Original Research Article

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

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, D. macrosoma measures 10.5 cm to 12.7 cm, D. akaadsi measures 7.9 cm to 19.0 cm, D. kuroides measures 9.4 cm to 14.9 cm, and D. scrombinus measures 10.3 cm to 18.0 cm. On average, the size of the individuals caught is smaller than the size at first smaturity (Lm). The growth pattern of mackerel scad fish varies between species. Fore 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] (Ohshimo et al. 2006). It is highly contributed socially and economically to people because it is the most widely consumed [2] (Khasanah et al. 2020). 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] (Kurniawan et al., 2020a & 2020b).

Apart from its role in economic and social aspects, several studies have been carried out on *Decapterus* sp., such as on aspects of the development of fish eggs [5] (McBride et al. 2002), utilization optimization [6] Farhan & Ginting, 2020). Furthermore, from biological aspects, such as genetics and population kinship [7] (Arnaud et al. 1999), size distribution, growth patterns, condition factors [8] (Pattikawa et al. 2018), and stock discrimination [9] (Retnoningtyas et al. 2023). 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] (Sadhotomo & Atmaja, 2012; Triharyuni et al., 2012) and based on the length of fish life [12,13] (Zamroni et al., 2019; Bintoro et al., 2019a). Although studies on stock identification such as morphometry, otolith measurements [14] (Manginsela et al. 2020), and potential evaluation approaches [15] (Zamroni et al. 2012) are prerequisites in the management of mackerel scad fish, population dynamics studies (fish size and distribution) and the pattern of fish growth are also important to be conducted.

The previous studies are often local in nature and in accordance with the interests and conditions of the waters being managed, for example, Ambon Waters [8] (Pattikawa et al. 2018), Fisheries Management Areas 716 and 715 [9] (Retnoningtyas et al. 2023), and Java Sea [16] (Bintoro et al., 2019b). Meanwhile, the studies conducted in Doreri Bay, Manokwari, were very limited, only on the growth aspect of the mackerel scad fish [17] (Randongkir et al. 2018). Other findings were also reported by [18] Sala et al. (2018) at Wondama Bay where the waters are close to Doreri Bay. Knowledge of biological aspects in particular is the basis for the development of fisheries management [19] (Dowling et al. 2015). Several fish sizes, including minimum landing size and fishing season, and the reproductive biology of fish stocks are important aspects of mackerel scad fish stocks management.

Boat lift nets in Doreri Bay are a type of dominant fishing tool 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. 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] (Randongkir et al. 2018; Sala et al. 2018; Suruan et al. 2019). Therefore, comprehensive and up-to-date data on the condition of the mackerel scad fish in Doreri Bay is needed to monitor its availability and sustainable use. 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 measure the status of the mackerel scad fishery in Doreri Bay.

2. MATERIAL 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 was the catch of mackerel scad fish and the size of total length and weight the individual fish samples.

There were 6 boat lift nets carrying out fishing operations in Doreri Bay, where fishing operations were carried out 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. 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 Figure 1.

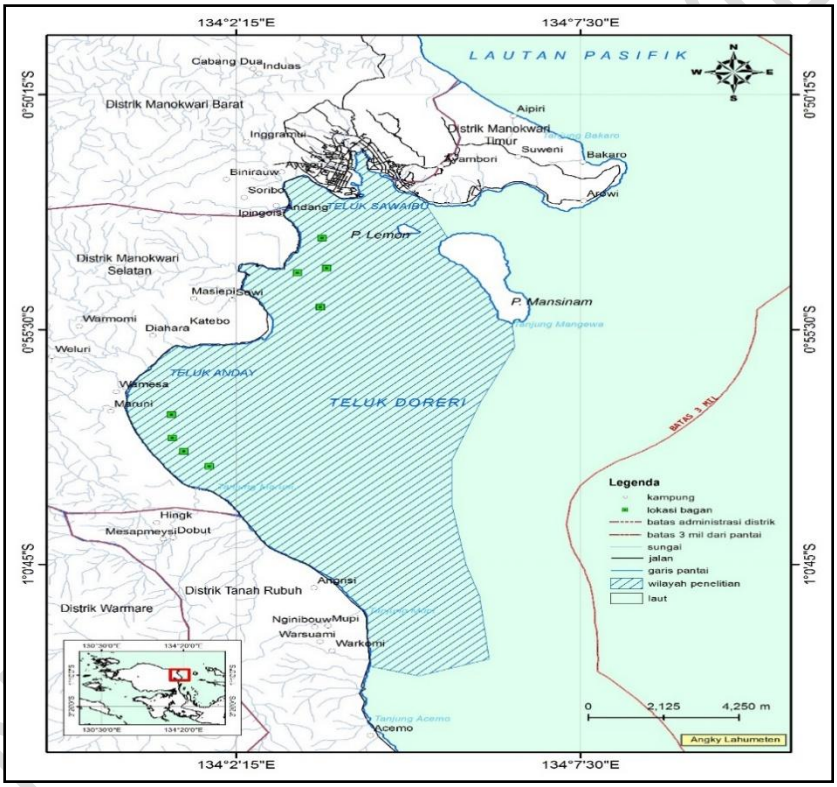


Figure 1. Fishing location of boat lift nets in Dorery Bay water

2.2 Data Analysis

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. To obtain the value of the initial equation, the log a value was transformed to the natural anti-logarithm. The value of a is the intercept (negative, positive, or equal to 0), the value of b is the slope or regression coefficient (negative or positive), and the value of b in the long-weight relationship equation indicates the type of fish growth. From this equation, if the value of b = 3 means that the weight gain of the fish is balanced with the increase in length, such growth is called isometric growth, whereas if the value of b ≠ 3 then the growth is called allometric. 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 fish (*Decapterus* spp) has an isometric growth pattern, namely the growth of Mackerel scad fish is proportional between the growth in length and weight.
- 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 ≠ 3 was [24] Weaver and Wuensch, (2013), as follows:

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

Where:
s_b = Standard error of b
b = regression coefficient (slope)
b* in this study is equal to 3
If t-count > t-table then the value of b ≠ 3 or allometric growth form and if t-count ≤ t-table then the value of b = 3 or isometric growth form.

3. RESULTS AND DISCUSSION

3.1 Catch

Catch production in April for the *Decapterus macerellus* type had a higher catch production of 18,966 kg, compared to the *Decapterus akaadsi* type which was 8,949 kg, and *Decapterus macrosoma* which was 6,610 kg (Figure 2). Catch production in May for the *Decapterus macerellus* species still had the highest total production value of 4,704 kg followed by other species. It was the same 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.

