ayodya et al 2021; Nursalim et al 2022) for its abundance, ease of capture, and strong market demand. The price of yellowtail fusilier in Karimunjawa fluctuates around IDR 20,000 per kg from seasonal changes, with prices being higher during the lean season than the peak season. The school of yellowtail fusilier around coral reefs makes catching easier. Its relatively fast reproductive frequency has made the stock of the fish abundant (Guerra 2020; Yuliana et al 2020; Ayodya et al 2021; Nursalim et al 2022; Kar et al 2023).

The Karimunjawa Islands was designated as a National Park in 1986. Karimunjawa Islands cover over 110,000 hectares of area, with some coral reef, seagrass, and mangrove ecosystems under the Marine Protected Area (MPA). MPA serves as "source area" or breeding stock area to protect reef fish biomass which will support the ecosystem outside this zone, including the yellowtail fusilier (Lester et al 2009; Edgar et al 2014; Yuliana et al 2020). The development of tourism in Karimunjawa Islands has brought economic benefits, yet puts direct and indirect pressures on the marine resources, including the greater demand for seafood (for consumption and bait), more intensive fishing, and habitat degradation (e.g., from anchoring, snorkeling, diving, and pollution). These factors simultaneously add the pressure on fish stocks, including yellowtail fusilier (Mous et al 2005; Madduppa et al 2013; Campbell et al 2013; Kennedy et al 2020). The present research was intended to analyze the biological characteristics and exploitation status of yellowtail fusilier in the Karimunjawa Islands.

Material and Method

Research location and time. The research was conducted in the Karimunjawa Islands (Figure 1) from July 2024 to July 2025. Fish data collection was carried out on Karimunjawa and Kemujan Islands, the two largest islands and main economic and fish trading centers in the archipelago.

