Some indicators for assessing the stock of redtail scad (*Decapterus kurroides* Bleeker, 1855) in Palabuhanratu Waters, West Java, Indonesia

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Abstract. The redtail scad fish (*Decapterus kurroides*, Bleeker 1855) is a dominant small pelagic fish that has high economic value. Therefore, it is important to maintain and manage redtail scad resources in an efficient and sustainable approach. This study was carried out in the Palabuhanratu Fishing Port, West Java in 2019. The objective of this study was to assess the stock of redtail scad as a basis for their sustainable management. The findings revealed that the distribution of the 3076 samples' total length ranged from 14.7 to 45.0 cm, with an average of 25.69 cm. The growth pattern was positively allometric. The sex ratio between males and females is unbalanced, and the most significant proportion of mature females was found in July. The bottom longline and gillnet catch a larger size of redtail scad than the handline. A legal size of 26 cm was recommended for the optimal size of the redtail scad. The asymptotic length (L_∞) and growth rate (K) were 45.43 cm and 0.61 year^{-1}, respectively. The exploitation rate (E) was 0.52 year^{-1}, indicating that a fisheries status leads to an overfishing condition.

1 Introduction

The redtail scad (*Decapterus kurroides* Bleeker, 1855) is a widely distributed carangid fish in tropical and subtropical waters of the Indo-West Pacific. It has a prominent red color on the tail and is one of the species under the genus Decapterus [1]. In Indonesia, redtail scad fish production is high, with a vast market share and medium price category[2]. In Palabuhanratu, West Java, scads are not only consumed by humans but also as bait fish in catching tuna and skipjack.

Reproductive biology parameters such as the size at maturity of gonads are critical parameters of life history in fisheries management that have undergone exploitation [3]. Individuals in the population must be protected so that they have the opportunity to reproduce before they reach the allowable catch size or enter the fishery [4].

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Stearns [1992] states that the size of fish as gonads mature is very important in the context of reproductive and exploitation strategies. In general, the large size of fish at gonad maturity has good potential in terms of reproduction. According to Pollock [1995], high fishery pressure can reduce the size of fish when gonads mature. Fish populations respond to exploitation with a decrease in size at gonadal maturity caused by increased mortality [7].

The purpose of this research is to identify numerous indicators for assessing the stock of redtail scad in Palabuhanratu waters, such as length-weight relationship, sex ratio, spawning season, length at first capture (Lc), length at first maturity (Lm), growth, and mortality. The findings of this study can be utilized as a reference for sustainable fish resource management and to monitor redtail scad fish populations.

2 Material and method

2.1 Data collection

The research was carried out in 2019 between February and December. At the fish landing site in Palabuhanratu, West Java, Indonesia, a total of 3076 fish samples had been collected (Figure 1). Three distinct fishing methods were used to catch the redtail fish samples: gillnet, bottom longline, and handline. Fish samples caught by fishers were weighed and measured for length. After the fish were measured, they were dissected, and the gonads were examined with a dissecting set. The "Standard Gonad Maturity Scale" is used to determine the gonad development stages [8].

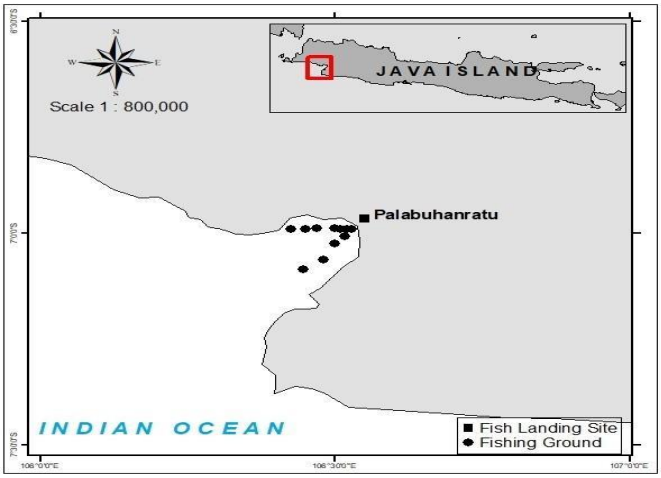

Fig. 1. Map of research for redtail scad in Palabuhanratu waters, West Java

2.2 Data analysis

The length-weight relationship was estimated by the formula [8] :

$$W=aL^b \quad (1)$$

W is the weight (g), with L is the total length (cm), a is the constant and b is the coefficient of growth.

