Biological characteristics of Indo-Pacific King Mackerel
(*Scomberomorus guttatus*, Bloch and Schneider 1801) in Moro Waters part of Kepulauan Riau, Indonesia

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**Abstract.** Research related to biological characteristics of Indo-Pacific King Mackerel in Indonesia is still rare, whereas fishing activity has been carried out. The study was conducted from 2014-2017 in Moro Waters, Riau Islands, Indonesia. The purpose of this study was to analyze the biological characteristics including length frequency, length weight relationship, Gonado Maturity Stages, Gonado Somatic Index (GSI), sex ratio, length at first maturity, fecundity and ova diameter. From length frequency were obtained mode size at 37-39 cm for male, 52-54 cm for female and 43-45 cm for transition sex. The growth pattern of king mackerel was isometric. The gonad fish were dominated of mature gonads by 52%, and the immature gonads by 48%, with level V was almost found every month. GSI shows that spawning season in January-August and peak season occurs in April-May. The results of chi-square test showed that there were significant differences number of males and females fish. The length at first maturity was at 47.4 cm, in the range between 46.3 to 48.5 cm. The fecundity ranged on 28.082-1.506,075 eggs, on a length of 45-55 cm. Based on the development of the ova diameter and Gonad Maturity Stage, the King Mackerel spawning pattern is partial spawner.

1. **Introduction**

Indo-Pacific King Mackerel (*Scomberomorus guttatus*) is one of the species of mackerel fish found in Indonesian Waters. Spread almost in all coastal waters and islands throughout Indonesia. The mackerel is a neritic species and migrates no further than Spanish mackerel (*Scomberomorus commerson*), has a habitat in less clear waters with lower salinity [1].

Indo-Pacific King Mackerel in the waters of the South China Sea (SCS) caught by drifting gillnet. Most of the ships used are traditional <10 GT boats. Some locations in the SCS which became the landing of Indo-Pacific King Mackerels, among others, are in Bangka, Belitung, Moro Waters, Tanjung Pinang and several other islands. The composition of gillnet catches in SCS is dominated by King Mackerel. Therefore, a research related to biological characteristics of the Indo-Pacific King Mackerel is needed.

Research on the biology of Indo-Pacific King Mackerel has been done by RIMF (Research Institute for Marine Fisheries 2013) in Indonesia Fisheries Management Area (IFMA) 573 Indian Ocean South Java with the location in Cilacap Waters. While some others research related to Indo-Pacific King Mackerel was done by [2] in the Mandapam Water India, [3, 4, 5] in the Gulf of Mannar and Palk Bay of India, [6] in Japanese Waters, [7] in the Gulf of Mexico, [8] in FAO area 51 Indian Ocean (Oman Waters), [9] in Veraval India, [10] in the Bay of Bengal Bangladesh, and [11] in India.
The purpose of this research was to analyze the biological characteristics of King Mackerel which includes length frequency, length weight relationship, gonad maturity level, sex ratio, gonad maturity index, length at first mature, food habits, fecundity and ova diameter. This research was expected to provide information for sustainable fisheries management.

2. Methods

2.1. Time and location of research
The biological sample was collected from 2014-2017. Indo-Pacific King Mackerel (*Scomberomorus guttatus*) was the object in this research. The survey location on the Moro Waters, part of Riau Island (South China Sea). The location of survey and sampling can be seen in figure 1.

2.2. Length frequency and length weight relationship
Length frequency and length weight relationship analysis is done by separating male and female fish. Length data and more weight are used to see changes between male and female fish related to the reproductive condition of the fish. Fork length data of fish and weight were collected by writer assisted by enumerator.

According to [12], length and weight relationship of fish of almost follow the cubic law, although not always follow the cubic law expressed by the formula \( W = aL^b \), because during the live fish will grow and evolve mean length and weight of the fish is always changing, then the formula written in the general form:

\[
W = aL^b
\]

where \( W \) is the weight of fish in grams, \( L \) is the length of fish in cm, while \( a \) and \( b \) are constants. Knowledge regarding the length and weight of fish is we can guess the weight of the length of the fish or otherwise, regarding the description of fish growth, plumpness, which is influenced by the environment.

