



Size Distribution and Growth Pattern of Mackerel Scad (*Decapterus Sp.*) Caught by Boat Lift Nets in Doreri Bay Waters, Manokwari Regency, West Papua, Indonesia and Its Management Implications

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aims: The present study aims to explore some of biological characteristics of mackerel scad, such as size structures and length and weight relationship in which that information is important for the management of the fish resources.

Place and Duration of Study: The data collection was conducted from April to June 2019 in the waters of Doreri Bay, Manokwari Regency.

Methodology: The data were collected from 6 boat lift nets during their fishing operation, 7 days every month for 3 months of research. The data collected was the catch of mackerel scad fish and the size of total length and weight the individual fish samples. The data were then descriptively analyzed to explore the fish size structures. Simple regression analyses was used to estimate the length weight relationship (LWR) of fish.

Results: The production of mackerel scad caught in the waters of Doreri Bay from April to June was around 68.5 tonnes which was dominated by the species *Decapterus macerellus*. The individual size structure of each species varies. *D. macerellus* has a size range of 17.8 cm to 25.7 cm, *Decapterus macrosoma* measures 10.5 cm to 12.7 cm, *Decapterus akaadsi* measures 7.9 cm to 19.0 cm, *Decapterus kuroides* measures 9.4 cm to 14.9 cm, and *Decapterus scrombinus* measures 10.3 cm to 18.0 cm. On average, the size of the individuals caught is smaller than the size at first maturity (L_m). The growth pattern of mackerel scad fish varies between species. For example species *D. macrosoma* tend to follow a positive allometric growth pattern, while *D. akaadsi* and *D. macerellus* tend to follow a negative allometric growth pattern.

Conclusion: Mackerel scad caught on average were dominated by individuals with a size less than the size of the first maturity (L_m); Growth pattern of Mackerel scad varied among different species and among different months; and Mackerel scad fish caught using boat lift nets in Doreri Bay, Manokwari Regency need to be managed properly by considering the minimum legal sizes and the aspect of carrying capacity.

Keywords: *Decapterus*; Dorery Bay; growth pattern; Manokwari; size composition.

1. INTRODUCTION

Mackerel scad (*Decapterus* sp.) is an important economic fisheries resource in tropical and subtropical waters [1]. It is highly contributed socially and economically to people because it is the most widely consumed [2]. Approximately 70% of animal protein consumed by the human comes from fish and this species is important in terms of food security, and is even used as a supplement to traditional food [3,4].

Apart from its role in economic and social aspects, several studies about *Decapterus* sp., are focused on the aspects of the development of fish eggs [5], utilization optimization [6]. In biological aspects are the studies about genetics and population kinship [7], size distribution, growth patterns, condition factors [8], and stock discrimination [9]. Other aspects related to the level of fish utilization have also been widely reported, with various approaches such as

production models based on the fish catch [10,11] and based on the length of fish life [12,13]. Further, studies on stock identification are especially about morphometry, otolith measurements [14], and stock potential estimation [15].

There are several studies are limited in local context in accordance with the interests and conditions of the waters being managed, for example, Ambon Waters [8], Fisheries Management Areas 716 and 715 [9], and Java Sea [16]. Meanwhile, the studies conducted in Doreri Bay, Manokwari, were very limited, only on the growth aspect of the mackerel scad fish [17]. Information available about the species is reported by Sala et al. [18] at Wondama Bay where close to Doreri Bay. Knowledge of biological aspects such as fish sizes (minimum legal size), fishing season, and the reproductive biology of fish stocks are important as basis information for the fisheries management [19].

Boat lift net in Doreri Bay are dominant fishing gear in catching scads, besides purse seines and hand lines. Scientific data on the dynamics of the mackerel scad fish population is still very limited in order to support management decision for the species in the bay. The lack of scientific data on mackerel scad fish resources in Doreri Bay is a challenge in determining and formulating appropriate management directions. In fact, mackerel scad fish is one of the main target of the fishery [17,18,20]. Therefore, comprehensive and up-to-date data on the condition of the mackerel scad fish in Doreri Bay is required. This study aims to determine the size distribution of the fish, the length-weight relationship, and the growth pattern of the mackerel scad fish and its management implications. Thus, the results of this study can be used to fulfil gap of information required for the management mackerel scad fishery in Doreri Bay.

2. MATERIALS AND METHODS

2.1 Data Collection

The data collection was conducted from April to June 2019 in the waters of Doreri Bay, Manokwari Regency. The data were collected from 6 boat lift nets during their fishing operation, 7 days every month for 3 months of research. The data collected consisted of the catch of mackerel scad fish and the total length and weight the individual fish samples.

Fishing operations of lift boat nets were taken place during the dark moon. Based on the results of field observations, the size of the boat lift nets was varied. Large boat lift nets have total length of 9 meters, with a length and width of nets were 40 x 40 meters, and while the small one has a total length of 7 meters, with a width and length of nets were 25 x 25 meters and 30 x 30 meters.