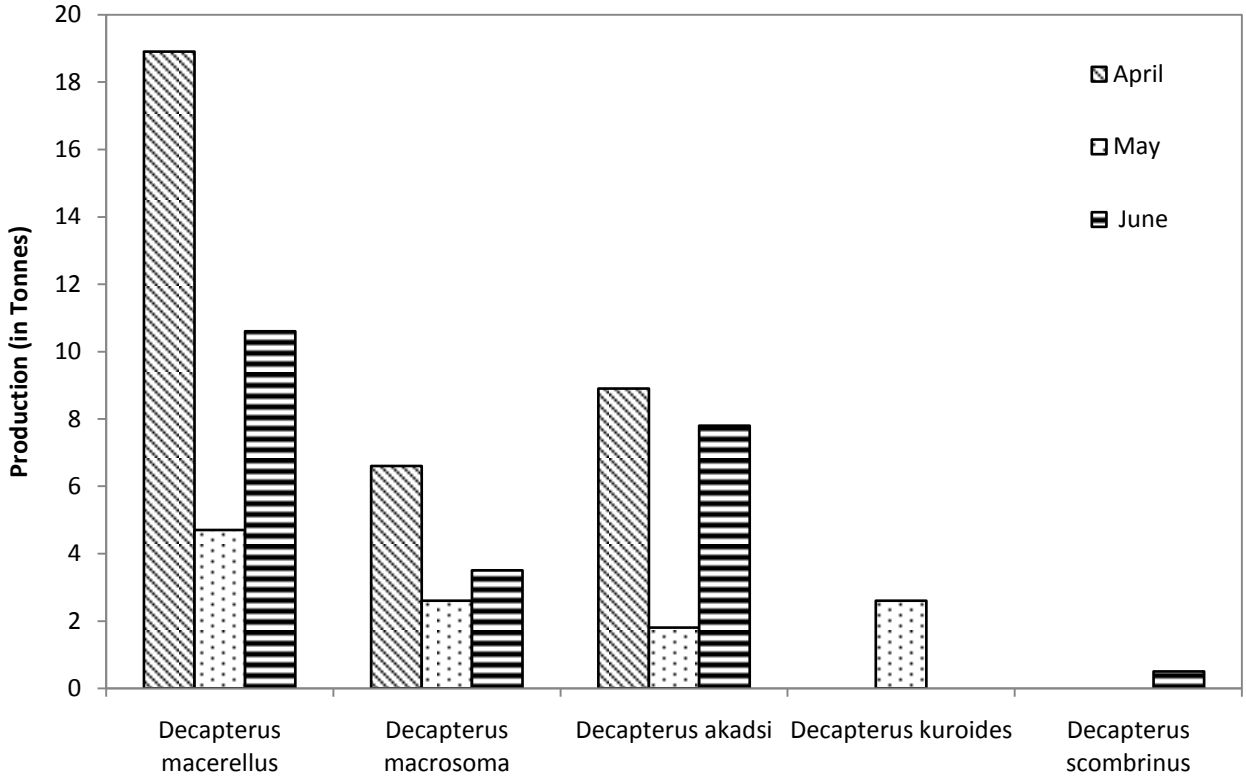


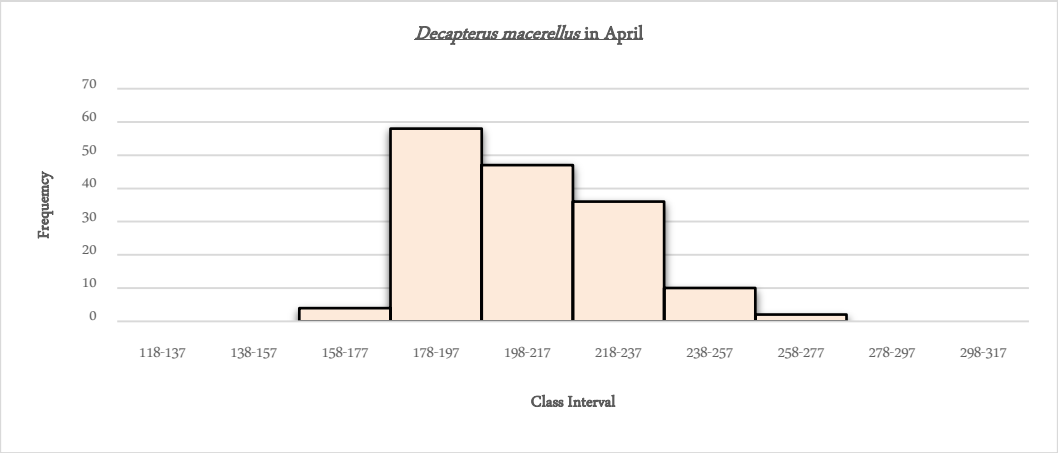
Figure 2. Total production of scad fish catches

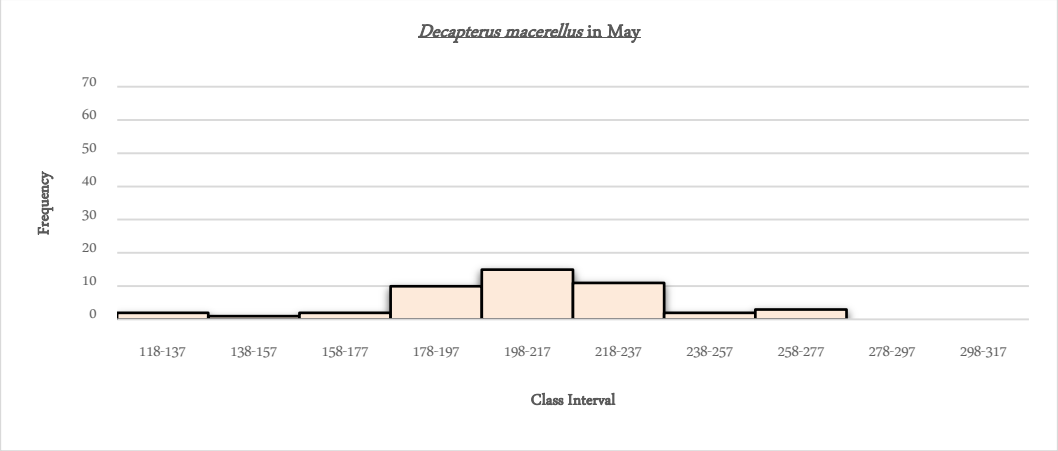
3.2 Fish Size Distribution

Frequency distribution of Mackerel scad fish sizes, namely; *Decapterus macerellus, Decapterus macrosoma, Decapterus akadasi* caught during April, May, and June 2019 (Figure 3). *Decapterus kuroides* was only found in May and *Decapterus scombrinus* was only found in June. The size of the Mackerel scad fish type called *Decapterus macerellus* caught using boat lift nets in Doreri Bay waters in April ranged from 158 – 277 mm from a total of 157 fish sample data. The most caught size in April ranged from 178 - 197 mm with a frequency of 58 fish.

The size of the fish that was caught the least was in the range of 258 – 277 in length with a frequency of 2 fish (Figure 3). In May, the type mackerel scad fish called *Decapterus macerellus* caught ranged in size from 118 – 277 mm from a total sample data of 46 fish. The size of the fish caught mostly ranged from 198 – 237 mm with a frequency of 15 fish, while the size of the fish caught the least ranged from 138 - 157 with a catch frequency of 1 fish. The size of the fish caught in June for the type *Decapterus macerellus* ranged from 138 – 317 mm out of 69 fish caught. The size that was caught the most ranged from 198 – 217 mm with a frequency of 31 fish. The size that was caught the least was in the range of 298 – 317 mm with a frequency of 1 fish. The size of Mackerel scad fish of the *Decapterus macerellus* type caught by boat lift nets in the waters of Doreri Bay in April - June varies

each month based on the highest catch frequency, where in April it 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 of *Decapterus macerellus* had no significant differences from the frequency of *Decapterus macerellus* landed at the Kendari Port which was caught with purse seine, with a length range of 182 – 317 mm for male and female fish [25] (Fadila et al. 2016).





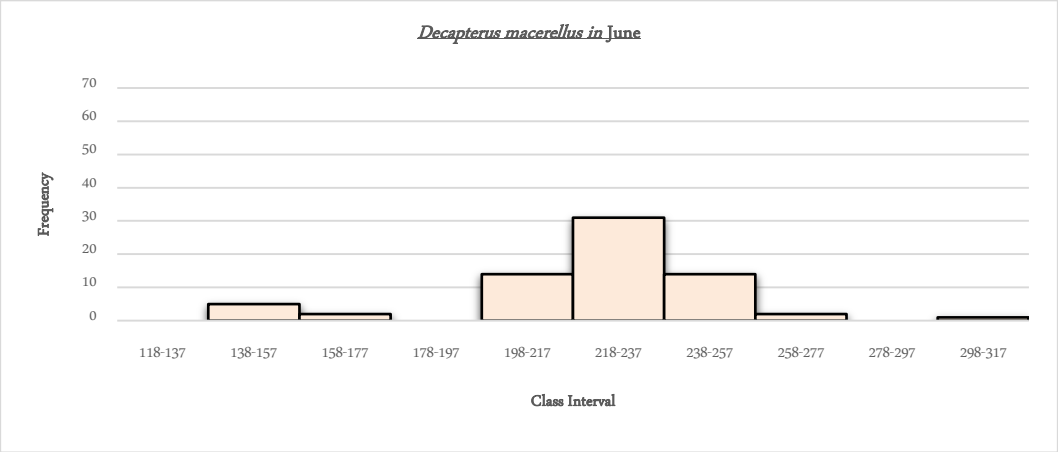


Figure 3. Frequency Distribution based on *Decapterus macerellus* Length Class Intervals in April, May, and June

The Mackerel scad fish size of *Decapterus macrosoma* type caught in April ranged from 82 – 265 mm from the data of 306 fish samples (Figure 4). The most caught size in April ranged from 105 – 127 mm with a frequency of 193 fish. The size of the fish that was caught the least was in the length range of 243 – 265 with a frequency of 1 fish. In May, mackerel scad fish of *Decapterus macrosoma* type caught ranged in size 59 – 288 mm from a total sample data of 80 fish. The size of the most caught fish ranged from 105 – 127 mm with a frequency of 26 fish, while the size of the fish that was caught the least ranged from 243 - 265 and 266 – 288 mm with a frequency of 1 fish respectively.