2.3. Level of gonad maturity
Observation of the gonad maturity level is done by splitting the sample by the dissecting set carefully so that the gonad does not participate in split until it can simplify the process of observation. After that it was then to observe directly to the color and size of the gonad. Thus, the identification of the gonad with reference to the order of the maturity level of gonads corresponding by [13] which divides the maturity stage male and female gonads into 5 stages (table 1).
Table 1. Criteria of gonad maturity stage by [13].

| Female | Stage | Category   | Description                                                                                                                                 |
|--------|-------|------------|---------------------------------------------------------------------------------------------------------------------------------------------|
| I      | Immature | Gonads elongated and slender, about one-third the length of the abdominal cavity, sex can be seen with a magnifying glass, ovarian clear gray to reddish. | Gonads enlarged but the eggs cannot be viewed one by one with the naked eye, ovary ovoid-shaped, reddish color with capillary vessels, ovaries fill about half the space below. |
| II     | Maturing | Gonads enlarged and swollen, egg easily seen with the naked eye, ovaries reddish orange, ovaries filling 2/3 of the body cavity. | Gonads filled the basement, have enlarged ovaries, eggs and ripe crisp, easy to get out of the lumen of the stomach of fish ovaries when pressed. |
| III    | Mature  | Gonads enlarged and swollen, egg easily seen with the naked eye, ovaries reddish orange, ovaries filling 2/3 of the body cavity. | Gonads filled the basement, have enlarged ovaries, eggs and ripe crisp, easy to get out of the lumen of the stomach of fish ovaries when pressed. |
| IV     | Ripe    | Gonads filled the basement, have enlarged ovaries, eggs and ripe crisp, easy to get out of the lumen of the stomach of fish ovaries when pressed. | Gonads filled the basement, have enlarged ovaries, eggs and ripe crisp, easy to get out of the lumen of the stomach of fish ovaries when pressed. |
| V      | Spawned/Spent | Eggs already released (post-spawning). Gonads shrunken and loose wall. | Ovaries very large and soft |

| Male |
|------|
| Stage | Category   | Description                                                                                                                                 |
| I     | Immature | Testis very smooth, flat like a ribbon but the sexes can be distinguished with a magnifying glass. Most sperm contained in the center channel. | Testes enlarged, triangular cross sections, colored reddish or white starting with capillaries, small and dense. |
| II    | Maturing | Testes enlarged, triangular cross sections, colored reddish or white starting with capillaries, small and dense. | Testes enlarged and swollen, slightly opaque white color, a little sperm out freely when in press / gonads cut, can be seen with the naked eye. |
| III   | Ripe    | Testes greatly enlarged, opaque white color no red spots, sperm easy out if the stomach is pressed a little fish or cut when the gonads. | Testes greatly enlarged, opaque white color no red spots, sperm easy out if the stomach is pressed a little fish or cut when the gonads. |
| IV    | Partly spent | Testes greatly enlarged, opaque white color no red spots, sperm easy out if the stomach is pressed a little fish or cut when the gonads. | Testes greatly enlarged, opaque white color no red spots, sperm easy out if the stomach is pressed a little fish or cut when the gonads. |
| V     | Spent   | Testes greatly enlarged, opaque white color no red spots, sperm easy out if the stomach is pressed a little fish or cut when the gonads. | Testes greatly enlarged, opaque white color no red spots, sperm easy out if the stomach is pressed a little fish or cut when the gonads. |

2.4. Sex Ratio
The sex ratio is analyzed by comparing the number of male fish with female fish, for example:

\[ X = \frac{M}{F} \]  

where: \( X \) = sex ratio; \( M \) = number of male fish; \( F \) = number of female fish.