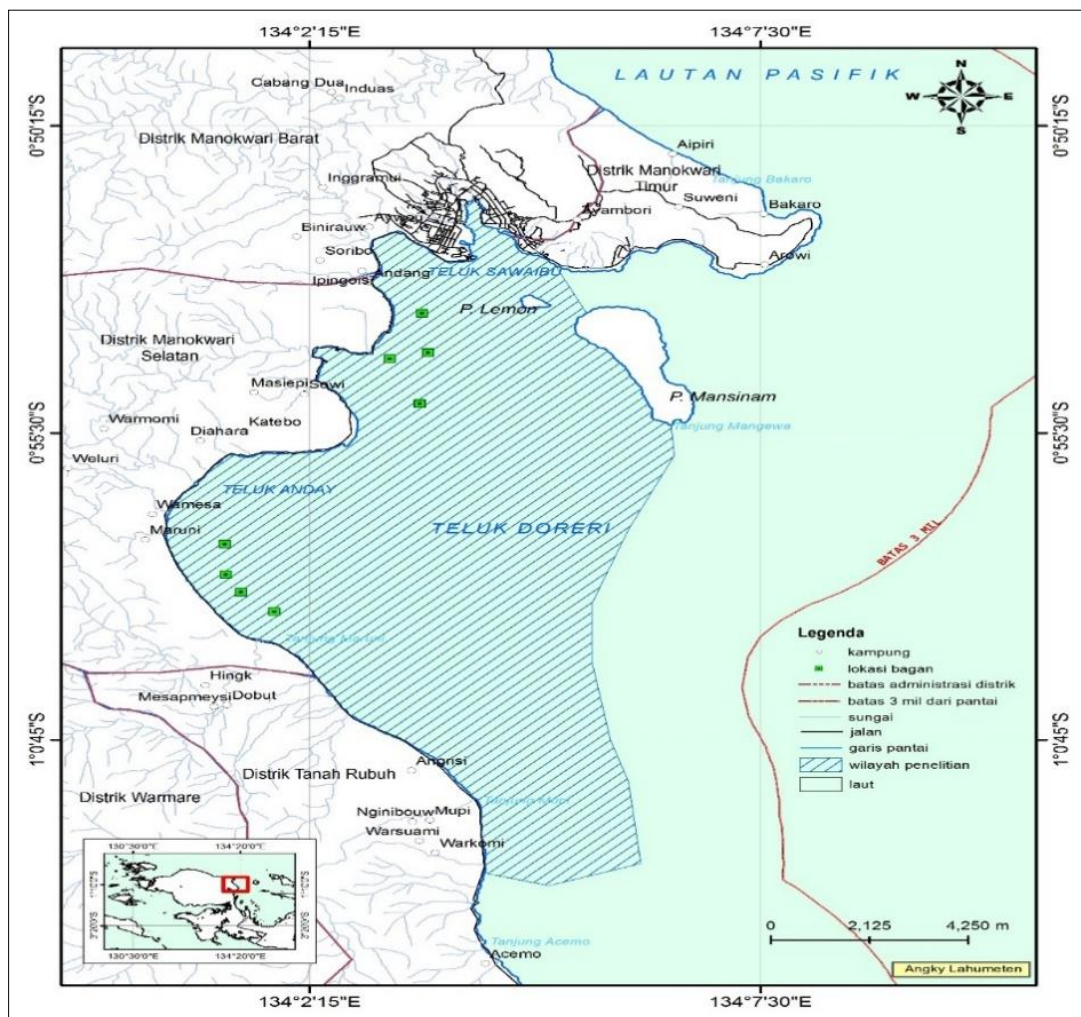


Fig. 1. Fishing location of boat lift nets in Dorery Bay water

The size of the boat lift nets affects the number and location of the catch. Large nets usually haul 3-5 times in one fishing operation, while small nets usually haul 2-3 times in one fishing operation. The plots of fishing locations of the 6 boat lift nets were presented in Fig. 1.

2.2 Data Analysis

2.2.1 Length – Weight Relationship (LWR)

To analyze the relationship between the length and weight of fish, the length of the fish is converted into weight by using power function [21] (Pauly 1984), namely:

$$W = aL^b$$

Where:

W = Weight of fish (gram);
L = Length of fish (Cm);
a and b = Constants

The b value is the power value that must match the length of the fish to be in accordance with the weight of the fish. The value of a is the intercept. The b value from the results of the long-weight relationship analysis describes the pattern of growth in length and body weight growth of fish [22,23] (Suruwaky & Gunisah, 2013; Jisr et al., 2018):

- Value of $b = 3$, scad (*Decapterus* spp) has an isometric growth pattern, namely the growth in length of Mackerel scad fish is proportional to weight growth.
- Value $b > 3$, scad (*Decapterus* spp.) has a positive allometric growth pattern (where

the weight gain is faster than the increase in length), or it tends to be fat.

- The value of $b < 3$, the scad Fish (*Decapterus* spp.) has a negative allometric growth pattern (the increase in length is faster than the increase in weight), indicating a thin condition of the Mackerel scad fish (*Decapterus* spp.).