The size of the fish of *Decapterus macrosoma* type caught in June ranged from 82-173 mm, with a total of 25 fish caught. The most commonly caught size ranged from 105 – 127 mm with a frequency of 20 fish out of a total sample of 25 fish caught. The fewest sizes caught were in the range of 82 – 104 mm and 128 – 150 mm with a frequency of 1 fish respectively. The highest number of Mackerel scad fish of the *Decapterus macrosoma* type caught in April - June were 239 fish ranging between 105 - 107 mm. According to Randongkir et al [17], the length distribution of Mackerel scad fish (*Decapterus macrosoma*) landed for males has a size of 109 – 303 mm and it is dominant in the class interval of 164 – 181 mm and for females with a size of 125 – 299 mm which is dominated in the class range of 162 – 176 mm with the highest catches in April. Another finding by Nursinar and Panigoro [26] stated that *Decapterus macrosoma* had the highest catches in the class interval range of 16.5 – 18.4 cm.

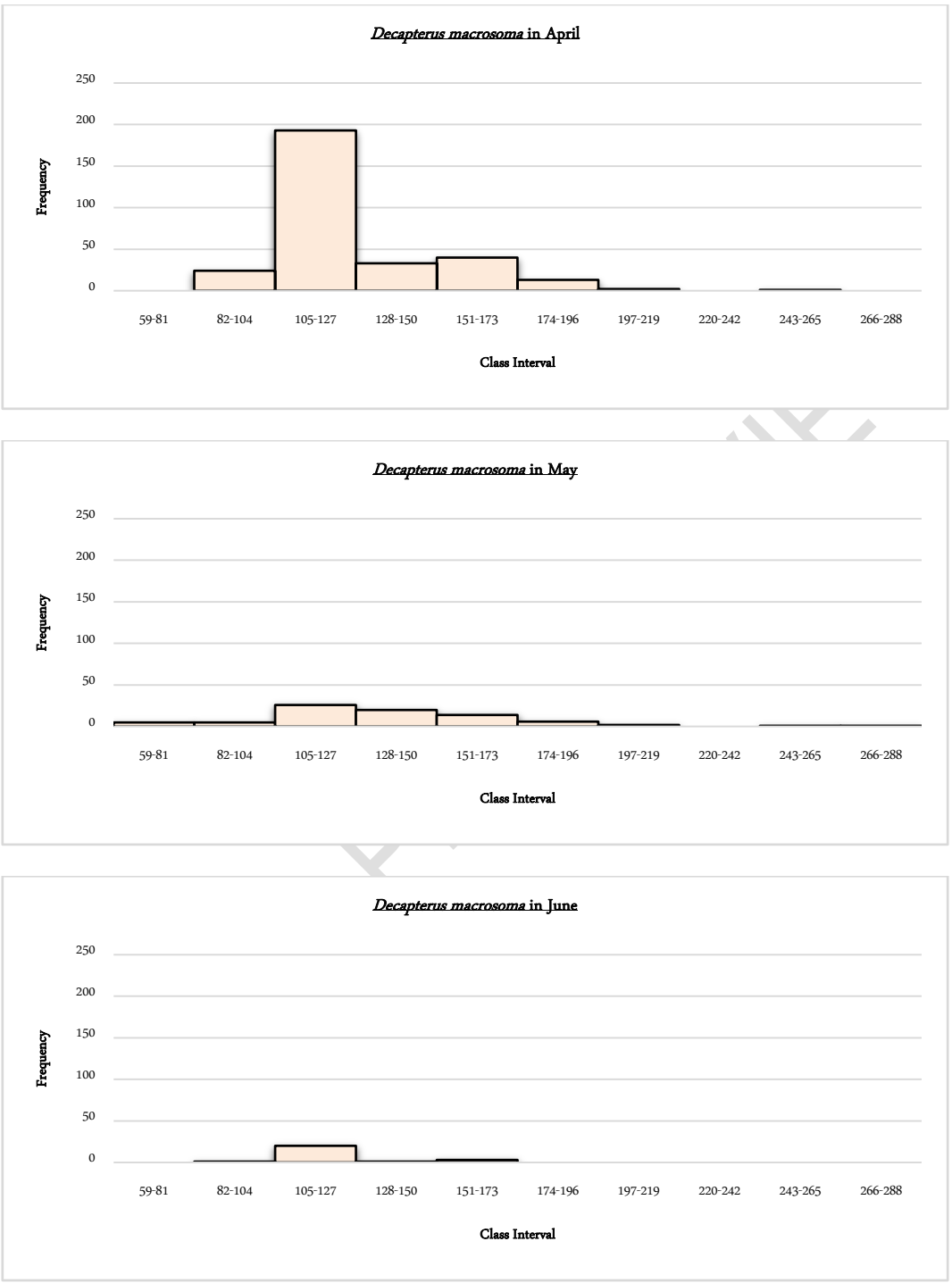
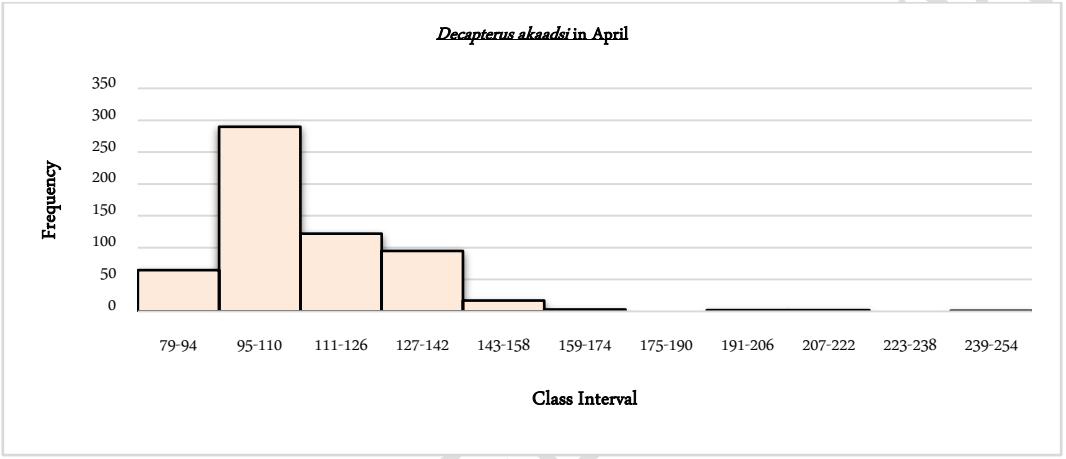
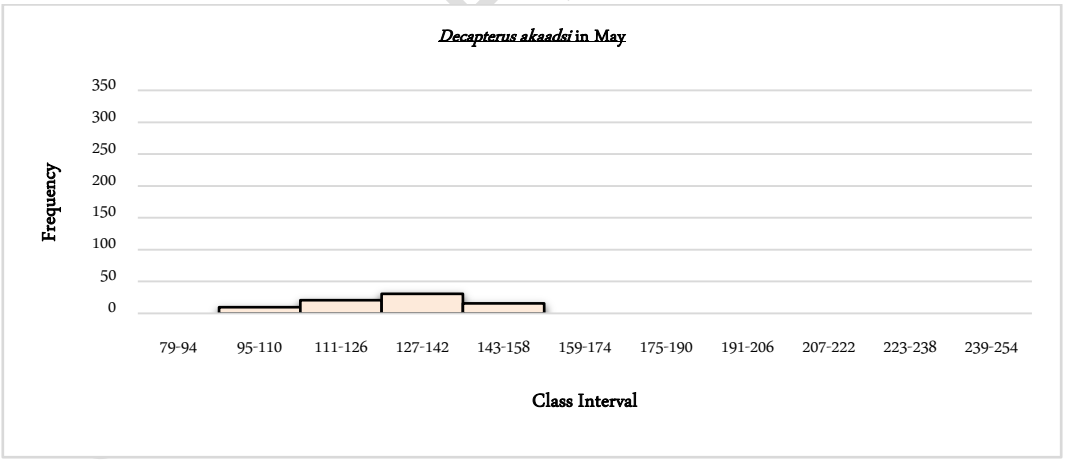


Figure 4. Frequency Distribution based on *Decapterus macrosoma* Length Class Intervals in April, May, and June.

The Mackerel scad fish size of the *Decapterus akaadsi* type caught in April ranged from 79 – 254 mm from data on 597 fish samples (Figure 5). The size of the fish caught in April mostly ranged from 95 – 110 mm with a frequency of 290 fish. The size of the fish that was caught

the least was in the length range of 239 – 254 with a frequency of 1 fish. In May, Mackerel scad fish of the *Decapterus akaadsi* type caught ranged in size from 95 – 158 mm from a total sample data of 78 fish. The size of the fish caught the most ranged from 127 – 142 mm with a frequency of 31 fish, while the size of the fish caught the least ranged from 95 - 110 with a frequency of 10 fish. The size of the *Decapterus akaadsi* type caught in June ranged from 95 – 190 mm from a total of 274 fish caught. The most caught size ranged from 127 – 147 mm with a frequency of 150 fish. The fewest sizes caught were in the range of 95 – 110 mm and 175 – 190 with a catch frequency of 3 fish for each size. The most dominant size of fish caught starting in April was the size between class intervals of 95 – 110 mm, while in May and June, the size of fish caught ranged from 127 – 142 mm.