The sex ratio was made in a bar graph from several months to see the difference in the percentage ratio. The sexs ratio test follows the way suggested by [14] with a Chi - Square test formula, as follows:

\[ X^2 = \sum_{i=1}^{k} \frac{(f_0 - f_n)^2}{f_n} \]  

where : \( X^2 \) = Chi – Square; \( f_0 \) = Observed frequency; \( f_n \) = Hoped frequency; Test table in real level 95% (n-1) with hypothesis as follows; \( H_0 \) : no real difference between male and female fishes; \( H_1 \) : real difference between male and female fishes; if, \( X^2 \) counts < \( X^2 \) table, \( H_0 \) accepted, \( H_1 \) denied; if, \( X^2 \) counts > \( X^2 \) table, \( H_1 \) accepted, \( H_0 \) denied [12].

2.5. Gonad Maturity Index (GSI)
Gonad Maturity Index (GSI) was analyzed with the formula put forward by [12] as follows:

\[ GSI = \frac{W_g}{W} \times 100\% \]
where: GSI = Gonad Maturity Index; \( W_g \) = weight of gonad (g); \( W \) = Somatic weight = fish weight minus gonad weight (g).

2.6. Length at first maturity (\( L_m \))

The value of \( L_m \) was analyzed by Spearman-Karber method in [16] as follows:

\[
m = X_k + X / 2 - \left( X \times \sum p_i \right)
\]

where: \( m \) = size logarithm of first matured gonad; \( X_k \) = logarithm of the last middle grade where it 100% mature gonad occurs; \( X \) = difference of mean value of logarithm; \( p_i \) = the proportion of gonad ripe fish in the i-th class.

\[
CL = \text{Anti log} \left[ m \pm 1.96 \sqrt{\frac{X}{\sum p_i \times q_i}} \right]
\]

\( CL = \) Confident limit (maximum and minimum); \( m \) = fish length of firstly matured gonad; \( n_i \) = the number of fish in the i-th class; \( q_i = 1 - p_i \).

2.7. Food habits

Food habits were analyzed using the frequency occurrence method. Each organism contained in the stomach is expressed in the percentage of all the stomach studied, except the empty stomach. Thus, we can see the frequency of occurrence of an organism that fish eats [15].

2.8. Fecundity

Fecundity was analyzed by the formula put forward by [15] as follows:

\[
F = \frac{G}{g} \times N
\]

where: \( F \) = fecundity (egg); \( G \) = total gonad weight (g); \( g \) = sub sample gonad weight (g); \( N \) = number of gonad sample (items).

The number of gonad sample is calculated with the gravimetric method, by calculating some parts of gonad samples given the Gilson solution. The samples were then weighed. After weighing the sample, it was then dissolved with water, 30 ml. From 30 ml of water containing the gonad sample, 1 ml was taken to be observed under a microscope.

2.9. Ova diameter

The ova diameter was measured with a scaled micrometer. The division of the ova diameter group was made at the 0.05 mm class interval [17]. Devaraj has divided the ova diameter of King Mackerel into 12 levels, as seen in table 2.

| Gonad Level   | Category | Diameter (mm) | Gonad Level | Category | Diameter (mm) |
|---------------|----------|---------------|-------------|----------|---------------|
| Immature      | A        | 0.03-0.10     | Ripe        | H        | 0.56-0.65     |
|               | B        | 0.10-0.15     |             | I        | 0.65-0.70     |
| Maturing      | C        | 0.15-0.20     |             | J        | 0.75-0.80     |
|               | D        | 0.20-0.30     | Spent       | K        | 0.80-0.88     |
|               | E        | 0.30-0.36     |             | L        | 0.90-0.98     |
|               | F        | 0.46-0.53     | Partly spent | S       | 0.23-0.35     |
|               | G        | 0.53-0.56     |             |          |               |

Table 2. Ova diameter category of King Mackerel [17].
3. Results

3.1. Length Frequency
From the range of length obtained were 10-75 cm, the length of male fish by 25% and female fish by 50% and transitional fish by 25%. From length frequency were obtained mode size at length 37-39 cm for male and 52-54 cm for female and 43-45 cm for transition on a sex change. Visually by comparing the morphological conditions of the gonads and the length of the fish can be separated the length of the fish as shown in figure 2.