The t-statistical test used to determine the value of $b = 3$ or $b \neq 3$ was [24] Weaver and Wuensch, (2013), as follows:

$$t = \frac{b-b^*}{s_b}$$

Where:

s_b = Standard error of b
b = regression coefficient (slope)
 b^* in this study is equal to 3

If $t\text{-count} > t\text{-table}$ then the value of $b \neq 3$ or allometric growth form and if $t\text{-count} \leq t\text{-table}$ then the value of $b = 3$ or isometric growth form.

3. RESULTS AND DISCUSSION

3.1 Catch

Catch in April for the *D. macerellus* type was 18,966 kg which was higher than that of *D. akaadsi* (8,949 kg), and *D. macrosoma*(6,610 kg) (Fig. 2). Catch in May for the *D. macerellus* species was also the highest (4,704 kg) followed by other species. The same catch composition was found in June, where the Mackerel scad fish species *D. macerellus* still dominated with the highest total production value of 10,577 kg, followed by *D. akaadsi* with a total production of 7,801 kg.

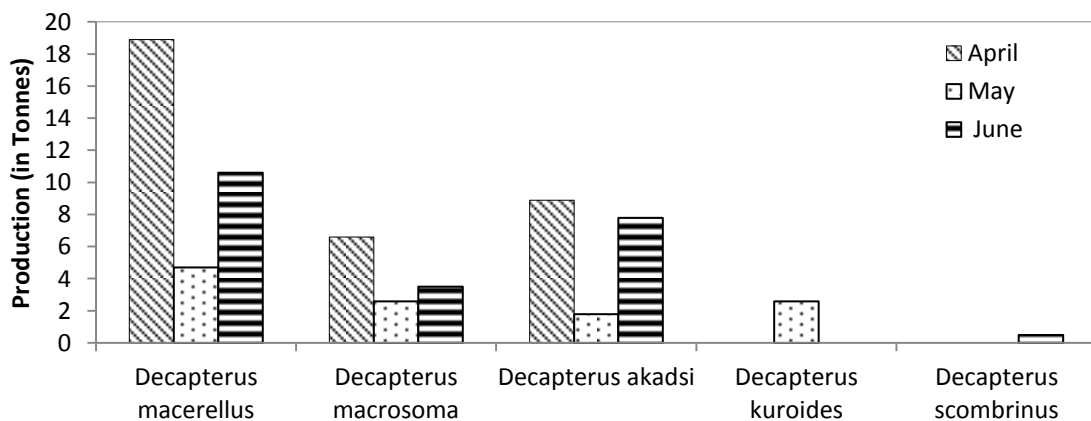


Fig. 2. Total production of scad fish catches

3.2 Fish Size Distribution

Frequency of size of *D. macerellus*, *Decapterus macrosoma*, *Decapterus akadasii* caught during April, May, and June 2019 is presented in Figs. 3, 4 and 5. *D. kuroides* was only found in May (Fig. 6) and *Decapterus scombrinus* was only found in June (Fig. 7).

The size distribution of *D. macerellus* caught using boat lift nets in Doreri Bay waters in April ranged from 158 to 277 mm, in May ranged from 118 to 277 mm from a total sample data of 46 fish. The size of the fish caught mostly ranged from 198 – 237 mm and in June ranged from 138 to 317 mm. In April the size was dominated by fish with a size range of 178 - 197 mm, in May it was dominated by the size fish that ranged from 198 – 217 mm and the highest was in June with the size range of 218 -237 mm. The length size composition of *D. macerellus* was not

significantly different from the frequency of *D. macerellus* landed at the Kendari Port caught by purse seine [25].

Size distribution of *D. macrosoma* type caught in April were ranged from 82 to 265 mm (Fig. 4). The most caught sizes were 105 – 127 mm. In May, *D. macrosoma* type were caught in ranged of size 59 – 288 mm, with the most caught fish ranged from 105 – 127 mm. In June, the species were caught at ranged of 82-173 mm, with the most commonly caught at ranged of 105 – 127 mm. According to Randongkir et al [17], the length distribution of *D. macrosoma* landed for males has a size of 109 – 303 mm and for females with a size of 125 – 299 mm with the highest catches in April. Another finding by Nursinar and Panigoro [26] stated that *D. macrosoma* had the highest catches in the class interval range of 165 – 184 mm.