The sex ratio was estimated by comparing the number of male and female redtail scad, and the chi-square test was used to investigate the balance condition.
The gonadosomatic index was estimated according to [11] as follows:

$$GSI=\frac{\text{Weight of the gonad (gr)}}{\text{Weight of fish (gr)}}x100 \quad (2)$$

The growth parameters were followed by the formula [12]:

$$Lt=L_{\infty}[1-e^{-k(t-t_0}] \quad (3)$$

Where L_{∞} is the asymptotic length, t_0 is the theoretical age when the length is zero, Lt is the length at age t, and k is the growth coefficient.
The value of t0 was estimated using the empirical equation [13]:

$$\text{Log } (-t0) = -0.392 - 0.275 * \log L\infty - 1.038 * \log K \quad (4)$$

Total mortality (Z) was estimated using the catch curve analysis. The empirical equation approach [13] was used to calculate natural mortality (M):

$$\text{Ln } M = -0.152 - 0.279 (\ln L\infty) + 0.6543 (\text{Ln } K) + 0.463 (\ln T) \quad (5)$$

Where M is natural mortality, L∞ is the asymptotic length, K is the growth coefficient, and T is the water temperature (ºC). The exploitation rate (E) was calculated from the ratio of fishing mortality and total mortality.

3 Result and discussion

The length frequency of redtail scad captured by bottom gillnets, handlines, and longlines ranged from 14.7 to 45.0 cm, with a mean size of 25.69 cm (Figure 2).

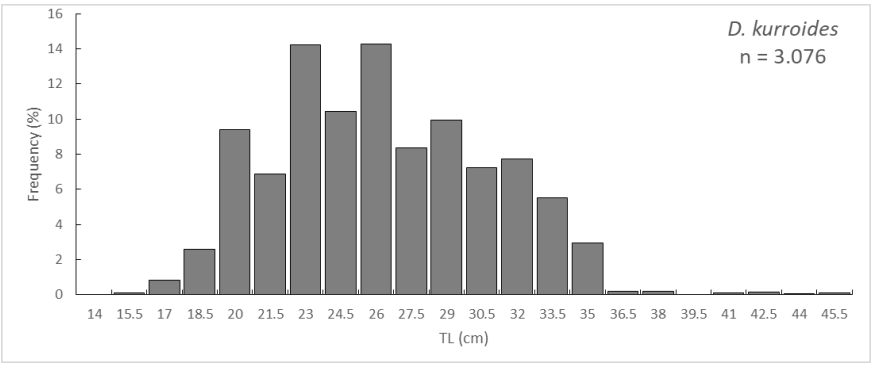

Fig. 2. Fish length distribution of the redtail scad (*D. kurroides*) in Palabuhanratu waters

The length range of the redtail scad was 14.7-45.0 cm TL. The largest scad from this study is larger than those from the Lingayen Gulf (25.5 cm) [15], Visayan Sea (28.5 cm), Davao Gulf (24.5 cm) [16], Samar Sea (29.5 cm) [17], Sulu (15.8 cm to 25.7 cm), Sibuyan Sea (16.2 cm to 21.3 cm), [18], and Iligan Bay, Southern Philippines (9.20 cm to 44.50 cmTL) [19]. This size gap may be caused by differences in ecological factors and spatial shifts in fishing pressure [20].

The growth pattern of *D. kurroides* was in allometric condition, with a growth coefficient of b 3.3202 and a coefficient of determination (R^2) of 0.9778 (Figure 3). The redtail scad population in West Java had a sex ratio of 1:1.7, totaling 191 males and 326 females (Figure 4). According to the analysis of the Chi-square test, the sex ratio of redtail scad is not balanced, indicating that the females were more dominant than males.