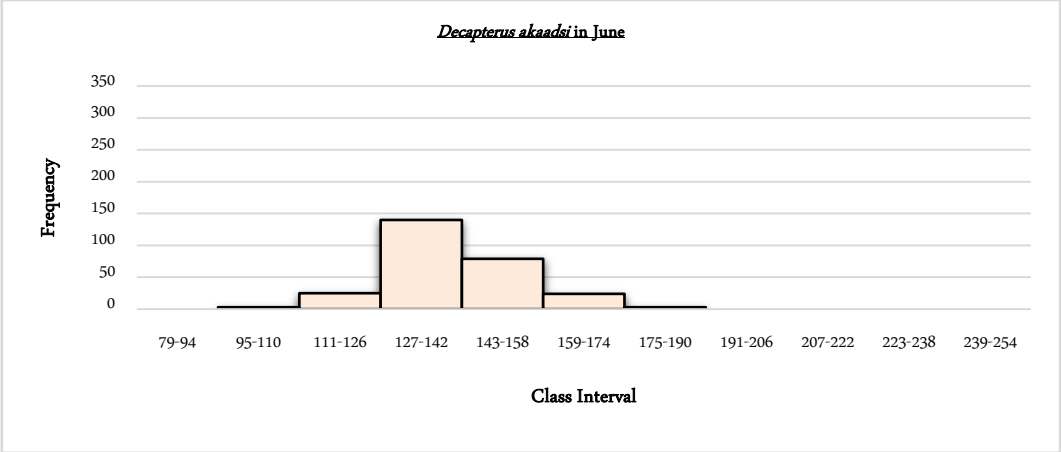


Figure 5. Frequency Distribution based on *Decapterus akaadsi* Length Class Intervals in April, May, and June

The range of *Decapterus kuroide* fish class ranged from 86 – 157 mm with a total frequency of 130 fish caught (Figure 6). The most caught size ranged from 142 – 149 mm with a total frequency of 30 fish. The smallest size of fish caught was in the class interval of 86 – 93 mm with a frequency of 4 fish (Frequency distribution based on class intervals is shown in Figure 17). The length ratio found in Doreri Bay waters was not different significantly from the *Decapterus akaadsi* species found in Amurang Bay waters with a length range of 141 – 190 mm [27].

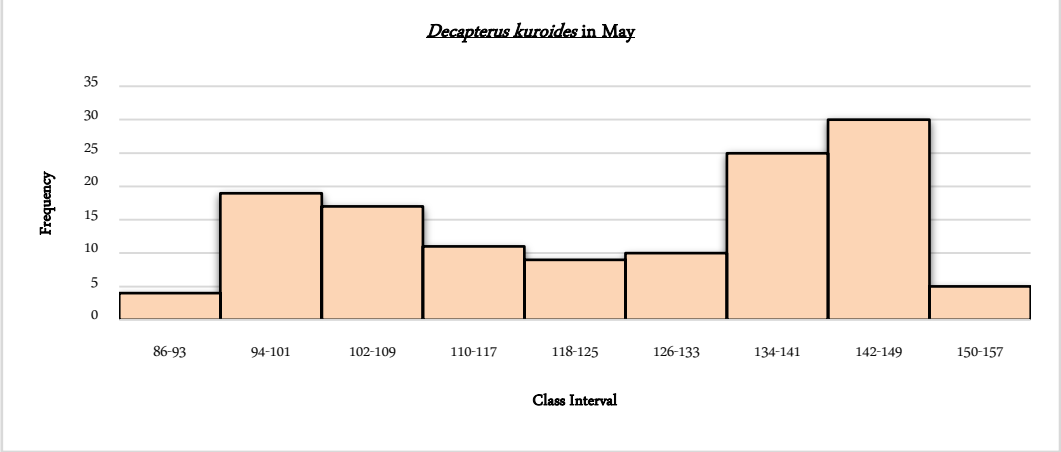


Figure 6. Frequency Distribution based on *Decapterus kuroides* Length Class Intervals in May

Mackerel scad fish of *Decapterus scombrinus* species 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 total frequency of catches was only 26 fish. The class interval with the highest catch ranged from 103 – 115 mm with a total catch frequency of only 11 fish and the class

interval with the fewest caught ranged between 142 – 154 and 168-180 with a catch frequency of 1 fish each. Frequency Distribution based on the class interval is presented in Figure 7.

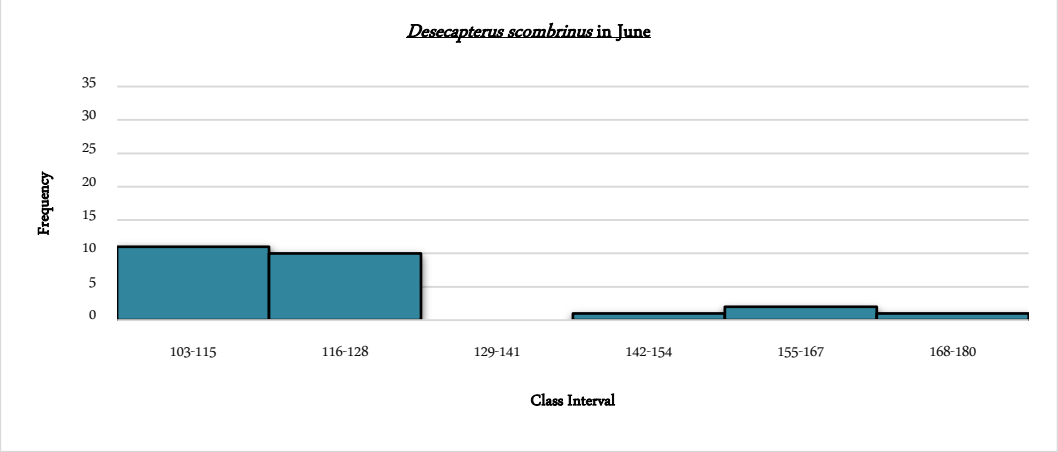


Figure 7. Frequency Distribution based on *Decapterus scombrinus* Length Class Intervals in June.

Comparison of class intervals based on research results with several studies that had been conducted previously in several regions (see Table 2) showed that the average length interval for the *Decapterus macerellus* type was 17.8 – 25.7, it is contradicted with research conducted in the Celebes Sea which was 10.3 – 32.2 with an Lm value of 50% equal to 26.89 [15]. Furthermore, the average class interval for *D. macrosoma* found was 10.5 – 12.7, it was different from the one found in the Java Sea, which was 14.5 – 15.5 with a 50% Lm value of 14.3 – 14.9 [28]. There was a difference in size between the length classes of *D. macrosoma* caught in the Doreri Bay and the Java Sea, it can be assumed that the influence of biological aspects such as food availability and breeding have an important role in the growth process of the Mackerel scad fish.

Fishermen's catch also has an important role, the length measured in table 2 was the fish length when they were caught. *D. akaadsi, D. kurroides* and *D. scrombinus* types in this study had a very significant difference in the length class interval based on research data reported by Fish Base in Pacific Waters (Table 2).

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			
D. macerellus	17.8-25.7	10.3-32.3	26.89	[12]	Celebes sea
D. macrosoma	10.5-12.7	14.5-15.5	14.3-14.9	[28]	Java Sea
			25.5	[29]	Coastal Fishing Port of Gunung Kidul

D. akaadsi	7.9-19.0	30.0	30.0	Fishbase	Yogyakarta Data Western Pacific
D. kuroides	9.4-14.9	30.0-45.0	-	Fishbase	West Pacific
D.scrombinus	10.3-18.0	30.0-50.0	-	Fishbase	Indo-Pacific

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

Analysis of fish growth patterns can be done through the length-weight relationship of fish. The value of the analysis of the length-weight relationship in fish can predict the weight of the fish based on length or vice versa [30]. Based on the results of the research conducted, there were several growth patterns for Mackerel scad fish species in Doreri Bay, Manokwari, both 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, namely diet, age differences, food availability, environmental conditions, and gonadal maturity levels. Fish that have gonad maturity appear for 10 months from March to December and those that have spawned appear in the same period and are not found from January to February.