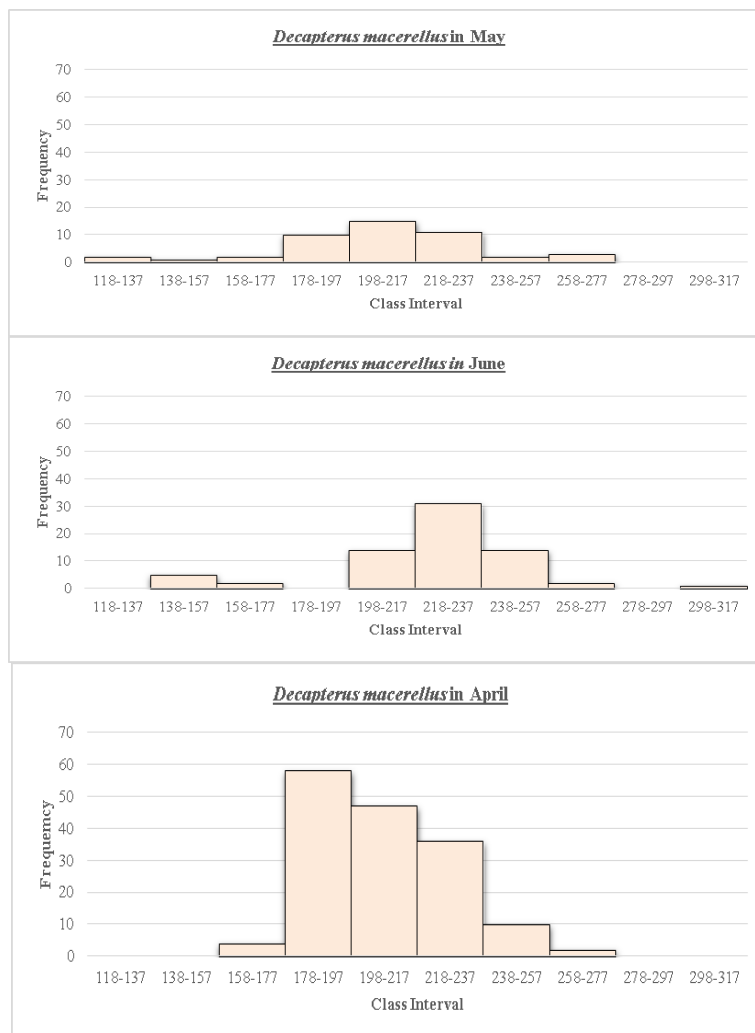


Fig. 3. Frequency distribution based on *Decapterus macerellus* length class intervals in April (top), May (middle), and June (bottom)

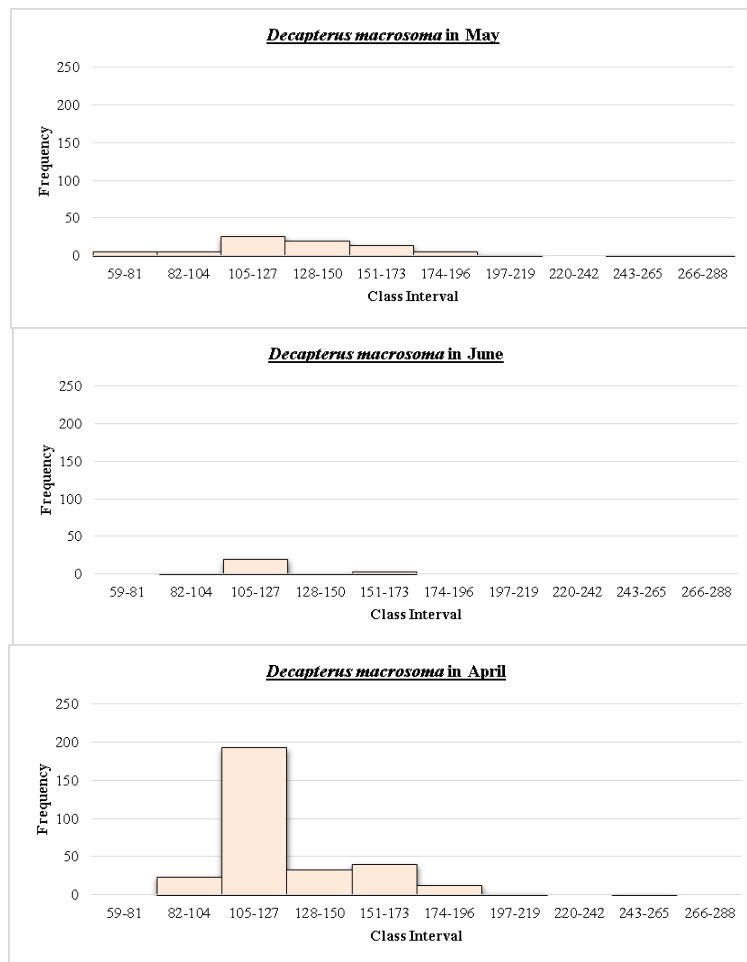


Fig. 4. Frequency distribution based on *Decapterus macrosoma* length class intervals in April (top), May (middle), and June (bottom)

Size composition of *D. akaadsi* type caught in April were ranged from 79 – 254 mm, with most catch was at ranged of 95 - 110 mm. In May, the sizes of *D. akaadsi* caught were distributed from 95 to 158 mm and the catch dominated by size of range 127 – 142 mm. *D. akaadsi* caught in June ranged from 95 – 190 mm where most individuals size ranged from 127 – 147 mm.

D. kuroides caught in May has sizes ranged from 86 to 157 mm with the most catches ranged from 142 to 149 mm (Fig. 6). The length size distribution caught in Doreri Bay waters was not different significantly from *D. akaadsi* taken in Amurang Bay waters with a length range of 141 – 190 mm [27].

D. scombrinus was only found in June with the least number of fish caught compared to other types of mackerel scad fish found in Doreri Bay waters. The size class intervals of the catch were ranged from 103 to 115 mm. Size distribution of the species caught in June is presented in Fig. 7.