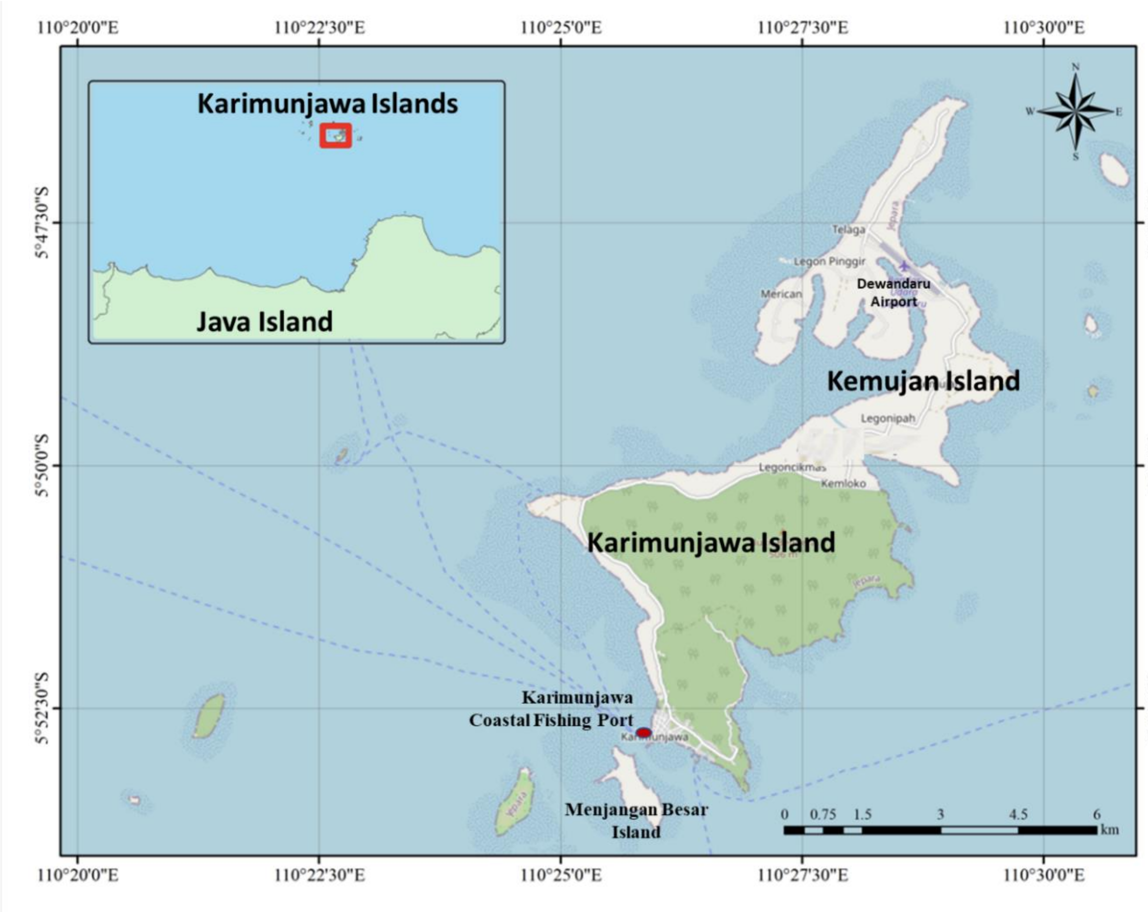

Figure 1. Karimunjawa Islands (research location).

Research materials. Morphometric data for yellowtail fusilier were obtained by measuring total length (TL, cm) and body weight (W, gr) from 1,583 fish samples collected from different fish trading locations. The sampling was conducted over 13 months, from July 2024 to July 2025, with a frequency of five days per month.

Analysis method. Data analysis was performed using Microsoft Excel and FiSAT II software. Fish growth parameters, including asymptotic length ($L\infty$) and growth coefficient (K) were measured using the ELEFAN I (Electronic Length Frequency Analysis) method based on Von Bertalanffy's growth model. t_0 was calculated using Gulland's empirical formula, while total mortality (Z) was calculated on FiSAT II. Natural mortality (M) was calculated using Pauly's empirical formula that included the average water temperature factor. The length at first capture (Lc50%) and length at first maturity (Lm) were also analyzed to determine the length-weight relationship using the folowing formulas:

$$W = a L^b \quad (1)$$

$$Ln\ W = Ln\ a + b\ Ln\ L \quad (2)$$

$$Lt = L_\infty (1-e^{-k(t-t0)}) \quad (3)$$

$$Log(-t_0) = -0.3922 - 0.2752\ Log\ L_\infty - 1.038\ Log\ K \quad (4)$$

$$Log\ (M) = -0.0066 - 0.279\ Log\ L_\infty + 0.6543\ Log\ K + 0.4634\ Log\ T \quad (5)$$

$$F = Z - M \quad (6)$$

$E = F/Z$ .... (7)

$E_{MSY} = 0.5$ .... (8)

where: W = fish weight (g);
L = total length (cm);
a and b = length-weight relationship constants;
$L\infty$ = asymptotic length (cm);
K = growth coefficient (per year);
t = fish age (years);
t_0 = theoretical age at which length equals zero (years);
T = water temperature (assumed 28°C);
Z = total mortality;
M = natural mortality;
F = fishing mortality;
E = exploitation rate.

The theoretical basis and formulas used in this analysis refer to Sparre & Venema (1998), Gayanilo et al (2005), Dutta (2023), and Wijayanto et al (2025).

Results. Figure 2 presents the results of the length-weight analysis, where the length-weight relationship for yellowtail fusilier is shown by the equation $W = 0.0201L^{2.8357}$ with an R^2 value of 0.9106.

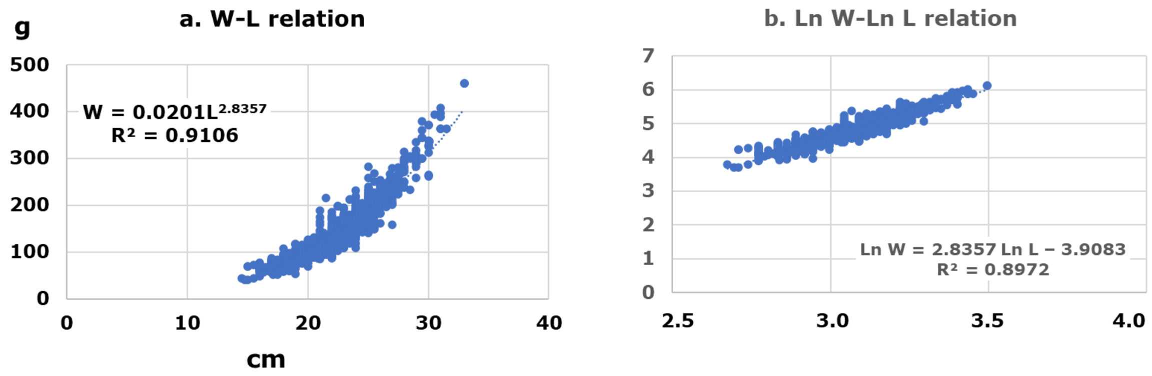

Figure 2. Length-weight relationship of yellowtail fusilier.