The growth pattern of the types of Mackerel scad fish based on the research results from April to June can be seen in some of the graphic images below. Based on the results of the t-test to determine the value of the growth pattern (b) between the length and weight of the mackerel scad fish, (*Decapterus* spp.) it is proven that the growth pattern for the types of mackerel scad fish caught by boats lifts nets fishermen in Doreri Bay, Manokwari Regency was very different based on the month of catch during the study, namely from April to June. Based on the results of the t-test for the *Decapterus macrosoma* type in April ($t\text{-}_{count}$ = 2.881 > $t\text{-}_{table}$ = 1.968), May ($t\text{-}_{count}$ = 4.033 > $t\text{-}_{table}$ = 1.991) and June ($t\text{-}_{count}$ = 4.326 > $t\text{-}_{table}$ = 2.069), it means that the growth pattern was positive allometric, namely weight growth was more dominant compared to the length of the b value in April (3.137), in May (3.013), and in June (3.755).

Decapterus macrosoma type has a positive allometric growth pattern, where the weight of the fish was more dominant than its length. The condition of fish is strongly influenced by habitat conditions, time of foraging, and availability of food in waters where fish will grow quickly due to the availability of sufficient food so that it can provide good nutrition for fish growth. The growth seen in Figures 8, 9, and 10 showed that the fishing activities of the bagan fishermen were carried out when the mackerel scad fish of *Decapterus macrosoma* type was looking for food or the fish had not eaten. In addition, fish nutrition greatly influences fish health, where fish will have a body with sufficient weight due to the influence of sufficient nutritional content for fish health.

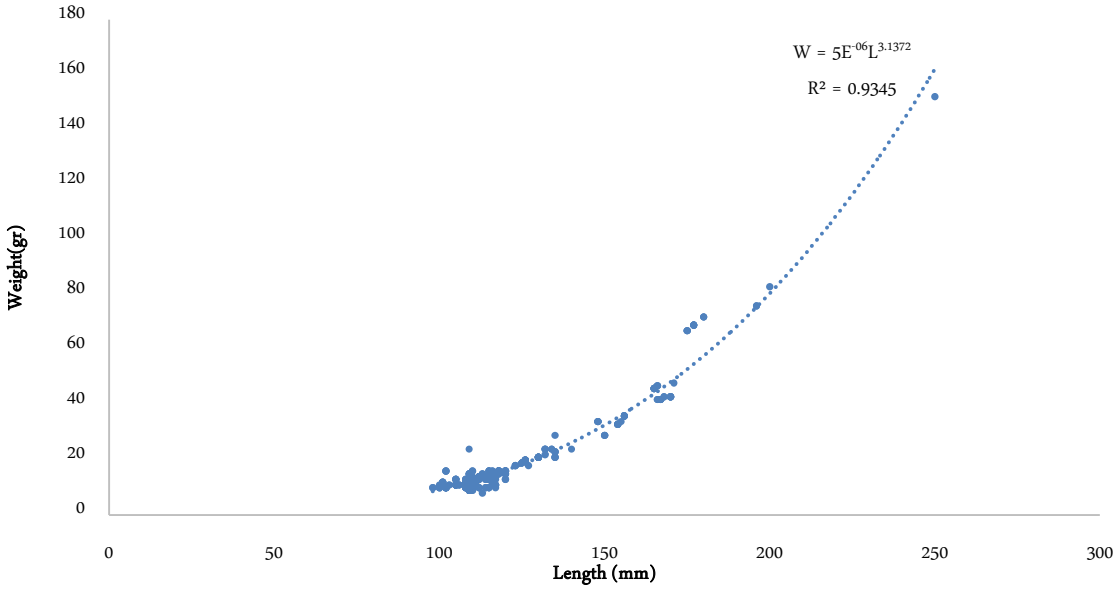


Figure 8. *Decapterus macrosoma* Growth Pattern in April

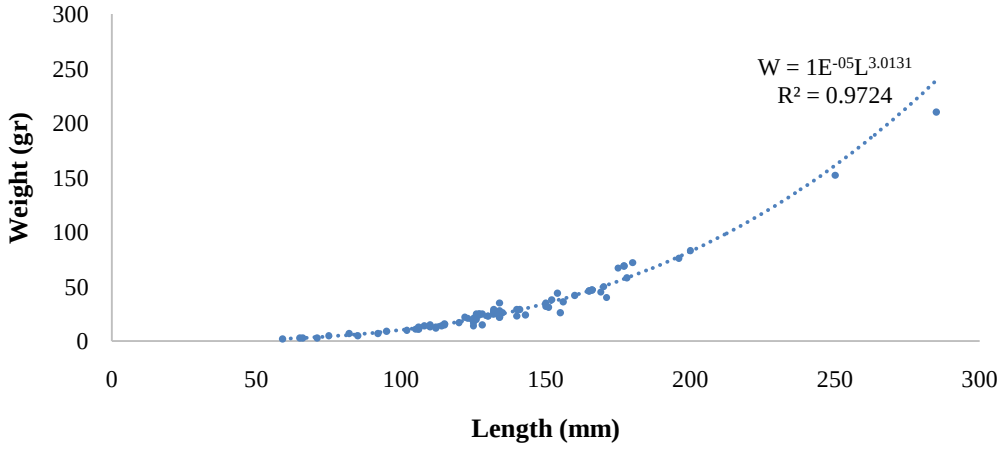


Figure 9. *Decapterus macrosoma* Growth Pattern in May

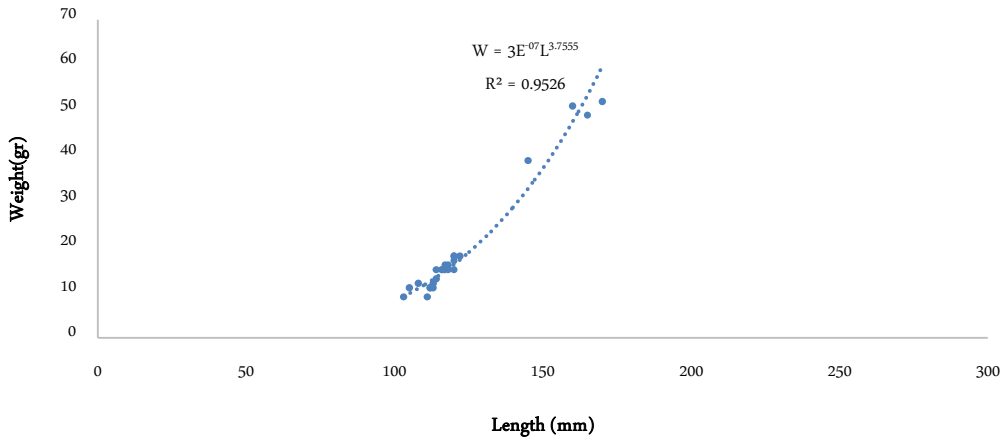


Figure 10. *Decapterus macrosoma* Growth Pattern in June

The results of the t-test for the *Decapterus akaadsi* type of mackerel scad fish in April were $t\text{-}_{count}$ = -3.434 < $t\text{-}_{table}$ = 1.964 meaning that the growth pattern was negative allometric, namely growth in length was more dominant than weight with b value of 2.8425, in May $t\text{-}_{count}$ = 2.868 > $t\text{-}_{table}$ = 1.995 indicating that the growth pattern was positive allometric, i.e. growth in weight was more dominant than in length with b value of 3.413, while in June $t\text{-}_{count}$ = -0.133 < $t\text{-}_{table}$ = 1.969 meaning that the growth pattern was negative allometric i.e. growth in length is more dominant than weight with b value of 2.989.

The type of *Decapterus akaadsi* had a slightly different growth pattern from the type of *Decapterus macrosoma*. Figures 11, 12, and 13 showed that the growth pattern of *Decapterus akaadsi* varies greatly for each month. In April the growth was negative allometric, in May the growth pattern was positive allometric, whereas, in June, the growth found was negative allometric. This proves that the fishing activity of boat lifts nets fishermen in Doreri Bay was strongly influenced by the month, the season, and the time of fishing.