Comparison of size ranges of mackerel scad caught in Dorery Bay based on the present research with several previous studies in various regions is presented in Table 1. It showed that the average length interval of *D. macerellus* was smaller than that taken in the Celebes Sea and also smaller than the size at first maturity (Lm), namely 26.89 cm [15].

The average class interval for *D. macrosoma* based on the present study was 10.5 – 12.7 cm which was smaller than the size of the species taken in the Java Sea (14.5 – 15.5 cm) and also less than the Lm of the species (14.3 – 14.9 cm) [28].

The other three species, *D. akaadsi*, *D. kurroides* and *D. scombrinus* caught in Dorery Bay had significantly different length class interval from that reported by Fish Base in Pacific Waters (Table 1). The average sizes of the species were very much smaller which indicated that most of the catch consisted of young fish.

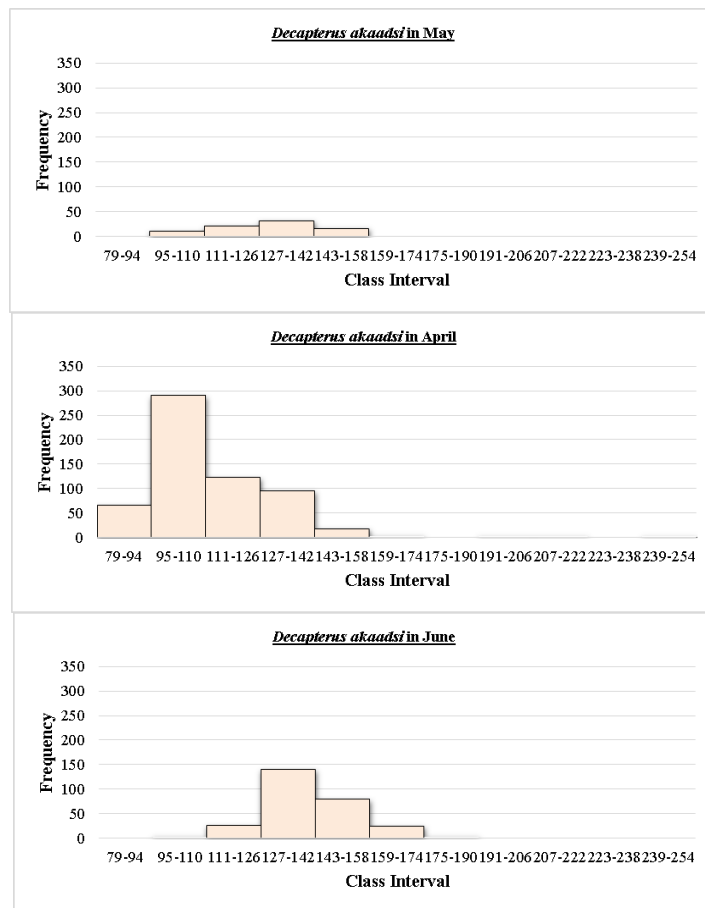


Fig. 5. Frequency distribution based on *D. akaadsi* length class intervals in April (top), May (middle), and June (bottom)

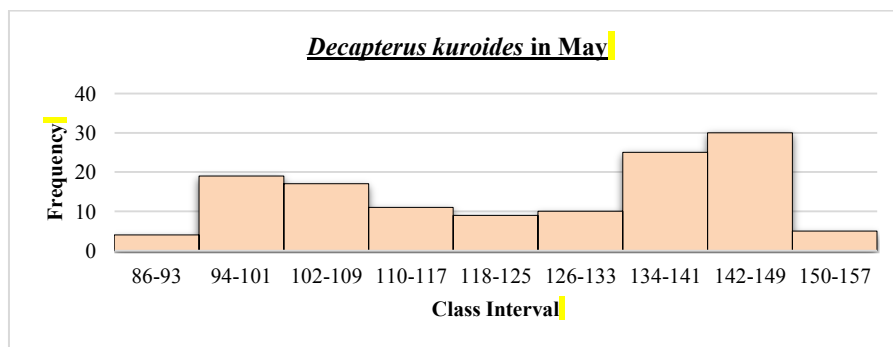


Fig. 6. Frequency distribution based on *Decapterus kuroides* length class intervals in may

3.3 Length and Weight Relationship of Mackerel Scad (*Decapterus* sp.)

The analysis of LWR of fish can predict the weight of the fish based on length or vice versa [30]. Based on the results of the present research there were several growth patterns for Mackerel scad fish species in Doreri Bay, Manokwari, positive allometric, negative

allometric, and isometric growth patterns. Fish growth patterns are strongly influenced by the fish's condition. The condition of fish is influenced by several factors, such as diet, age differences, food availability, environmental conditions, and gonadal maturity levels.

The LWR analysis (Fig. 8) of *D. macrosoma* found the estimation value of b in April equals to

3.14 ($t_{\text{count}} = 2.881 > t_{\text{table}} = 1.968$), in May equals to 3.01 ($t_{\text{count}} = 4.033 > t_{\text{table}} = 1.991$) and June equals to 3.76 ($t_{\text{count}} = 4.326 > t_{\text{table}} = 2.069$) was positive allometric, which explains that weight gained was more dominant than length gain. These may relate to habitat conditions, time of foraging, and availability of food in waters where fish grow faster when there is sufficient food. The fishing activities of the boat lift nets were carried out when the mackerel scad fish was looking for food, for example planktons attracted by light and gathering around the boat lift nets.