Figure 3 shows that the length at first capture (Lc50%) for yellowtail fusilier in Karimunjawa waters is approximately 19.8 cm TL. This value was obtained from the length frequency distribution analysis, which generated a sigmoid curve with a midpoint at 19.8 cm, indicating that 50% of the fish population becomes vulnerable to capture at this length.

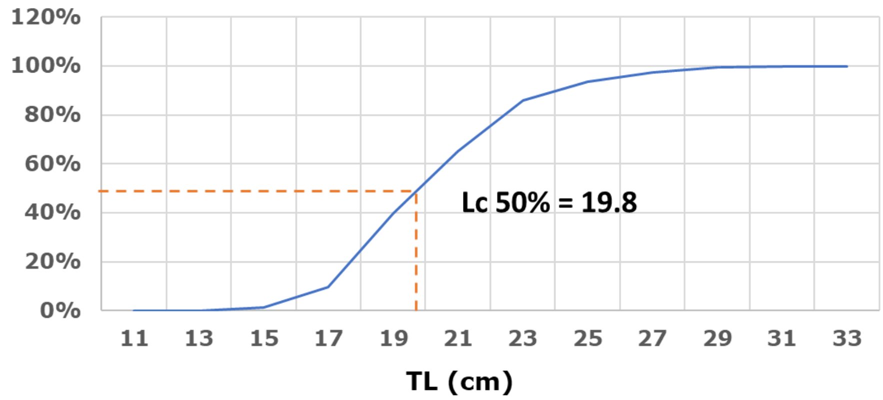

Figure 3. Lc50% analysis of yellowtail fusilier

The total length (TL) composition data from the data and the exploitation rate analysis are shown in Table 1 and Table 2, respectively.

Table 1

Size composition of yellowtail fusilier

Interval of TL (cm)	*Middle value*	*Frequency*	*Percentage*	*Cumulative percentage*
10.0-12.0	11.0	1	0.06%	0.06%
12.1-14.0	13.0	0	0.00%	0.06%
14.1-16.0	15.0	20	1.26%	1.33%
16.1-18.0	17.0	130	8.21%	9.54%
18.1-20.0	19.0	481	30.39%	39.92%
20.1-22.0	21.0	398	25.14%	65.07%
22.1-24.0	23.0	333	21.04%	86.10%
24.1-26.0	25.0	118	7.45%	93.56%
26.1-28.0	27.0	63	3.98%	97.54%
28.1-30.0	29.0	29	1.83%	99.37%
30.1-32.0	31.0	8	0.51%	99.87%
32.1-34.0	33.0	2	0.13%	100.00%

Table 2

Growth, mortality, and exploitation parameters of yellowtail fusilier

Location	*L∞ (cm)*	*K*	*M*	*F*	*Z*	*E*	*Status*	*Reference*
Karimunjawa	36.65	0.86	1.53	2.44	3.97	0.61	Over exploited	Present study
Karimunjawa	38.69	0.22	0.33	1.69	2.02	0.84	Over exploited	Putra et al (2024)
Karimunjawa	36.23	0.42	0.99	0.68	1.67	0.41	Sustainable	Yuliana et al (2016)
The Seribu Islands	38	0.4	0.8	1.008	1.8	0.56	Over exploited	Zamani et al (2011)
Philippines	34.50	0.65	1.30	2.60	3.90	0.67	Over exploited	Russ et al (2004)
Great Barrier Reef	38.00	0.70	1.20	1.60	2.80	0.57	Over exploited	Russ et al (1996)

The asymptotic length (L∞) of yellowtail fusilier ranges between 34.5 to 38.69 cm across various locations (Russ et al 1996, 2004; Zamani et al 2011; Yuliana et al 2016; Putra et al 2024). The growth coefficient (K) of yellowtail fusilier was recorded within the range of 0.22-0.86 per year. The distribution patterns and recruitment timing of yellowtail fusilier in the research site are presented in Figures 4 and 5.

