Length distribution, gonad maturity level, and catchable size of fish caught around FADs in Ternate Sea

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Abstract. Pelagic fishery business in Ternate Sea are mainly based on FADs fishing operations. Increase of intensive fishing activities will also increase the pressures on local pelagic fish resources of Ternate Sea in the future. So far, there has been limited scientific information related to the fish caught by local fishers. The aim of the study was to investigate length distribution, gonad maturity level (GML), and catchable size of fishes caught around FADs. The research was conducted in August 2020 in Ternate. The research method was a survey research by collecting samples of fish caught from gill nets and hand lines for total 30 fishing trips. The study results showed that the catch consisted of mackerel scads and yellow scads. The mackerel scads caught by gill nets were between 13-26 cm in size and dominated by the 19-20 cm size class, while fishes sizes caught by hand line were between 14-27 cm which were dominated by the 18-19 cm size class. Yellow scads caught with both gill nets and handlines showed the same length range of 12-23 cm, which was dominated by the size class of 18-19 cm. Mackerel scads caught with gill nets and handlines were dominated by fish in GML II (47%) followed by GML III (32%). GML of yellow scads caught with gill nets was dominated by GML III by 75%, while for fishes caught by hand line the percentage of GML III is 68%. The mackerel scads caught with gill nets and handlines were dominated by the non-catchable size category (100% for gill nets and 98.79% for handlines). On the other hand, all yellow scads caught with both gill nets and handlines are entirely (100%) of catchable size.

1. Introduction
Pelagic fishery business in Ternate waters is generally based on FADs. FADs are owned by local fishermen and installed permanently. The fishing gear used for catching fish on FADs are gill nets and handlines. This fishing activity is carried out intensively every day and takes place in the morning and evening.

The Ternate FADs based fishery business has advantages, among others: 1) the distance between the fishing base and FADs is relatively close, so it is quite efficient in terms of time and fuel oil requirements, 2) the fish caught are in fresh condition and can be directly marketed in Ternate City, so that the quality and price maintained, 3) FADs are easily monitored by the owner at any time so that they last up to the age limit of use.
The advantages and benefits of FAD fishing business will have effects on intensification of pelagic fishing activities in Ternate waters. Thus, efforts are needed to control the utilization rate of pelagic fish in Ternate waters. Both controlling the number of catches and controlling the fish catchable size. [1] stated that fishing businesses that tend to increase production without paying attention to the composition of the catch, especially the size of the fish caught, can disrupt stock stability and even threaten the sustainability of fish resources. In other words, overexploitation will threaten the sustainability of capture fisheries business in Ternate waters. Based on this description, it is necessary to conduct a study to obtain data and information on the size of the fish caught, the maturity level of the gonads, and the number of fish with catchable size in Ternate waters.

The results of this study are expected to be useful for FAD fishermen in planning schedule of fishing trips and operations and selection of fishing gear. In addition, this information is also useful for local governments in determining management policies related to the size of fish that are allowed to be caught, and determining the net mesh size according to fishing main species target.

2. Method
The research was carried out in August 2020 in the waters of Ternate, North Maluku Province. Data collection was carried out for fifteen days in the morning and evening according to the fishing gear operation trips. The tools and materials used in the study consisted of styrofoam containers, a ruler, sample fish, and ice cubes.

The research method used is a survey, by collecting samples of fish caught from fishing gear operation using FADs. Fish samples were taken from each fisherman in sufficient quantities. Fish samples were separated in different containers based on the type of fishing gear. This sample collection consisted of 30 fishing operation trips. The types of data collected consisted of fish length (TL) and fish TKG based on the type of fishing gear. Measurement of fish length used a ruler with millimetres scale. TKG observations were made visually based on the criteria developed by [2].