![Figure 2](image)

**Figure 2.** Length frequency of Indo-Pacific King Mackerel and the length of the transition on a sex change.

3.2. Length weight relationship
From the length weight relationship of King Mackerel fish was obtained a value = 0.00007; the value of b = 2.425 and the value of $R^2 = 0.752$, while the female fish value $a = 0.00002$, $b = 2.782$ and $R^2 = 0.664$. Length weight relationship of the male female was obtained values $a= 0.00002$, $b = 2.738$ and $R^2 = 0.905$. The average weight of captured male fish is 0.2 kg (200gr), while female fish is 1.04 kg (1040 gr). From the value of b value shows the growth pattern of King Mackerel both of male and females is negative allometric, while the b value from both sexes after t test was isometric. The length weight relationship of King Mackerel is presented in figure 3.

![Figure 3](image)

**Figure 3.** Length weight relationship of Indo-Pacific King Mackerel, for male and female fish.
3.3. Gonad maturity level
The number of gonad samples were 3307, consisting of 15% male gonads, 70% female gonad and 15%
from transition gonads of fish. Gonad maturity level obtained showed that gonad level III and IV were more dominant from month to month (2014-2017). Gonad level I-II could mostly be found in male fish, whereas gonad level V, which was an indication of spawning fish, was found almost every month. Especially for male fish sperm cells in gonads consist of several levels, some are ready for fertilization and some are still developing. Gonad maturity level is presented figure 4.

![Gonad Maturity Stages](image)

**Figure 4.** Gonado maturity stages of King Mackerel for (a) male and (b) female.

3.4. Gonado Somatic Index (GSI)
The King Mackerel spawning season was suspected in January-August. Spawning season usually occurs one or several months after the highest peak of GSI. Peak spawning season occurs there April-May. GSI value is presented in figure 5.
In figure 6, the parabolic line indicates that the GSI value rises up to a length of 48 cm, then down at length > 55 cm. At the same length of fish, the magnitude of GSI shows varying values as well.

Figure 5. Gonado Somatic Index of Indo-Pacific King Mackerel.

The GSI value of Indo-Pacific King Mackerel also changes with the increasing of Gonad Maturity (table 3). In gonad level V, there was a decrease in GSI value for female fish.

Table 3. The relationship of Gonado Maturity Stages and Gonado Somatic Index of Indo-Pacific King Mackerel.

| Sex    | Gonad Level | GSI                  |
|--------|-------------|----------------------|
|        | Range       | Average              |
| Male   | I           | 0.105-2.564          | 0.441                |
|        | II          | 1.350-2.040          | 1.695                |
| Female | III         | 1.652-10             | 3.893                |
|        | IV          | 2.354-16.625         | 6.467                |
|        | V           | 0.836-12.5           | 4.907                |

3.5. Length at First Maturity ($L_{fm}$)
The calculation of length at first maturity value of King Mackerel which was 47.4 cm, in the range of 46.3-48.5 cm. Based on the $L_{fm}$ value, the percentage of Indo-Pacific King Mackerel catch by gillnet
that its immature fish reached 48% and the mature fish reached 52%. The percentage of monthly gonad maturity can be seen in table 4.

Table 4. Monthly gonad maturity of Indo-Pacific King Mackerel.

| Month | N   | Gonad Maturity (%) |
|-------|-----|--------------------|
|       |     | Immature | Mature |
| Feb   | 229 | 43       | 57     |
| Mar   | 272 | 40       | 60     |
| Apr   | 542 | 38       | 62     |
| May   | 383 | 42       | 58     |
| Jun   | 183 | 24       | 76     |
| Jul   | 275 | 43       | 57     |
| Aug   | 196 | 52       | 48     |
| Average | 48 | 52     |

3.6. Sex ratio
From 3307 samples from February 2014 to June 2017, it could be obtained that the number of male and female fish was 0.4: 1. The sex ratio is shown in figure 7. The chi square test showed that there was a significant difference of the number of male and female fish (table 5).