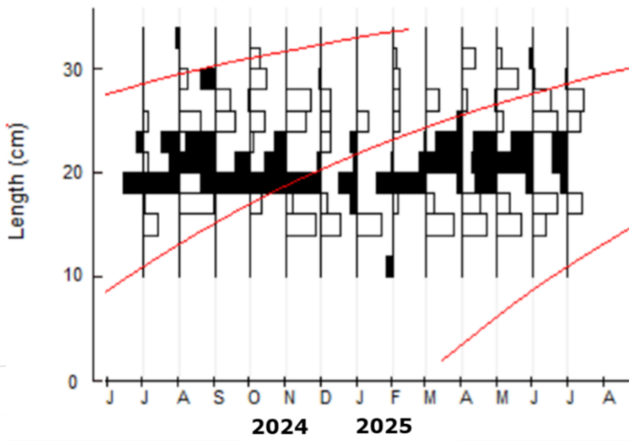

Figure 4. Distribution of yellowtail fusilier.

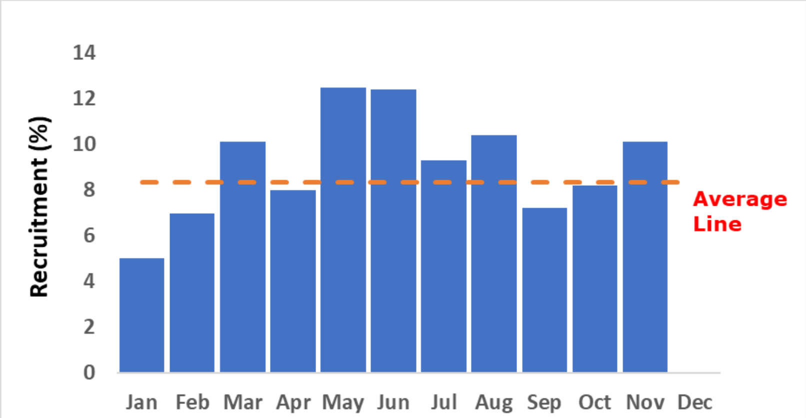

Figure 5. Recruitment pattern of yellowtail fusilier.

Yellowtail fusilier sized 17-23 cm dominated the area during the research period, with few individuals reaching sizes close to L∞.

Discussion. As shown in Figure 2, b (2.8357) is lesser than 3, which indicates a negative allometric growth pattern where length growth is more dominant than weight gain (Le Cren 1951; Tesch 1971; Froese 2006). As previous researchers found, the value b is was indeed lesser than 3 (Putra et al 2024). Variations in b values in different locations can be influenced by environmental factors that include fish physiology and fishing pressure (Stergiou & Moutopoulos 2001; King 2007). The intensive fishing in Karimunjawa could be a factor that formed this negative allometric growth (Jennings et al 2009).

Lc50% reflects the selectivity of fishing gear and relates to stock sustainability potential. The Lc50% value should be compared with the length at first maturity (Lm) to assess sustainability (Hordyk et al 2015; Prince et al 2015). Previous studies indicate that Lm for yellowtail fusilier generally exceeded 20 cm. Pratiwi (2017) reported Lm 20.1 cm while Nigrum (2019) reported Lm 23.3 cm in Karimunjawa. Meanwhile, the Lc50% obtained in this research shows that yellowtail fusilier is mostly caught before reaching maturity, suggesting a risk of overfishing, eventually leading to the decline in fish stock (Muallil et al 2014; Heino et al 2015; Birkmanis et al 2020).

Russ et al (2004) documented frequent capture of fusiliers (Caesionidae) in the Philippines, including yellowtail fusilier, at sizes < 20 cm despite Lm ranging 21-23 cm, rendering populations vulnerable to stock decline from high coral reef exploitation (Lavides et al 2016). On the other side, Russ et al (1996) reported Lm = 23 cm for yellowtail fusilier in Australia's Great Barrier Reef, where fine-meshed gear reduced Lc50% to 19 cm. Inter-location Lc50% variation is influenced by ecological factors that include food availability, coral habitat condition and water temperature affecting fish growth (Robinson et al 2017; Mbaru et al 2020), as well as technical factors such as fishing gear type/size, operational intensity, seasonal patterns (Goetze et al 2015). These findings highlight the importance of implementing minimum catch size regulations that align with maturation size, thereby ensuring individuals have an opportunity to spawn before capture (Hordyk et al 2015; Prince et al 2015).