Descriptive analysis was used to determine the distribution of length and TKG of each type of fish based on the type of fishing gear. The grouping of fish length data into the catchable/unfit to catch category was based on the results of previous studies (Table 1).

| Table 1. Fish length grouping of catchable and non-catchable size. |
|--------|------------------|-------------------|------------------|
| No    | Fish species     | Fish length (cm)  | Reference        |
|       |                  | Non-catchable     | Catchable        |
| 1     | Mackerel scads   | < 25.8 cm         | 25.8 cm          | Ilksan dan Ihsan, 2009 |
|       | (Decapterus macarellus) |                  |                  | Ihsan, 2009            |
| 2     | Yellow ‘selar’   | < 11.9 cm         | 11.9 cm          | Fish base              |
|       | (Selaroides leptolepis) |                  |                  |                         |

3. Results
3.1. Fish species caught around FADs
There were only two species of fish caught by all fishers around FADs during the study, namely mackerel scads (Decapterus macarellus) and yellow scads (yellow trevally) (Selaroides leptolepis). The total number of fish samples collected was 2,903 fish, consisting of 1,896 caught by gill net samples and 1,034 from hand line. The number of sampled fish by species consisted of 1,782 yellow scads and 1,121 mackerel scads (Table 2).
3.2. Fish size distribution
The total length of mackerel scads caught with gill nets ranged from 3 to 26 cm, while those caught with handlines ranged from 14 to 27 cm. The size distribution of mackerel scads caught around FADs with gill nets was mostly in the 19-20 cm size group, while those caught with handlines were 18-19 cm group (Figure 1).

![Figure 1. Size distribution of mackerel scads (a) = caught by gill net; (b) = caught by hand line](image)

3.3. Gonad maturity level
Analysis of the gonad maturity level (GML) of mackerel scads showed varying results. The graph in Figure 3 shows that fish caught with gill nets and handlines have gonad maturity levels I, II, and III, while GML IV was not found during the study. All samples of mackerel scads, both caught with gill nets and hand line, were more in GML II, namely 47%. Based on the fishing gear, the most mackerel scads caught samples were in GML III, which were 32% for samples caught with gill nets and 30% for those caught with handlines.

![Figure 2. Size distribution of yellow scads (a) = caught by gill net; (b) = caught by hand line](image)
The distribution of the gonad maturity level of all samples of yellow scads caught with gill nets and hand lines was dominated by TKG III, 75% and 68%, respectively. The proportions of fish with TKG I and TKG II were found to be smaller, namely TKG I (6%) and TKG II (16%) for fish caught with gill nets and TKG I (7%) and TKG II (25%) for fish caught with hand lines.

3.4. Catchable size

The percentage of mackerel scads caught by gill nets was 100% in non-catchable size, while for fish caught by handlines it was 98.79%. On the other hand, all (100%) yellow scads caught by both gill nets and handlines were of suitable size or catchable size (Table 3).
4. Discussion

FADs in Ternate waters have main components consisting of rafts, buoys, attractors, ballast, and ballast ropes. Rafts are designed and constructed as permanent FADs as a place to operate gill net. FADs are placed in water locations that are relatively close to the coast, which is around 1-2 miles from the coast and are installed at sea with a depth of 200 m or more.

The fishing gear operated around FADs consists of gill nets and handlines. The gill nets used are surface gill nets with the following specifications: 27 m long, 1.5 m deep, and mesh size 1.5 inches. The specifications of the hand lines are as follows: the size of the main line number 30 with a length of 100 m, size of the branch line number 20 with a weight of tin weighing 400 g, type (J) fishing hooks with size number 20; number of hooks used are usually 10 pieces, using artificial bait made of silk and is a combination of red and yellow.

Fishing operations are carried out on two trips in a day, namely in the morning at 05.30-09.00 local time, and in the afternoon at 17.00-20.00 local time. The gill nets are operated by fishermen who are on the FADs, while the hand lines use boats that are operated around the FADs. After completing fishing operations in one trip, fishers immediately land their catch on the beach.

During the study, the catches obtained from gill nets and handlines were mackerel scads and yellow scads. These two fish species are fish known to have association with FADs. [3], stated that those species have behaviour to swim in groups (schooling) that makes them easy to catch.