Table 5. Chi square test of sex ratio Indo-Pacific King Mackerel.

| Month | Obs. Frequency | Hoped Frequency | X2 Hitung |
|-------|----------------|----------------|-----------|
|       | Male | Female | (fn) | Male | Female |
| Feb   | 6    | 12     | 9    | 1    | 1      |
| Mar   | 7    | 24     | 15.5 | 4.7  | 4.7    |
| Apr   | 13   | 93     | 53   | 30.2 | 30.2   |
| May   | 21   | 64     | 42.5 | 10.9 | 10.9   |
| Jun   | 19   | 39     | 29   | 3.4  | 3.4    |
| Jul   | 25   | 56     | 40.5 | 5.9  | 5.9    |
| Aug   | 38   | 49     | 43.5 | 0.7  | 0.7    |
| Sep   | 15   | 36     | 25.5 | 4.3  | 4.3    |
| Oct   | 20   | 46     | 33   | 5.1  | 5.1    |
| Nov   | 21   | 41     | 31   | 3.2  | 3.2    |
| Total | 69.5 | 69.5   |       |       |        |
| Average |     | 138.9  |       |       |        |

X² calculated = 138.9
X² table at 0.05 (n-1) = 9
X² table = 16.9
X² calculated > X² table, h1 is rejected; h0 accepted
There was significant difference of sex ratio between male and female of King Mackerel
Figure 7. Sex ratio of Indo-Pacific King Mackerel

3.7. Food habits
Types of stomach contents showing that the King Mackerel diet cannot be obtained because all samples indicate empty stomach condition and contain crushed fish only, so that were difficult to identify. Some fish stomach samples contain juvenile fishes that were still intact, but the morphological form was difficult to identify.

3.8. Fecundity
Fecundity of King Mackerel ranged from 28,082 - 1,506,075 eggs, at 45-55 cm length. Fecundity and fork length relationship of King Mackerel showed a strong relationship, with an $R^2$ value of 0.8457 (figure 8). This indicates that each increase in length greatly affects the number of eggs, up to a certain size.

Figure 8. Fecundity and fork length relationship of King Mackerel.

3.9. Ova Diameter
The ova diameter at gonad level IV ranged from 0.03 to 1.98 mm, with an average of 0.64 mm. From all sizes of ova diameters, the range from 0.03-1.97 mm with interval 0.05 was obtained. In this study, it could be found that the condition of immature eggs with < 0.53 mm diameter has matured diameter of > 0.53 mm and < 0.78 mm and spawn egg conditions (diameter > 0.80 mm). In February, the condition of immature eggs of 1%, has matured by 13% and ready to spawn by 86%. In August, the percentage of immature eggs by 42%, has matured by 54% and ready to spawn at 4%, while in
October the condition of immature eggs by 19%, has matured by 80% and ready to spawn by 2%, as seen in figure 9.

Figure 9. Ova diameter of Indo-Pacific King Mackerel.

4. Discussion

The length of the male fish is dominated by the mode range at 37-39 cm, while the female fish mode values at length 49-51 cm. The average length of male fish caught is 38 cm, while the female fish at length 49 cm. Transition of sex change from male to female at length 43-45 cm. The obtained sample shows the different growth of King Mackerel individual fish. This can be proved by the presence of fish samples of the same length but different conditions of gonadal development. Sometimes the length of 44 cm fish has turned into a female, and sometimes until the new length 45 seen there is a change. The average length of King Mackerel fishing with gillnet were 49-51 cm. This shows that the fish caught predominant mature fish. In hermaphrodite fish the use of fishing gear is very influential on the proportion of the size of the fish caught. Gillnet operated in Moro Waters and its surroundings is good because it dominantly catches the size of the adult fish, so that young fish can grow. In the protandrous hermaphrodite species the number of male fish remaining in the waters is primary factor to the development of the testes to the ovaries [18].