The result of LWR for *D. akaadsi* showed the value of b in April was 2.84 ($t_{\text{count}} = -3.434 < t_{\text{table}} = 1.964$) and in June was 2.99 ($t_{\text{count}} = -0.133$

$< t_{\text{table}} = 1.969$) which indicated negative allometric growth pattern. In May, the value of b equals to 3.413 ($t_{\text{count}} = 2.868 > t_{\text{table}} = 1.995$) indicating positive allometric growth pattern. These results shows that the growth pattern of *D. akaadsi* (Fig. 9) varied between month. It may related to food availability and maturity state of the fish.

The results of LWR analysis of *D. macerellus* (Fig. 10) showed the value of b in April equals to 2.18 ($t_{\text{count}} = -7.549 < t_{\text{table}} = 1.975$), in May equals to 2.53 ($t_{\text{count}} = -1.723 < t_{\text{table}} = 2.015$), and in June equals to 2.73 ($t_{\text{count}} = -0.754 < t_{\text{table}} = 1.996$). These figures explain the growth pattern of *D. macerellus* in the three observed months was negative allometric.

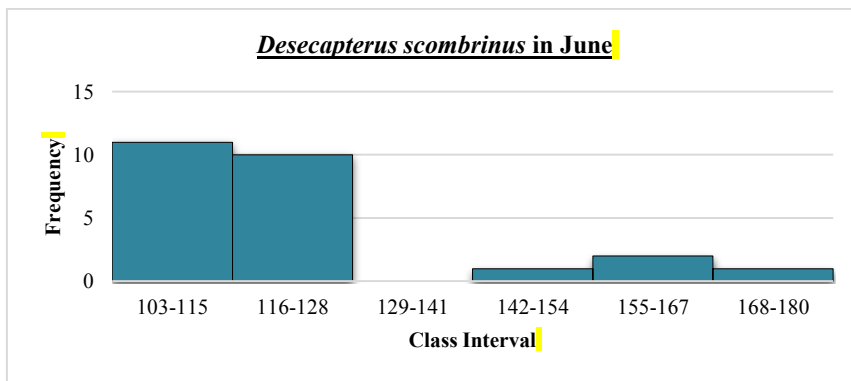
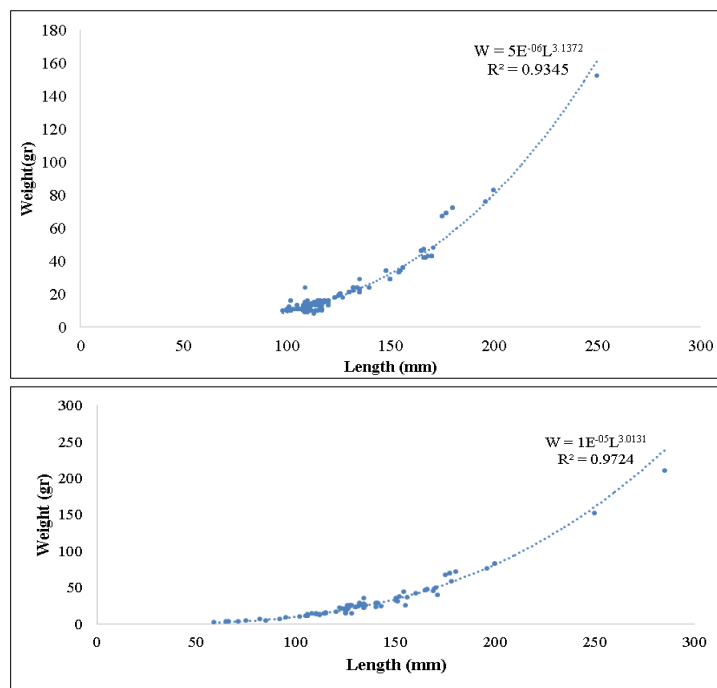


Fig. 7. Frequency distribution based on *Decapterus scombrinus* length class intervals in June



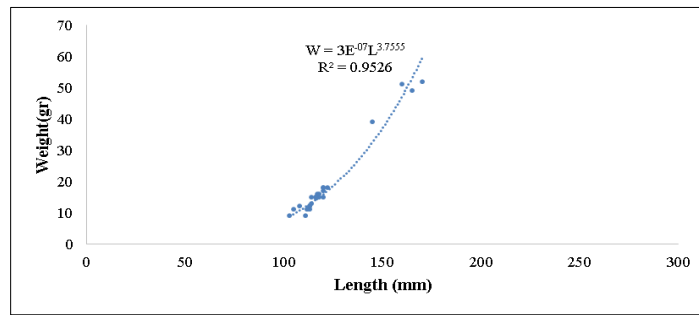


Fig. 8. *Decapterus macrosoma* growth pattern in April (top), May (middle) and June (bottom)