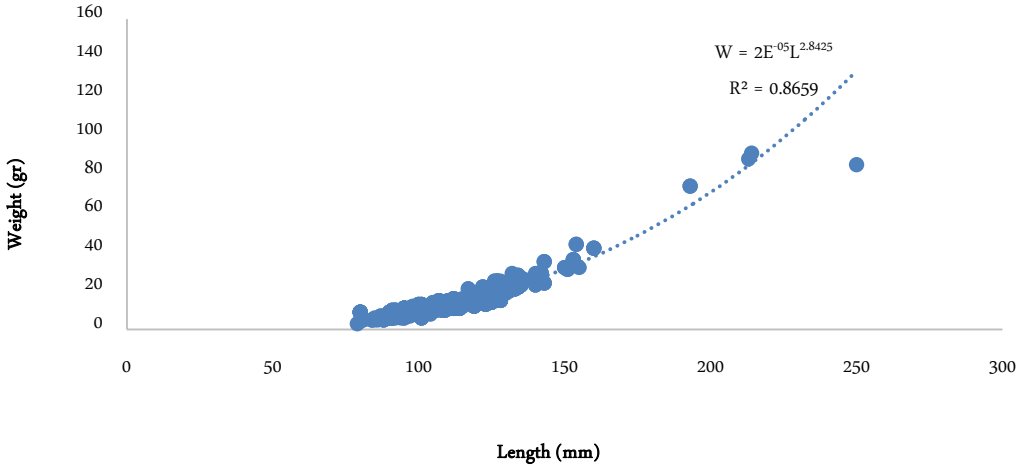


Figure 11. *Decapterus akaadsi* Growth Pattern in April

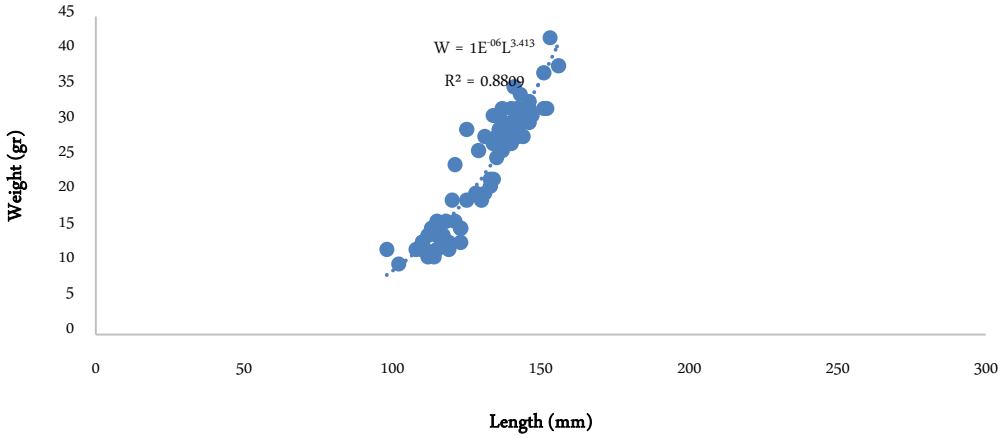


Figure 12. *Decapterus akaadsi* Growth Pattern in May

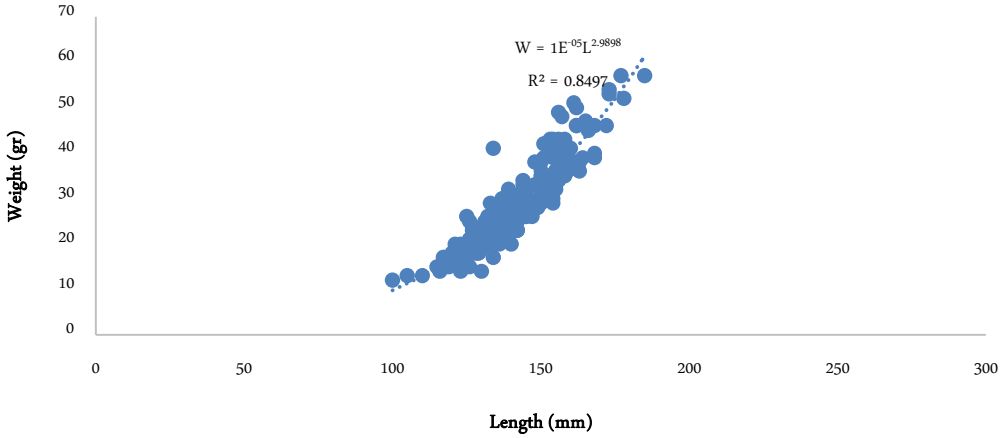


Figure 13. *Decapterus akaadsi* Growth Pattern in June

The catches of *Decapterus akaadsi* in April and June had more dominant weight growth compared to Length growth. It is presumed that the fish had finished their eating activities or were influenced by the condition of the eggs (fish gonads) which might have entered the Gonad Maturity Level phase 5 or 6, so it greatly affects the weight of the fish. When fish are spawning, the IKG value increases because most of the metabolic results are focused on gonadal development, otherwise it decreases after spawning. However, the fish caught in May showed a different condition, the fish had more dominant length compared to the weight, which means that *Decapterus akaadsi* when caught by boat lift nets fishermen, had not carried out foraging activities or had not yet entered the gonad maturity stage.

The results of the t-test on *Decapterus macerellus* in April ($t\text{-}_{count}$ = -7.549 < $t\text{-}_{table}$ = 1.975), May ($t\text{-}_{count}$ = -1.723 < $t\text{-}_{table}$ = 2.015), and June ($t\text{-}_{count}$ = -0.754 < $t\text{-}_{table}$ = 1.996), meaning that the growth pattern was negative allometric, namely the b value was < 3, as follows; April 2.184, May 2.527 and June 2.732.

Mackerel scad fish of *Decapterus macerellus* type (Figures 14, 15, and 16) had a slightly different growth pattern from the types of *Decapterus macrosoma* and *Decapterus akaadsi*. The growth pattern that occurs in *Decapterus macerellus* for April had a negative allometric growth pattern. The condition of *Decapterus macerellus* growth pattern illustrates that the catches of the boat lift nets fishermen in Doreri Bay in April occurred when the fish were doing feeding activities or after eating, besides that they were also influenced by fish that might have entered the TKG phase with severe conditions influenced by eggs or food in the body of *Decapterus macerellus*.