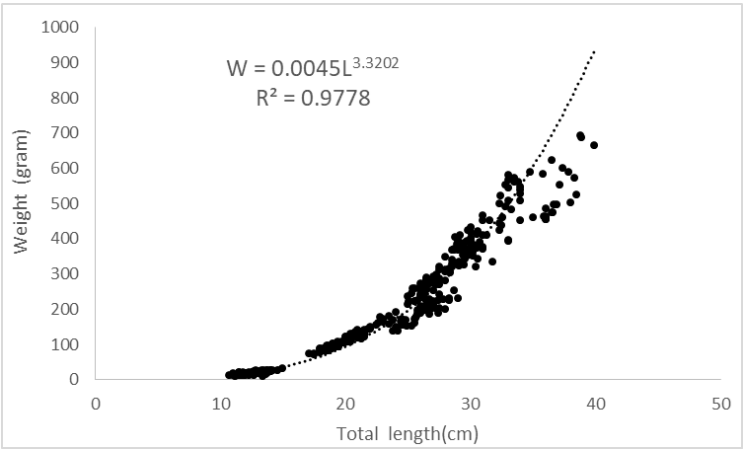

Fig. 3. Length-weight relation of the redtail scad (*D. kurroides*) in Palabuhanratu waters

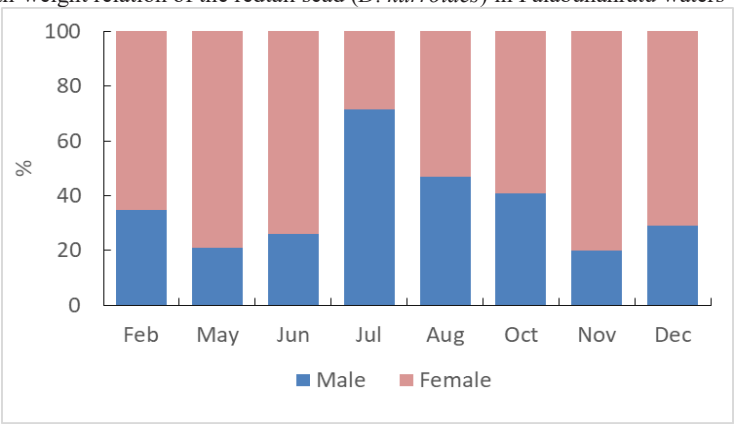

Fig. 4. Fish length distribution of redtail the scad (*D. kurroides*) in Palabuhanratu waters

The redtail scad's growth pattern is allometric, meaning that its length increase is outpacing its weight rise, according to the t-test result of $t_{value} > t_{table}$ (Figure 3). The length-weight relationship yielded growth trends that matched those documented by Huang et al. (2022) in the Eastern Taiwan Waters and Guzzman (2020) in the Lingayen Gulf. A number of factors, including sex, inheritance, age, sickness, gonad maturity, food supply, and water temperature, might affect differences in growth patterns in different places. Variations in growth stem from variations in sex, habitat, and fish growth phases, which include larval, juvenile, and mature gonad stages [23].

Figure 5 shows the percentage of gonadal somatic index (GSI) and gonad maturity stage of female redtail scads for each month. Eight months' worth of observations revealed that a high percentage of gonad maturity stage IV was found in May–August, with July having the highest percentage, while the same percentage was found in female fish in May–November, with July having the highest percentage. The redtail scad's average monthly GSI varies from 1.21 to 15.72. Figure 5 shows that the GSI value peaked in July (15.72) and fell to its lowest in December (1.21).