The relative stability of L∞ values (Russ et al 1996, 2004; Zamani et al 2011; Yuliana et al 2016; Putra et al 2024) suggests limited geographical influence on maximum size, although environmental factors such as prey availability, habitat quality, fishing intensity can cause variations (Jørgensen et al 2007; Sharpe & Hendry 2009; Baudron et al 2014; Audzijonyte et al 2016; Thorson et al 2017). The present research estimate of L∞ 36.65 cm in Karimunjawa aligns with prior research in the same location (Yuliana et al 2016; Putra et al 2024). Whereas, the lower L∞ (34.5 cm) found in the Philippine could be due to different environmental conditions and fishing pressure (Russ et al 2004). Since the maximum length is influenced by genetics, prey availability, stock density, environmental quality, and fishing pressure, L∞ can decline under excessive exploitation (Beverton & Holt 1957; Pauly 1983; Sparre & Venema 1998; King 2007).

The growth coefficient (K) values (Table 2) indicate moderate to fast growth rates, with the relatively high K in Karimunjawa (0.86/year) suggesting accelerated growth, potentially as a biological response to intense fishing pressure, in contrast to the lower values reported from other local studies (Putra et al (2024): 0.22/year; Yuliana et al (2016): 0.42/year). The K value of 0.65/year in the Philippines (Russ et al 2004) and the wide overall K variations likely represent biological adaptations to differing fishing pressures and local ecosystem productivity (Enberg et al 2009; Sharpe & Hendry 2009; Brunel & Dickey-Collas 2010; Audzijonyte et al 2016; McLean et al 2019).

The exploitation rate (E) reflects the level of resource utilization, with Gulland's (1971) reference point of E = 0.5 considered optimal. Most locations exceeded this threshold (Table 2), indicating overexploitation: Karimunjawa (present study: E = 0.61; Putra et al (2024): E = 0.84; Zamani et al (2011): E = 0.56), the Philippines (E = 0.67; Russ et al (2004)), and the Great Barrier Reef (E = 0.57; Russ et al (1996)). The only exception was reported by Yuliana et al (2016), who recorded a sustainable level in Karimunjawa (E = 0.41), making it an outlier. Collectively, these findings reaffirm that excessive fishing pressure poses a serious threat to the sustainability of yellowtail fusilier stocks across regions (Pauly & Zeller 2016; Cinner et al 2018; Hilborn et al 2020).

The length distribution (Figures 4-5) reveals size truncation from overexploitation, with juvenile dominance in Karimunjawa (Putra et al 2024). Strategies to maintain the fish sustainability should include strict regulation on the minimum catch sizes > 19.8 cm (Lc50%) to allow pre-capture spawning (Muallil et al 2014; Hordyk et al 2015; Prince et al 2015). Recruitment that occurs year-round with peaks in May-June (12.46% and 12.38% of total recruitment) coincides with coral reef fish spawning seasons that are affected by water surface temperature, primary productivity, and lunar phases (Sadovy de Mitcheson & Colin 2012). Putra et al (2024) also reported a continuous recruitment pattern in Karimunjawa, reflecting an adaptive strategy of schooling species to enhance larval survival (Russ et al 1996). Since recruitment dynamics represent a critical phase in the life cycle, they are particularly important for fisheries management (Kritzer & Liu 2014; Gaines et al 2018; Pinsky et al 2021).

The yellowtail fusilier management in Karimunjawa should prioritize the minimum size regulations, spawner protection, and seasonal closures during recruitment peaks to prevent further stock decline while supporting ecosystem sustainability and fisher welfare (Cinner et al 2018; Hilborn et al 2020). Comprehensive policy formulation requires further research on gonad maturity, sex ratios, migration patterns, spawning grounds, and nursery areas (King 2007; Campbell et al 2013; Wijayanto et al 2025).

Conclusions. The population of the yellowtail fusilier in Karimunjawa Islands is under high exploitation pressure. The length-weight relationship analysis resulted in a negative allometric growth pattern (b = 2.8357). Lc50% value of 19.8 cm TL shows that most fish are caught before reaching maturity size. The growth parameters show an asymptotic length ($L\infty$) of 36.65 cm TL and a growth coefficient (K) of 0.86. Based on the data, the growth rate of the yellowtail fusilier is relatively fast that it can reach larger sizes within short period of time. Unfortunately, the high fishing pressure prevents the fish from reaching bigger sizes. The exploitation rate (E) of 0.61 exceeds the recommended optimal limit (E = 0.5), indicating overexploitation, since the recruitment occurs throughout the year, with May to June as the peak. This research concludes that the yellowtail fusilier population in Karimunjawa is under pressure, thereby stricter management should be immediate applied.

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Conflict of interest. The authors declare that there is no conflict of interest.

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