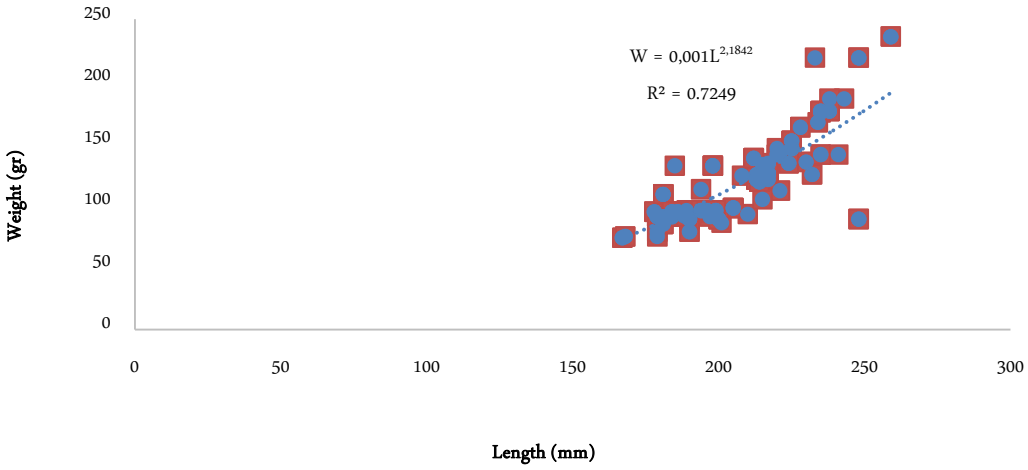


Figure 14. *Decapterus macerellus* Growth Pattern in April

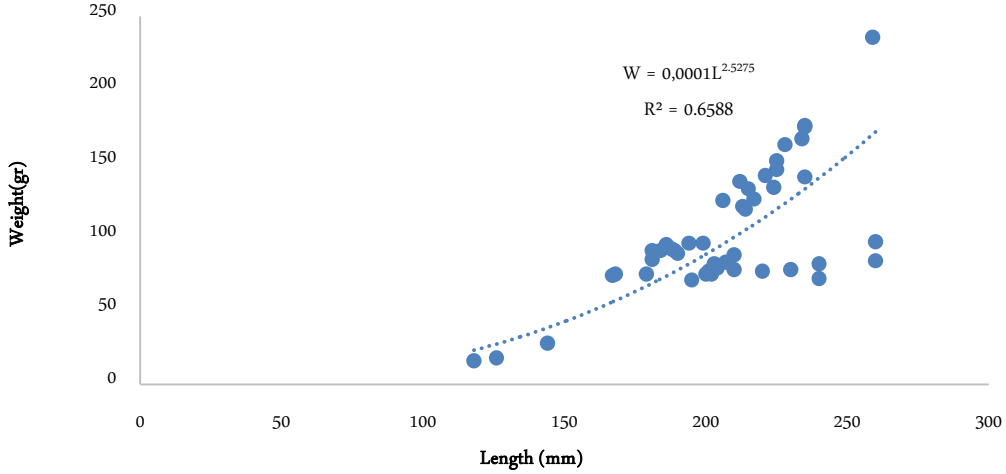


Figure 15. *Decapterus macerellus* Growth Pattern in May

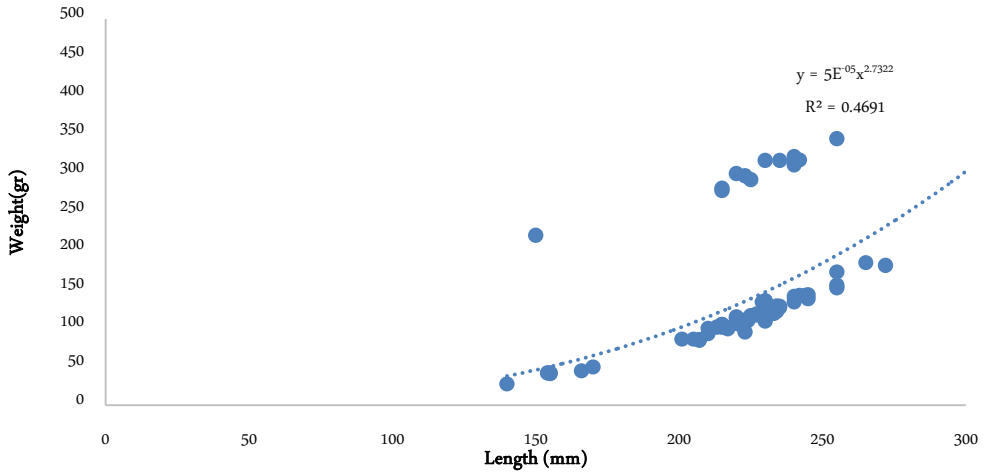


Figure 16. *Decapterus macerellus* Growth Pattern in June

The results of the t-test on the *Decapterus kurroides* species found in May with $t\text{-}_{count}$ = -1.881 > $t\text{-}_{table}$ = 1.979 indicating that the growth in length was more dominant than in weight, namely the value of b is 2.829 (b <3). The results of the analysis of the growth pattern, *D. kurroides* has a negative allometric growth pattern, where the length of the fish was more dominant than its length. The estimation of differences in growth patterns in the same month is because *Decapterus kurroides* and *Decapterus macrosoma* have different growth patterns, growth forms, foraging times, and conditions of gonadal maturity depending on the species. *Decapterus kurroides* caught by boat lift nets fishermen had a weight that was suspected to be strongly influenced by stomach contents and also the nutritional condition of the fish so the weight of the fish is very dominant.

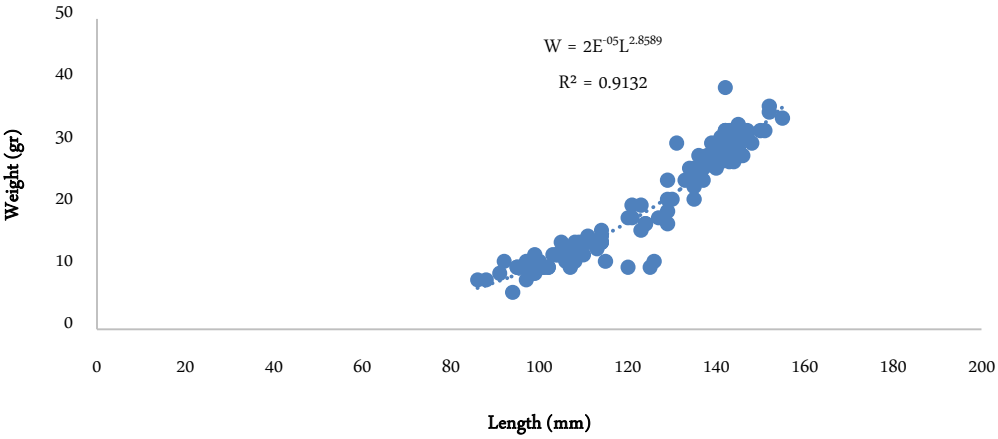


Figure 17. *Decapterus kurroides* Growth Pattern in May

Based on the results of the t-test on the type of *Decapterus scombrinus* which was only found in June with $t\text{-}_{count}$ = 4.326 > $t\text{-}_{table}$ = 2.067 i.e. b value > 3 indicating that the growth pattern was positive allometric (weight growth was more dominant than length) with b value is 3.755. Figure 18 showed that the *Decapterus scombrinus* type had the same case as the *Decapterus kuroides* type which was only found in June. However, it had a different growth pattern from *Decapterus kuroides*, where the growth pattern obtained based on the analysis results was a positive allometric growth pattern, namely, weight is more dominant compared to length conditions. The catch of fishermen proves that *Decapterus scombrinus* was only found in June, meaning that this type of mackerel scad fish is a seasonal fish species that is only found in certain months and also foraging activities, season, time, and migration are only carried out during certain seasons. So based on the identification results of fishermen's catches, this type was only found in June.

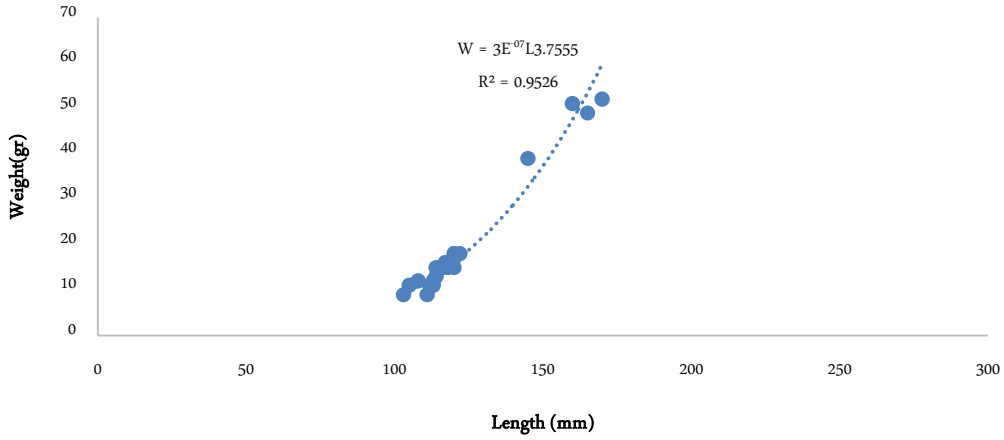


Figure 18. *Decapterus scombrinus* Growth Pattern in June

The b value in the length-weight relationship fish is indirectly related to the condition factor. The condition factor or often called the K factor is one of the most important things in growth. It is used to determine the plumpness of the fish in the form of a number calculated based on an analysis of the length-weight relationship of the fish [31].

The value of the 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 can be caused by season, habitat, gonadal maturity, sex, stomach fullness, and fish health. The difference in the b value is also due to the difference in the number and size variations observed. 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].

3.4 Fish Management Implications

The mackerel scad fish fisheries management policy is an action that can be taken to maintain the stock of mackerel scad fish resources in water so that it remains sustainable. Appropriate management policies to maintain the sustainability of mackerel scad fish resources in Doreri Bay are described as follows:

1. It is necessary to pay attention to the fishing season, size suitable for catching, and production of mackerel scad fish catches in Doreri Bay waters, Manokwari Regency for several types of mackerel scad fish such as *Decapterus kuroides, Decapterus macrosoma,* and *Decapterus akaadsi.* From the research data, it can be seen that the catch of *D. kuroides* was found in May with a production value of 2.265 Kg, and the class interval caught was dominated by class intervals ranging from 142 – 149 mm where *D. kuroides* was only found in May. The most dominant type of *Decapterus macrosoma* caught was 105 – 127 mm with a total production of 6.610 kg. The type of *Decapterus akaadsi* class interval caught is dominated by the class range of 95 – 142 mm with a production of 7.801 Kg.

2. The increase and decrease in the amount of production of mackerel scad fish (*Decapterus* spp.) caught with boat lift nets in the waters of Doreri Bay, Manokwari Regency, needs to be monitored. It is necessary to organize the fishing areas for Boat Lift Nets fishermen in the waters of Doreri Bay, Manokwari Regency concerning the Regulation of the Minister of Maritime Affairs and Fisheries Number 59/PERMEN-KP/2020 concerning Fishing Routes and Fishery Management Areas of the Republic of Indonesia and the High Seas. Where for the API (fishing equipment) called Boat Lift Net is operated on the IB Fishing Line and II Fishing Line in all the fishery management areas of the Republic of Indonesia (WPPNRI).

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.

REFERENCES

[1] Ohshimo, S., M. Yoda, N. Itasaka, N. Morinaga and T. Ichimaru. Age, growth and reproductive characteristics of round scad Decapterus maruadsi in the waters off west Kyushu, the East China Sea. Fisheries Science. 2006;72: 855-859.

