Sex ratio, age group and length at first maturity of mackerel scad (*Decapterus macarellus* Cuvier, 1833) in the Southern waters of Ambon, Eastern Indonesia

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Abstract. The existence of mackerel scad in Ambon waters, Moluccas Indonesia has decreased from year to year mainly due to the over exploitation. This research aimed to study the biological aspects, in particular were sex ratio, age group and length at first maturity of mackerel scad (*Decapterus macarellus*) from this area. Sampling was done on September 2016 to July 2017 at the southern waters of Ambon Island. Samples collected were dissected to determine their sex and their gonad maturity level then measured. Bhattacharya method was used to determine age group while Spearman-Kaber method was used to identify length at the first maturity of this species. It was found that mackerel scad in the southern waters of Ambon Island had an equal number of male and female that consists of four age groups with length at first maturity for male and female were 24.9 cm and 24.8 cm, respectively.

1. Introduction

The fishes of the family Carangidae including the genus *Decapterus* are economically important resources in tropical and subtropical waters [1]. These fishes have widespread distribution and being categorized as coastal pelagic fish, spending their life between two marine habitats: coral reefs and open-ocean. Adult mackerel scad prefer clear oceanic water around islands, occasionally found near the surface, but generally at depths between 40-200m [2,3].

Ambon is a small island belongs to an archipelago province in Indonesia, Maluku. The waters around the Ambon Island is affected by Banda Sea, so it has various marine resources including reef fish and small pelagic species [4, 5, 6, 7, 8, 9]. One of the small pelagic fishes found in the waters around Ambon Island are mackerel scads (*Decapterus* spp). Those species are caught all year round by traditional fishers using mini purse seine or locally called *jaring bobo* [8].

Recent study showed that increasing number of purse seine operating in Ambon Island waters is not resulted in significant increasing of mackerel scads production [8, 10]. Thus, there is concern about sustainability of mackerel scads in this area.

One of the species of the genus Decapterus that is captured by traditional fishers in Ambon Island is *Decapterus macarellus*. Research on mackerel scad (*D. macarellus*) related to its size distribution, growth pattern and population dynamic had been done by some researchers [3, 9, 10]. This paper aims to fill the gap on that information by studying sex ratio, age group/cohort and length at first maturity of mackerel scad (*D. macarellus*) captured in Southern waters of Ambon Island. This information is important to fulfil existing information in order to manage small-scale fisheries in Ambon Island waters particularly the stock of mackerel scads (*Decapterus* spp).
2. Materials and Method

2.1. Data collection
Sample of mackerel scad (D. macarellus) was collected randomly on monthly basis at fish landing site around Ambon Island (Figure 1). Collected fishes were put into cool box and brought to the laboratory for further examination. In Laboratory, fishes were dissected to determine their sex and gonad stage maturity and then measured. Total length was measured to the nearest mm using measuring board from the tip of the mouth to the end of the tail.

![Map showing fish landing site (black circle)](image)

**Figure 1.** Map showing fish landing site (black circle)

2.2. Data analysis
Determination of sex ratio was based on formula according to Khouw (2016) [11]:

\[
NK = \frac{N_{JB}}{N} \times 100\%
\]

where  
NK : sex ratio  
NJB : number of male or female  
N : total number of sample observed.

Chi-square \((\chi^2)\) test was used to examine any deviation from the 1:1 ratio of male and female [6, 12]. Age group/cohort was analyzed using length frequency data and determined by using Bhattacharya method [8, 13]. Length at first maturity was determined by using Spearman- Kaber method to produce cumulative percentage frequency curve of mature fish [14]. Microsoft Excel 2010 and FiSAT II ver. 1.1.2 program were applied to process the data.
3. Result and Discussion

3.1. Sex ratio
A total of 2771 individuals of mackerel scad (D. macarellus) were collected during the study. The number of male (1368 individuals) is slightly lower than female (1403 individuals) with the ratio between male and female is 1:1.02, respectively. The result of Chi-square test shows that there is no significant deviation from the normal ratio 1:1 ($\chi^2_{\text{calc.}}=0.44 < \chi^2_{\text{table}}=3.84$ (p=0.05; df=1), thus the number of male is equal to the number of female. The sex ratio between male and female in this study is similar to the study on the same species in West Sulawesi [15] as well as to different species such as D. macrosoma in Bone strait [16].