Length weight relationship in both male and female fish shows an allometric pattern. Changes in the value of b from young fish to mature fish indicate the growth of fish, one of which is the development of fish reproduction organs. Negative allometric growth can mean weight gain of fish slower than its length increase. Similarly, the length, weight of the fish caught should also be in equal proportion between males and females in order to the sustainability of fish populations to be maintained.

The maturity level of gonad was dominated by gonad level IV, the maturity of male fish gonads was only found from level I-II. The research has not found male fish gonads in level IV or V. While female dominant fish was found in level III-V. The length of the male fish on level I-III was found in the length of fish < 45 cm, whereas the female fish began to be seen at length > 45 cm. This leads to the notion that Indo-Pacific King Mackerel (Scomberomorus guttatus) allegedly strong is a protandri fish (hermaphrodit protandrous), a fish whose body has a gonad that performs a process of differentiation from the male phase to the female phase.

This research has been going on for four years. From all samples that have been obtained showed female fish can be seen visually on the length of fish > 45 cm. Male fish found at length < 45 cm, and not found at length > 45 cm. Females are widely found starting at 45 cm length, and are not found at lengths <45 cm. The question is why no male fish are found in larger fish sizes, and vice versa for female fish. Judging from the number of samples that have been obtained (2674 gonad samples) in four years, it is thought there is something strange about this Indo-Pacific King Mackerel. Very little literature supports to decide that the fish is hermaphrodite. Finally, I proceed to histology test of gonad samples for both visually visible male and female. Temporary results indicate strongly that the species is protandrous hermaphrodite. How details of the pattern of changes that occur cannot I submit
because the process is being done in the laboratory. This certainly needs further research to prove the truth.

The value of GSI increases with the increase of fish length to a certain size. GSI indo-Pacific King Mackerel value continued to increase from level I to IV, then began to fall on level V because there were fish spawning. The peak spawning season of King Mackerel in Moro Waters is thought to take place in January-August, so the indo-Pacific King Mackerel has partial spawner type. Spawning season takes place at a relatively long time. Gonad level V as a fish spawn has been found almost every month. This spawning season is different from the one reported by [2] in Indian Waters, such as in May-August with a spawning peak in July. Whereas [5] reported indo-Pacific King Mackerels in Mannar Gulf Waters and Palk Bay spawning from January to August, with spawning peaks in April-May.

King Mackerel gonad was dominated by ripe fish gonad, it was suspected that gillnet drift has a high selectivity in terms of the length at first capture. The average length at first captured should be greater than the length at first maturity (Lm), i.e. 47.4 cm, in the range of 46.3-48.5 cm. The mesh size should be made larger so that young fish can escape and multiply (until spawning).

The Lm value of King Mackerel in Moro waters is almost the same as in Indian waters, but bigger than the one reported by [19] in Cilacap waters. There are several things that affect the value of Lm, including: genetic differences, environment, and food habits. The value of Lm from the previous study is presented in table 6.

Table 6. Length at first maturity of Indo-Pacific King Mackerel.

| No | Location                        | Lm (cm)     | Ref   |
|----|---------------------------------|-------------|-------|
| 1  | India                           | 48.52       | [2]   |
| 2  | Teluk Mannar and Palk Bay       | 46.5 (45.1-48) | [5]   |
| 3  | Cilacap water, Indian Ocean     | 42.3        | [19]  |
| 4  | Moro water, Kepulauan Riau      | 47.4 (46.3-48.5) | Present study (2017) |

From the Chi square test to the sex ratio of Indo-Pacific King Mackerels showed a significant difference between the number of male and female fish. This shows that the number of male fish is less than that of female fish. This condition is still good for the sustainability of the resources of indo-Pacific King Mackerel in Moro waters.

In the hermaphrodite population, sex ratios are also strongly influenced by the high fish catch pressure on species [20]. If the operated gillnet has a small meshsize then the sex ratio will be dominated by the male fish, if the large meshsize (>4 inch) then the sex ratio in female fish dominance. The sustainability of the hermaphrodite species depends greatly on the balance of the sex ratio between the captured male and female.