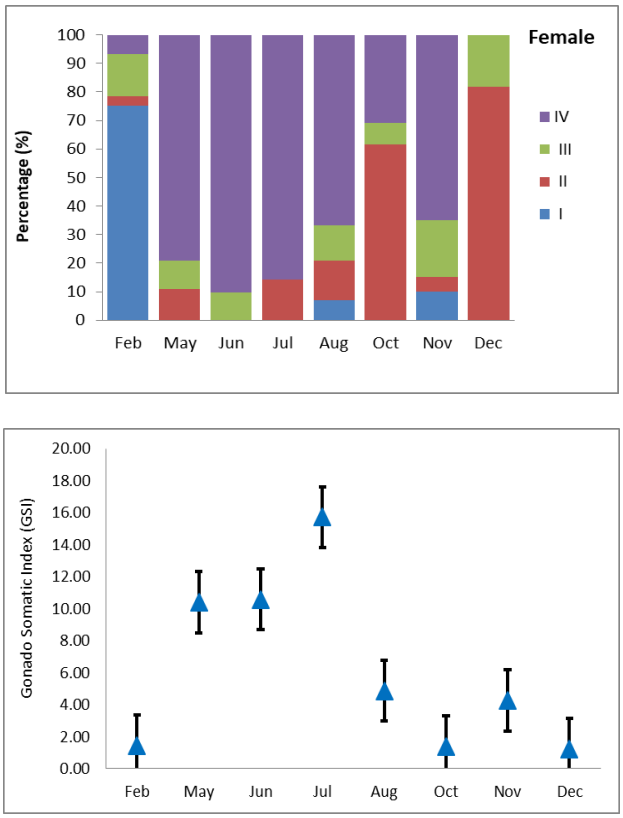

Fig. 5. Redtail scad fish (*D. kurroides*) gonadal maturity stage and gonadal somatic index (GSI) in Palabuhanratu waters

With 191 males and 326 females, the redtail scad fish had a sex ratio of 1: 1.7. The sex ratio of redtail scads is unequal, according to the findings of the analysis using the Chi-square test. This indicates that females were more dominant than males, contributing to the recruitment process. The study's findings are consistent with earlier studies conducted in the predominantly female Iligan Bay in the Southern Philippines [19]. The redtail scad's sex ratio is unbalanced, indicating that different populations of male and female fish exist in the wild to ensure the survival of the species.

In Palabuhanratu waters, the redtail scad spawning season peaks in July and runs from May to November, according to data on the gonad maturity stage and gonadal somatic index (GSI). Huang and colleagues (2022) reported primary reproductive season for *D. kurroides* in the Waters of Eastern Taiwan was from April to July. But [19] reported *D. kurroides* female mature at 17.2 cm in Iligan Bay, Southern Philippine. Numerous factors, such as genetic variations, environmental conditions, fishing pressure, and food availability, affect size at maturity [24], [25].

Length at first capture (Lc) of the redtail scad in Palabuhanratu waters is 26.03 cm (gillnets); 23.38 cm (handlines); 26.78 cm (bottom longlines) (Figure 6) and length at maturity (Lm) is 25.9 cm.

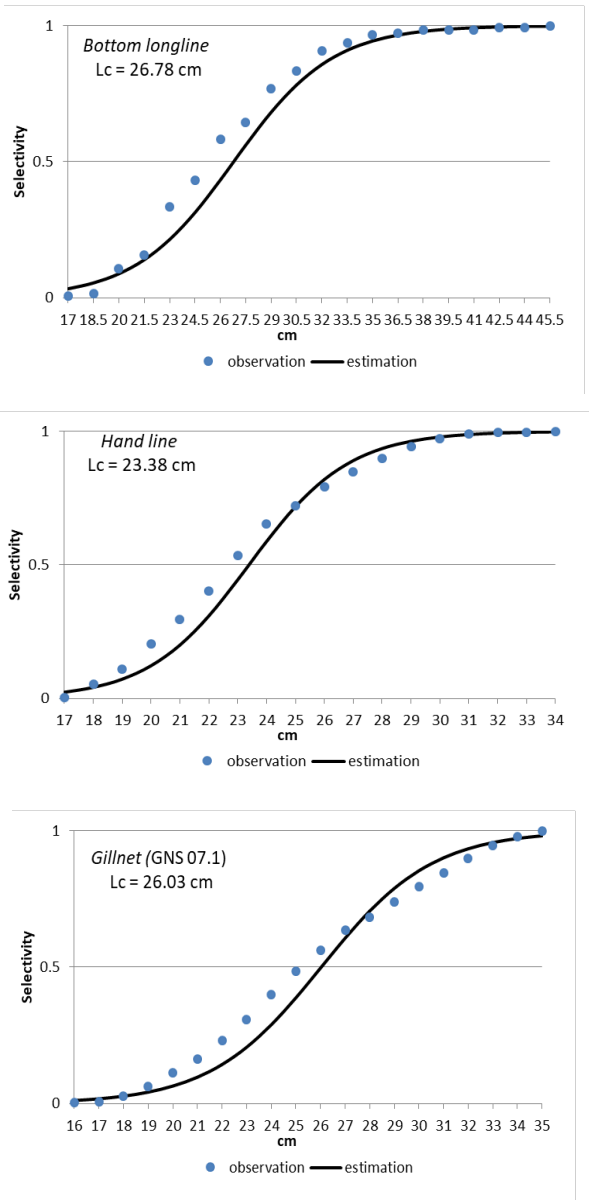

Fig. 6. Length at first capture (Lc) of redtail scad fish (*D. kurroides*) in Palabuhanratu waters