3.2. Age group
Length frequency data can be converted into several normal distributions or pseudo cohort of a population that represented age groups in the population [8, 13]. Moreover, it is stated that those normal distributions can be separated into age groups if their separation index (SI) is equal or larger than 2.00 (SI $\geq$ 2.00) [17].

Age groups or number of cohorts of mackerel scad (D. macarellus) in the Southern Ambon Island waters is shown in Table 1 and Figure 2. The output of FiSAT Program in Table 1 shows that SI values between two sequential groups ranging from 2.05 to 2.26 and these values are larger than 2.00, which indicated that those normal distributions are well separated and can be converted into pseudo cohort or age groups. Table 1 and Figure 2 show that there are four age group of mackerel scad (D. macarellus) during the study periods. Similar results are also found in other species namely D. macrosoma which occupying the same area [8] or other waters in Indonesia [18].

Table 1. Age groups, mean length, number of individual and separation index based on output of FiSAT program for mackerel scad (D. macarellus)

| Group | Mean Length (cm) | SD (cm) | Population (ind.) | Separation Index |
|-------|-----------------|--------|-------------------|-----------------|
| 1.    | 14.55           | 1.73   | 255               | 2.26            |
| 2.    | 20.59           | 1.35   | 1353              | 2.26            |
| 3.    | 24.71           | 1.32   | 624               | 2.21            |
| 4.    | 27.74           | 1.07   | 482               | 2.05            |

Figure 2. Normal curve represented age groups of mackerel scad (D. macarellus)
Data in Table 1 shows that age group 2 with the mean length 20.59 cm dominates the number of individual i.e. about 50% of the total individual in all age groups. Furthermore, Figure 2 shows that mode in length frequency distribution occurs at mid-length 20.5 cm. If the number of individuals in age group 1 and age group 2 are combined, together these two groups consists about 60% of the total population. This figure indicated that purse seine used by traditional fishers catches more young mackerel scad (*D. macarellus*) than adult ones, so young fishes have no chance to spawn at least once before they are caught. If this pattern of exploitation is still continue, in long run it can have negative impact on the stock and threat its sustainability [17].

3.3. Length at first maturity

Study on length at first maturity of a given species is very important in order to manage fisheries because it related to determine the smallest fish captured by a fishing gear. Length at first maturity of mackerel scad (*D. macarellus*) in the Southern waters of Ambon Island is presented in Figure 3 (male) and Figure 4 (female).

![Figure 3](image1)

**Figure 3.** Cumulative percentage frequency curve of mature male of mackerel scad (*D. macarellus*)

![Figure 4](image2)

**Figure 4.** Cumulative percentage frequency curve of mature female of mackerel scad (*D. macarellus*)

$L_{50\%} = 24.9 \text{ cm}$

$L_{50\%} = 24.8 \text{ cm}$
As mention before, as many as 2771 individuals of mackerel scad (D. macarellus) were collected during the study. However, only 20% of those numbers are mature i.e. gonadal maturity stage III – V while the rest about 80% are immature fish (stage I and II) for both male and female. Figure 3 and Figure 4 show that the smallest mature mackerel scad (D. macarellus) captured by traditional fishers using purse seine in the Southern waters of Ambon Island occurred at mid-length 20.5 cm for both male and female fishes. Furthermore, cumulative percentage frequency curve in Figure 3 and Figure 4 also show that 50% of mature fish captured is almost similar for both sex i.e. $L_{50\%} = 24.9$ cm and $L_{50\%} = 24.8$ cm for male and female mackerel scad (D. macarellus), respectively. This result is in accordance with mackerel scad (D. macarellus) found in Kendari waters [19], but higher and lower than the same species found in Celebes Sea [20] and Tomini bay [21], respectively. Variation in the length of first maturity of the same species could be due to differences in mesh size of the fishing gear used and differences of environmental condition in the fishing ground [20].

4. Conclusion
Based on the result of this study, it can be concluded that population of mackerel scad (D. macarellus) in Southern Ambon Island waters has an equal number of male and female, which consists of four age groups or cohorts. Mackerel scad captured by traditional fishers using purse seine in this area mostly consist of young or immature fish, so sustainability of the stock is in danger.

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