Total length of mackerel scads caught in FADs using gill nets and handlines had relatively the same size, ranging from 13 to 27 cm, and the highest distribution was in the 18-20 cm size range. The length range of the mackerel scads found in this study is different from that reported by [4], which were caught in January-May in the waters of North Maluku with a length range of 211-311 mm for males and 215-315 for females. The length range is not much different from that reported by [5] in the Sulawesi seas with the fork length range of 10.25-32.25 cm. The smaller fish length was reported by [6] in Latuhalat waters, Ambon, at a fork length range of 7.5-28.6 cm and [7] in Likupang Bay, North Sulawesi, at a fork length range of 8.4-25.2 cm.

The total length of the yellow scads samples in this study were in the range of 12-23 cm, and were distributed most dominantly in the length size range of 18-19 cm. The dominant length size of this yellow scads is the same as reported by [8] in the waters of Manado Bay, which is in the range of 18.0-18.5 cm. While yellow scads caught in the waters of Southeast Maluku are dominated by a fish length in range of 161-167 mm [9]. There is a difference in the length of those different samples (study results) caused by different location conditions or environment, different fishing seasons, and different specifications of fishing gears. Changes in fishing season is followed by the addition of a new fish cohort in an area, thus increasing the variety of fish size in that location. Likewise, the variation in the size of fish caught is greatly influenced by the use of fishing gear types, especially the type of gill nets which is largely determined by net mesh size used.

Information about spawning period of a fish population, whether they are at the beginning of spawning period or at the end of spawning period, can be investigated from fish gonad maturity levels [10]. In general, small pelagic fish may spawn throughout the year and the peak of spawning can be expected by looking at a high percentage of gonad maturity levels. The results of the study showed that mackerel scads caught in the waters of Ternate were distributed in TKG I, II, and III with the highest percentage in TKG II which was 47%. The distribution of TKG indicated that schools of juvenile-sized mackerel fish had tendency to settle around FADs for forage and shelter.

The study could not confirm whether Ternate waters were spawning grounds for kite fish, but the distribution of GML can be used to predict that Ternate sea is part of spawning area of mackerel scads. As stated by [2], North Maluku populations of blue mackerel scads (D. macarellus) can spawn several times in one season. Distribution of gonad maturity levels of yellow scads caught at FADs with both gill nets and hand lines were dominated by fishes at GML III, at 75% and 68% respectively. According to [5], when fishes caught are dominated by fish in GML III, it is an indication that the fish population is still in a gonad developing condition. The presence of fishes that have GML III and GML IV indicates the presence of fishes that are in a spawning period.
Analysis of comparisons between the length range of fish in the study and the length of the first fish to mature gonads (LM) showed that kite fish caught during the study period were almost entirely unfit to catch. For catching with gill nets, all fish caught or 100% not worth catching while for catches with fishing rods 98.70% are not worth catching. In contrast to the fish population. Samples of selar fish caught during the study, either with gill nets or fishing rods, were entirely or 100% worth catching.

Use of gill nets by fishers with mesh sizes of 1.5 inches and hand lines using hooks no 20 are found to catch fishes of non-catchable size. It is necessary to adjust the size of net mesh size to avoid further fishing of non-catchable size scads. [11] reported that the use of gill nets with FAD with a mesh size of 5.5 inches would only catches fish of a certain size. The same thing also applies to hand line fishing that the regulation of hook size will also help to limit catching fishes of non-catchable size.

5. Conclusion

Fishing catch of gill nets and hand line in FADs in Ternate sea was consist of two pelagic species, mackerel scads (Decapterus macarellus) and yellow scads (Selaroides leptolepis). Mackerel scads captured with gill nets and hand lines were dominated by small size fishes, while for yellow scads they were dominated by bigger size fishes. Based on the species catchable, almost all mackerel scads caught during the study were in non-catchable size, while for yellow scads they were all in catchable size. Mackerel scads caught during the study were dominated by fishes at GML II while for yellow scads they were dominated by GML III. Study results recommends that Ternate City Government needs to develop fishing management to regulate allowable net mesh size and hook size to make sure that local fishers only catch target fishes at their catchable sizes.

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