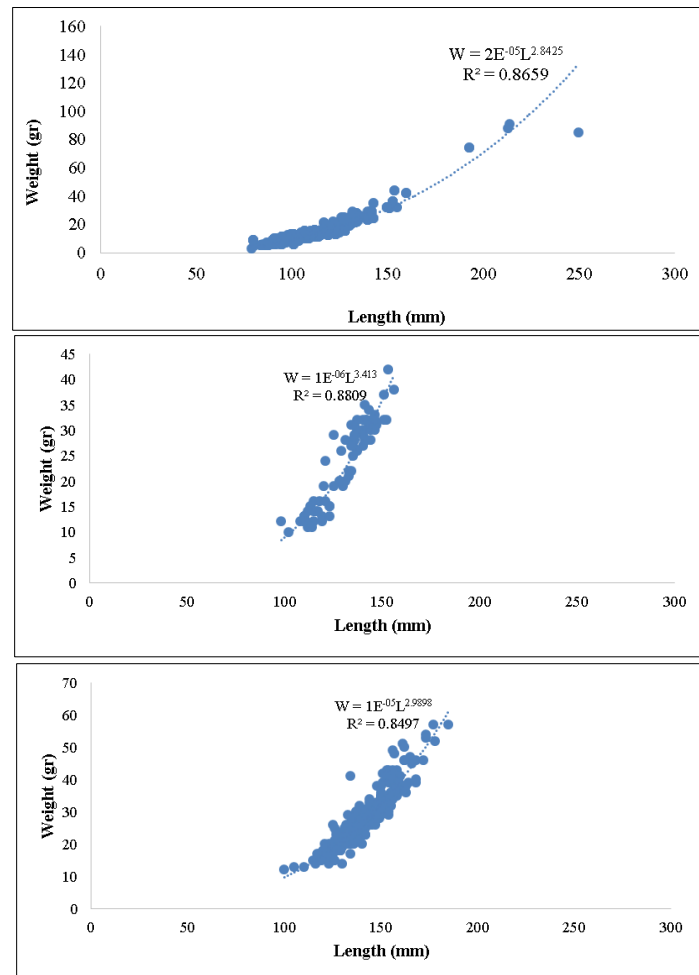


Fig. 9. *Decapterus akaadsi* growth pattern in April (top), May (middle) and June (bottom)

Based on the analysis of LWR for *D. kurroides*, it was found that in May, the value of b was 2.83 (see Fig. 11) with $t_{\text{count}} = -1.881 > t_{\text{table}} = 1.979$. This indicates that the species has negative allometric growth pattern). On other hand, the species of *D. scombrinus* caught in June had b value of 3.76 (Fig. 12) with $t_{\text{count}} = 4.326 > t_{\text{table}} = 2.067$ which indicate a positive allometric growth pattern.

The b value in LWR of fish is indirectly related to the condition factor. The condition factor is one of the most important things in fish growth. It is used to determine the plumpness of the fish in the form of a number calculated based on an analysis of the LWR of the fish [31]. The value of fish condition factor will increase towards the peak of spawning and decrease after spawning because the main energy source

is used for gonad development and the spawning process. A decrease in the condition factor of male and female fish can occur because they have just finished spawning or are adapting to the environment. According to Lawson and Doseku [32], differences in *b* values may be influenced by season, habitat, gonadal maturity, sex, stomach fullness, and fish health. There

are two influential factors in the study of fish growth, namely internal and external factors. Internal factors include heredity, sex, disease, hormones, and the ability to utilize food, while external factors include food availability, competition in utilizing space and water temperature, fishing time, and environmental pressure [31].

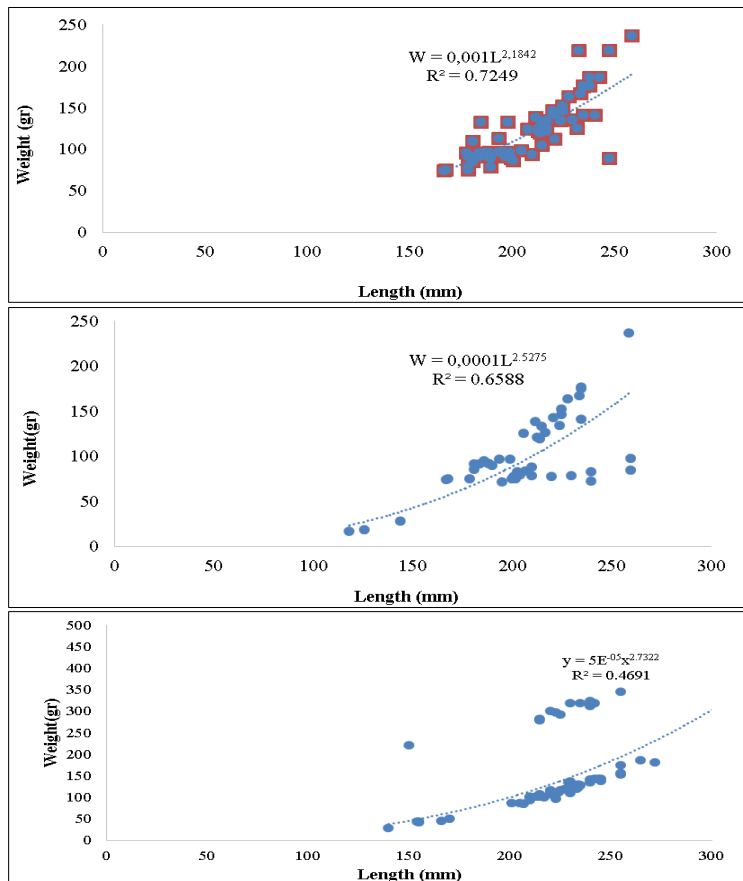


Fig. 10. *Decapterus macerellus* growth pattern in April (top), May (middle) and June (bottom)