[2] Khasanah, A.N., Saputra, S.W. and Taufani, W.T. Population dynamic of Indian scad (Decapterus russelli) based on data in tasikagung fishing Port of Rembang. In *IOP Conference Series: Earth and Environmental Science.* 2020;530, No. 1, p. 012004). IOP Publishing.

[3] Kurniawan, A., Permadi, A. and Purnomo, A.H. Optimum Proportion of Indian Scad (Decapterus Russelli) Protein Concentrate In Traditional Food Cake Designated For Undernourished Children Diet. *Russian Journal of Agricultural and Socio-Economic Sciences*. 2020a;3(99): 170-182.

[4] Kurniawan, A., Permadi, A. and Purnomo, A.H. Children's Responses to the Addition of Indian Scad (Decapterus russelli) Fish Protein Concentrated and Flavor to Traditional Food. *Jurnal Airaha*. 2020b;*9*(1).

[5] McBride, R., Stengard, F. and Mahmoudi, B., 2002. Maturation and diel reproductive periodicity of round scad (Carangidae: Decapterus punctatus). Marine Biology. 2002;140, pp.713-722.

[6] Farhan, M.D. and Ginting, L.N. Optimizing the utilization of scad fish (Decapterus spp.) resources on the northern coast of Aceh. In *IOP Conference Series: Earth and Environmental Science*. 2022; 951, No. 1, p. 012054.

[7] Arnaud, S., Bonhomme, F. and Borsa, P. Mitochondrial DNA analysis of the genetic relationships among populations of mackerel scadl (Decapterus macarellus, D. macrosoma, and D. russelli) in South-East Asia. Marine Biology. 1999;135, pp.699-707.

[8] Pattikawa, J.A., Ongkers, O.T.S., Tetelepta, J.M.S., Uneputty, P.A. and Amirudin, A., 2018. Some biological aspects of mackerell scad (Decapterus macarellus) in Ambon Island waters, Indonesia. *International Journal of Fisheries and Aquatic Studies* 2018;*6*(4), pp.171-175.

[9] Retnoningtyas, H., Yulianto, I., Wiryawan, B., Kleinertz, S. and Palm, H.W. Stock discrimination of mackerell scad Decapterus macarellus (Cuvier, 1833) in eastern Indonesia based on metazoan fish parasite composition. Regional Studies in Marine Science. 2023;61, p.102840

[10] Sadhotomo, B. and Atmadja, S.B., 2016. Synthesis of the study of small pelagic fish stocks in the Java Sea. Indonesian Fisheries Research Journal. 2016;18(4), pp.221-232. Indonesian.

[11] Triharyuni, S., Hartati, S.T. and Nugroho, D., 2016. Potential Evaluation of Mackerel scad (Decapterus spp.) in WPP 712–Java Sea. Indonesian Fisheries Research Journal. 2016;20(3), pp.143-152. Indonesian.

[12] Zamroni, A., Kuswoyo, A. and Chodrijah, U. Biological aspects and population dynamics of the blue scad mackerel (Decapterus macarellus Cuvier, 1833) in the Sulawesi Sea. BAWAL Widya Capture Fisheries Research. 2019;11(3), pp.137-149. Indonesian.

[13] Bintoro, G., Lelono, T.D. and Syehbiarachman, H. Biological aspect of Indian scad (Decapterus russelli) caught by purse seine in north coast of Sumenep waters, East Java. In IOP Conference Series: Earth and Environmental Science. 2019a;239, No. 1, p. 012016). IOP Publishing.

[14] Manginsela, F.B., Mamuaya, G.E., Rompas, R.M. and Lumingas, L.J., 2020. The Size and The Shape of Sagittal Otolith of Redtail Scad, Decapterus kurroides Blekeer 1855 from Kema Bay, North Minahasa Regency, North Sulawesi, Indonesia. Omni-Aquatic. 2020; 16(3), pp.99-110.

[15] Zamroni, A. Population Genetic Structure of Malalugis Fish (Decapterus macarellus) in The Waters Around The Island of Sulawesi Based on Mt-DNA Marker. 2012. Indonesian.

[16] Bintoro, G., Lelono, T., Rudianto. & Utami, N., 2019b. Biological aspects of Indian Scad (Decapterus russelli Ruppell, 1830) in South Site of Madura Strait Waters, East Java. IOP Conf. Ser. Earth Environment. sci. 370. Institute of Physics Publishing. 2019b;p. 012040. https://doi.org/10.1088/1755- 1315/370/1/012040.

[17] Randongkir, Y.E., Simatauw, F. & Handayani, T. Growth Aspects of Scad Decapterus macrosoma on Fish Point Sanggeng-Manokwari Regency. J. Sumber d. Indopacific Aquatics. 2018;2(1):15-24. https://doi.org/10.30862/jsai-fpik-unipa. Indonesian

[18] Sala, R., Bawole, R., Runtuboi, F., Wopi, I.A. and Budisetiawan, J., 2018, March. Population dynamics of the yellow stripe scad (Selaroides leptolepis Cuvier, 1833) and Indian mackerell (Rastrelliger kanagurta Cuvier, 1816) in the Wondama Bay Water, Indonesia. In IOP Conference Series: Earth and Environmental Science. 2018;139, No. 1, p. 012026). IOP Publishing.

[19] Dowling, N.A., Dichmont, C.M., Haddon, M., Smith, D.C., Smith, A.D.M. and Sainsbury, K. Guidelines for developing formal harvest strategies for data-poor species and fisheries. Fisheries Research. 2015;171, pp.130-140.

[20] Suruan, S., Lahumeten, F., Bawole R. and Sala R. Types of flying fish (Decapterus Spp) Based on Bagan Fishermen's Catches in Doreri Bay, Manokwari Regency, West Papua Province. Journal of Aquaculture and Fish Health. 2019;8(2): 105-112. Indonesian

[21] Pauly D. Fish population dynamics in tropical waters: A manual for use with programmable calculators. ICLARM, Manila. 1984;325 p

[22] Suruwaky, M.A. and Gunisah, E. Identification of the level of exploitation of Indian mackerell (Rastrelliger kanagurta) reviewed from length-weight relationships. Journal of Aquatics. 2013;4(2), pp.131-140.

[23] Jisr, N., Younes, G., Sukhn, C. & El-Dakdouki, M.H. Length-weight relationships and relative condition factor of fish inhabiting the marine area of the Eastern Mediterranean city, Tripoli-Lebanon. Egypt. J. Aquat. Res. 2018;44:299–305. https://doi.org/10.1016/j.ejar.2018.11.004.

[24] Weaver, B. and Wuensch, K.L. SPSS and SAS programs for comparing Pearson correlations and OLS regression coefficients. Behavior research methods. 2013;45, pp.880-895.

[25] Fadila, M., Asriyana and Tadjuddah M. Several Aspects of Reproduction Biology of Mackerell Scad (Decapterus macarellus) Caught by Purse Seine Landed in Ocean Fishing Port of Kendari. Journal of Waters Resort. Manag. 2016;1, pp.343-53.

[26] Nursinar, S. and Panigoro, C. Age group analysis and growth of Decapterus macrosoma in the waters around Gorontalo. The NIKe Journal. 2015;3(1). Indonesian

[27] Baweleng, S., B. M. Fransine and R. R. S. Joudy. Study Of Otolith Flying Fish, Decapterus Akaadsi, Abe 1958 From Amurang Bay. Platax Scientific Journal. 2018;6(2): 66-76. doi:10.35800/jip.6.2.2018.20630.

[28] Prihartini, A., Anggoro, S. and Asriyanto, A. Analysis of the biological appearance of scad mackerel (Decapterus spp) caught by purse seine landed at PPN Pekalongan. Diponegoro University Postgraduate Program. Semarang. 2006; 89 pp. Indonesian

[29] Liestiana, H., Ghofar, A. and Rudiyanti, S. Biological Aspects of Mackerel scad (Decapterus macrosoma) Landed at PPP Sadeng, Gunungkidul, Yogyakarta. Management of Aquatic Resources Journal (MAQUARES). 2015;4(4), pp.10-18. Indonesian

[30] Alnanda, R. 2017. Resources Management Strategy for Scad Mackerel (Decapterus Russelli) in the Malacca Strait Waters. Bogor: Postgraduate School, Bogor Agricultural University. Thesis. 2017. Indonesian

[31] Effendi, M.I. Fishery Biology. Nusatama Library Foundation. Yogyakarta. 2002;163p.

[32] Lawson, E. O. andDoseku PA... Biology of Round Sardinella, Sardinella aurita (Valenciennes, 1847) from Majidun Creek, Lagos, Nigeria. World Journal of Fisheries and Marine Sciences. 2013;5(5):575–581. DOI: 10.5829/idosi.wjfms.2013.05.05.74144