Redtail scad's length at first capture was 26.03 cm for gillnets, 23.38 cm for handlines, and 26.78 cm for bottom longlines. This study demonstrated that the bottom longline and gillnet caught a larger size of redtail scad than the handline. Furthermore, the length at first capture for the gillnet and bottom longline was greater than the length at first maturity of 25.9 cm, showing that the majority of the redtail scad was caught after they spawned. To ensure the viability of the resource, a minimum legal size should be implemented for the fishery, allowing a minimum catch size of Lm size (Lm = 25.9 cm).

Redtail scad fish population dynamics analysis results indicated that asymptotic length (L_∞), growth rate (K), and t_0 were 45.43 cm, 0.61 year^{-1}, and 0.3171 year^{-1}, respectively (Figure 7). According to the analysis, the redtail scad's total mortality (Z) was 1.72 year^{-1}.

Incorporating the average annual temperature of 29°C in the Palabuhanratu waters into Pauly's empirical equation (1980) yielded natural mortality (M) of 0.81 year^{-1} and fishing mortality (F) of 0.91 year^{-1}. Redtail scad fish had a fishing mortality rate that was marginally greater than their natural mortality rate and an exploitation rate (E) of 0.52 years^{-1}.

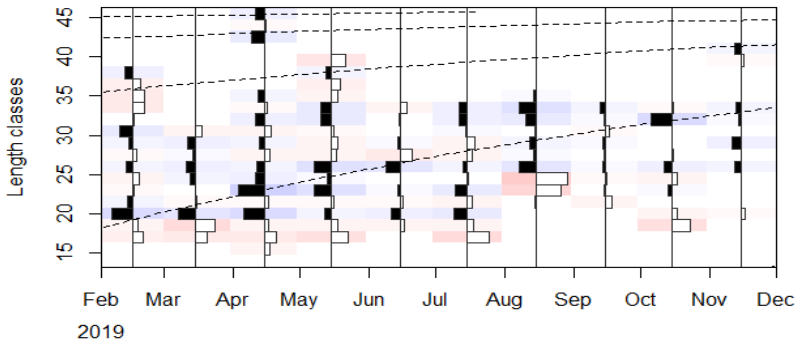

Fig. 7. Von Bertalanffy's growth equation curve of redtail scad fish (*D. kurroides*) in Palabuhanratu waters.

From the redtail scad's population dynamics study, the asymptotic length (L_∞) and growth rate (K) were 45.43 cm and 0.61 year^{-1}, respectively. *D. kurroides* develops at a rate of 0.52 year^{-1} for females and 0.39 year^{-1} for males in Eastern Taiwan, with asymptotic lengths of 30.44 cm for females and 32.45 cm for males [21]. Asymptotic length and growth rate might be different due to genetic and environmental variables. [26, 27]. The exploitation rate (E) of redtail scad fish was 0.52, and the fishing mortality rate (F = 0.91 year^{-1}) was higher than the natural mortality rate (M = 0.81 year^{-1}). Gulland (1983) noted E = 0.5 as the optimal degree of exploitation. The exploitation rate is slightly over its optimal value. In this condition, two management options that may be employed are to reduce fishing efforts and to consider temporarily suspending fishing activities. Fisheries management must be based on appropriate and credible scientific data while also considering the fisher's capacity to continue fishing and suggesting non-fishing activity that might compensate for seasonal closures or reduced fishing efforts.

4 Conclusions

This study found that the spawning season of redtail scad (*Decapterus kurroides*) in Palabuhanratu occurred in July. Gillnet and bottom longline captured a larger size of redtail scad than handlines. A minimum legal size of 26 cm was recommended for an optimal size of *D. kurroides*. The fisheries status of *D. kurroides* has been in overfishing condition.

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