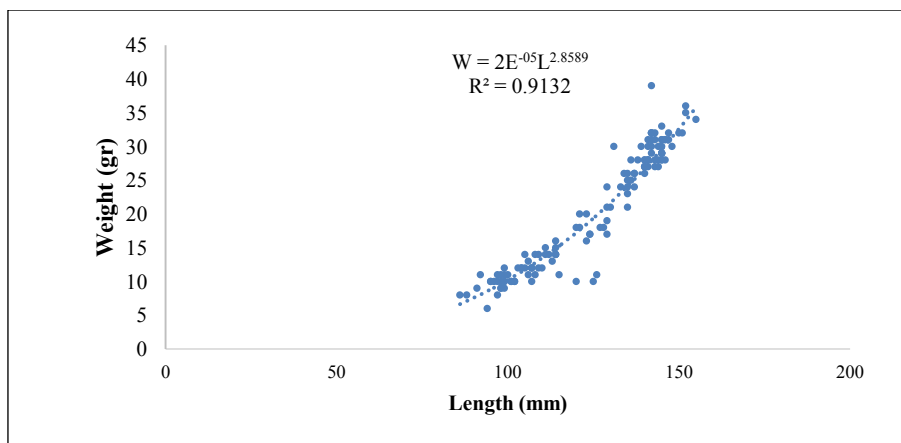


Fig. 11. *Decapterus kurroides* growth pattern in May

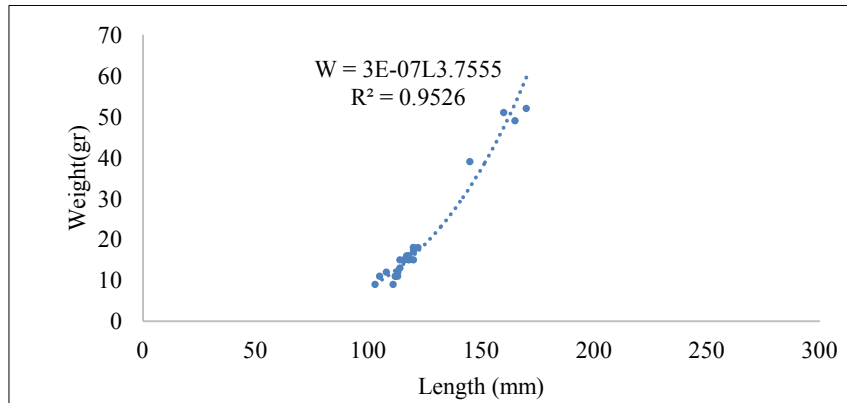


Fig. 12. *Decapterus scombrinus* growth pattern in June

Table 1. Comparison of class intervals between this research results with literature studies of mackerel scad fish (*Decapterus spp*) for the Lm50% category

Species	Average class intervals		L _m 50%	Data source	Site
	Present study	Literature			
<i>D. macerellus</i>	17.8-25.7	10.3-32.3	26.89	[12]	Celebes sea
<i>D. macrosoma</i>	10.5-12.7	14.5-15.5	14.3-14.9	[28]	Java Sea
			25.5	[29]	Coastal Fishing Port of Gunung Kidul Yogyakarta Data
<i>D. akaadsi</i>	7.9-19.0	30.0	30.0	Fishbase	Western Pacific
<i>D. kuroides</i>	9.4-14.9	30.0-45.0	-	Fishbase	West Pacific
<i>D. scombrinus</i>	10.3-18.0	30.0-50.0	-	Fishbase	Indo-Pacific

3.4 Fish Management Implications

The results of the present study reveal some important information to support the management of the mackerel scad fish fisheries, in particularly in the local context of Dorery Bay. Firstly, catch production of mackerel scad fish (*Decapterus spp.*) caught with boat lift nets in the waters of Doreri Bay, Manokwari Regency need to be monitored regularly in order to warrant the sustainability of the fishery. Secondly, there were significantly high proportion small sizes of individuals in the catch. It is necessary to pay attention on the individual size of catch in order to prevent fishers targeting young and immature individuals since it could lead to growth and recruitment overfishing.

4. CONCLUSION

- Mackerel scad caught by boat lift net fishing gear in Doreri Bay, on average were dominated by individuals with a size that is still young or smaller than the size of the first maturity (L_m).

- Growth pattern of Mackerel scad varied among different species.
- Mackerel scad fish caught using boat lift nets in Doreri Bay, Manokwari Regency need to be managed properly by considering the minimum legal sizes and the aspect of carrying capacity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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