Food habits of the indo-Pacific King Mackerel cannot be identified because the stomach is dominantly dissected containing the destruction of fish and in a state of emptiness. [11] from Indian waters reported that types of King Mackerel diet, such as, *Sardinella* spp., *Dusumerei* sp., *Rastrelliger* spp., *Decapterus* spp., *Trichiurus* spp., and *Stolephorus* sp. (anchovy). Many stomach samples were dominated by empty conditions. This condition was occurred because the fishermen mostly catch fish at night when feeding period of King Mackerel has been completed or were not eating, so the prey fish have been destroyed digested. Pelagic fish such as King Mackerel is supposed have a feeding period in the morning until late afternoon. [21] reported that indo-Pacific King Mackerel is a surface feeder, eating some of the pelagic fish on the surface. Active foraging in the morning at 6 to 10 a.m, and late in the afternoon until 10 p.m. The young fish (1-3 years) consume more food than the old fish. Indo-Pacific King Mackerel in Moro Waters allegedly different feeding times than those reported by [21]. Traditional fishermen operating gillnet (setting) between 7 or 8 p.m, and take the result (hauling) at 2 or 3 a.m. Indo-Pacific King Mackerel caught dominant stomach is empty, it can be concluded that the
King Mackerel is more active during the day (diurnal), including in foraging (prey) from the early morning until late afternoon or early evening.

Fecundity of King Mackerel in the Moro Waters almost identical to that reported by [8] in the Indian Ocean (FAO area 51), Siddeek report that fecundity increased from 385,000 eggs at age 2 years to 1,100,000 eggs at age 4 years. The relation of the number of eggs to the length indicates a strong $R^2$ value, meaning the strong relationship between the length and number of mackerel eggs or the variation of the number of eggs in the same length [15]. From the ova diameter data of three months, it showed that spawning period of King Mackerel takes place over a long period. In this study it was also found that the ova diameter was more than 1 mm, unlike the one reported by [17] that did not find ova diameter of >1 mm in the waters of Mammar Bay and India Palk Bay. The ova diameter of King Mackerel in Moro Waters is greater than in Indian Waters. This could be due to genetic and environmental differences. Ova diameter and fecundity of mackerel vary in each waters influenced by age composition, environmental factors such as food availability, population density, water temperature, dissolved oxygen and racial differences [12].

In figure 9, it is seen that in February, March, and April there is an egg diameter that is in size ready to spawn. In February and March the percentage of mature eggs has been reduced by spawning, while in April the number of mature eggs still has a larger percentage. This indicates that spawning in April is still longer than in February and March. In August and October there are also egg sizes ready for breeding but the percentage is smaller than February-April. From figure 9 the development of egg diameter per month shows the type of Indo Pacific King Mackerel is asynchronous, the oocytes from each stage of development of egg diameter is not indicated by the dominant group [22]. The spawning pattern of Indo-Pacific King Mackerel based on egg diameter is partial spawner, that is fish spawning his eggs at once, but several times in one spawning season [23].

5. Conclusion
The Gonad Maturity Level of King Mackerel was dominated by matured gonads rather than immature gonads, with gonad level V was found almost every month. The spawning season of mackerel fish takes place in January-August. The Gonad Maturity Index continues to rise as the fish size increases to a certain length, then it will drop to a fish length of > 55 cm. There was a significant difference of sex ratio between male and female of King Mackerel. The length at first maturity of Indo-Pacific King Mackerel was 47.4 cm, in the range of 46.3-48.5 cm. The fecundity of King Mackerel ranges from 28,082-1,506,075 eggs, with 45-55 cm length. Relationship of fork length and fecundity showed strong correlation with the $R^2$ value of 0.728. The ova diameter of King Mackerel caught in Moro water has a larger than that reported in Indian Waters. The spawning pattern of mackerel fish is partial spawner.

6. Suggestion
It is suggested to clarify the observation of indo-pacific king mackerel gonads, need to be done histological analysis on gonads. The results of the histological analysis can later be used to validate visual observations of the gonads, since gonad morphological assessment is highly subjective

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