Biological Aspect Analysis of Indian Mackerel (*Rastrelliger kanagurta* Cuvier, 1816) Caught by Purse Seine in Probolinggo Waters, Madura Strait, East Java

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**Abstract.** Indian mackerel (*Rastrelliger kanagurta*) is one of pelagic fish caught in Probolinggo waters using purse seine. This research was conducted from January until May, 2017 at Paiton Fishing Port, Probolinggo. The purpose of this research was to identify biological aspects of Indian mackerel namely sex ratio, gonad maturity level (GML), gonado somatic index (GSI), length-weight relationship, length at first mature (*Lm*), length at first capture (*Lc*), and growth parameters such as *L∞*, *K*, and *t0*. The research was using direct method survey. Fish samples were taken directly from fishing vessels landed their catch in Paiton Fishing Port, Probolinggo. Result showed that sex ratio female and male was 1 : 1.19 with proportion of female and male 44.63% and 54.38% respectively. Gonad maturity level (GML) was dominated by immature fish (91.3%). Gonado Somatic Index (GSI) ranged from 0.0079 to 0.679. The formula of length and weight relationship was \( W = 0.0007275L^{3.15} \) with the growth type of positive allometric. Length at first mature (*Lm*) of male and female was 22.9 cm and 22.5 cm respectively. In addition, Length at first capture (*Lc*) of Indian mackerel was 17.02 cm. Growth parameters of fish were *L∞* = 23.40 cm, *K* = 1.03 per year, and *t0* = -0.165 year. Based on GML and *Lc* values, it can be concluded that the Indian mackerel resource in Probolinggo waters was mostly caught before mature.

**Keyword:** Paiton, gonad maturity level, biological aspects, Indian mackerel, purse seine.

1. **Introduction**

East Java capture fisheries areas consist of two main waters namely South and North Coasts. The former is located in Hindia Ocean while the latter occupies Java Sea. One of important fishing ground of East Java North coast waters is Madura Strait where Probolinggo waters is located in Paiton Fishing Port is one of important fishing bases located in Probolinggo waters. Common fishing gear used to exploit fisheries resources in this area was purse seine. While the fisheries resources in Madura Strait were dominated by pelagic fish [1].

Indian mackerel (*Rastrelliger kanagurta*) is one of dominant pelagic fisheries resources in Probolinggo waters which has quite high economic value. As time goes on fishing activities in Probolinggo waters still continue while catch of pelagic fish including Indian mackerel tended to decrease year by year. This condition was caused by the increase of catch effort was not in accordance with stock availability. Research about fish biology will be useful to illustrate reproduction ability hence...
predict availability of the stock [2]. Purpose of this research was to identify biological aspects of Indian mackerel (R. kanagurta) in Probolinggo waters.

2. Materials and methods

2.1 Research sites
The research was conducted in the Paiton Fishing Port, Probolinggo, East Java. The dominant fishing gear operated was purse seine. Sample data was collected during purse seine operation from January to May 2017.

a. Data retrieval
The total length of the fish was measured using ruler. Fish weight was determined by digital scales (0.01 g). Sampling was taken for 5 months with two times sampling every month, at the beginning and end of month. Samples were taken randomly in fish landing site.

b. Data analysis
Sex ratio can be counted using formula [3]:

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

Where X is the sex ratio, and M and F are amount of male or female fish. While gonad maturity level (GML) can be determined from this following [4]:

1. A male fish: have a testicles, the big or small of testicles, colour of testicles, size of testicles in a body cavity, and out where abouts of liquid of the testicle.
2. A female fish: have an ovary, the big or small of ovary, colour of ovary, size of ovary in a body cavity, smooth and badness of the ovary, and the size eggs in the ovary.

Calculation of gonado somatic index (GSI) can be performed using this formula [5]:

\[ \text{IKG} = \frac{B_g}{B_t} \times 100\% \]

Where: IKG is gonado somatic index, Bg is the weight of gonad, and Bt is body weight

Analysis of length and weight relationship can be illustrated using formula as follow [6] [7]:

\[ W = a L^b \]

Where: W is body weight, L is body length, and a and b are constants value.

The b value is used to justify length weight relationship coefficients. It can be both allometric or isometric. Justification was done by conducting t-test with formula \( b_1 - b_0 \) \( S_b \). Where b1 is b from length and weight relationship value, b0 is 3, and Sb1 is deviation standard coefficient. If the b = 3 value is isometric and if b ≠ 3 is positive or negative allometric.

The length at first mature (Lm) referred to as length fifty (L50). Estimation of Lm can be performed by using formula [8]:

\[ Q = \frac{1}{1 + e^{-a(L - L_m)}} \]

Where Q = frequency of mature length class, 1 = the maximum value indicated 100% mature, e = 2.718, a = constants, L = length class interval (cm). The equation is confirmed in linear form:

\[ \ln \left( \frac{Q}{(1 - Q)} \right) = -a \times L_{50} + a \times L \]

And then the value of length at first mature calculated by

\[ L_m = \frac{a}{b} \]

The estimation of growth parameters can be calculated using the Von Bertalanffy model as follows [8]:

\[ L_t = L_\infty \left[ 1 - e^{-k(t - t_0)} \right] \]

Where: \( L_t \) = fish length at t-age (mm)
\( L_\infty \) = maximum length (mm)
\( k \) = growth coefficient (t^-1)
\( t \) = age of fish
\( t_0 \) = the hypothesis of fish age at zero length.
Analysis of length at first capture ($L_c$) can be known from the length frequency data that is from calculation of the highest mode middle value and frequency of the middle value in a class. The mean value of standard deviation of length fish of each sample can be identified by using linear equations as follow:

$$\ln fc (z) = a - bx \left[ L + \frac{dL}{2} \right]$$

Where $\ln fc (z)$ is the difference between two length classes in $\ln$, $a$ and $b$ = constants. So that $L_c$ value can be formulated as follows $L_c = \frac{a}{b}$ Where $a$= intercept and $b$ = slope.

The recruitment can be analyzed by FISAT II program by length frequency distribution. The parameters used are growth parameters obtained based on calculations with Von Bertalanffy's model. The value input at FISAT II program among others $K$, $L_\infty$, and $t_0$. The natural mortality ($M$) can be analyzed using empirical formula introduced by Pauly [9] as follow:

$$\log M = 0.0066 - 0.279 \log L_\infty + 0.6543 \log K + 0.4636 \log T$$

Where:
- $L_\infty$ = growth parameters (cm)
- $T$ = average annual aquatic environment temperature (°C)
- $M$ = natural mortality
- $L_\infty$ = length at the growth equation of Von Bertalanffy
- $T$ = Average surface water temperature (°C)

Pauly’s equation suggested to count fish types that have a schooling habit multiplied by 0.8 [11].

$$M = 0.8 e^{(0.0152 \cdot 0.279 \ln L_\infty + 0.6543 \ln K + 0.4636 \ln T)}$$

Where:
- $M$ = natural mortality
- $L_\infty$ = length at the growth equation of Von Bertalanffy
- $T$ = Average surface water temperature (°C)

3. Results and discussion

3.1 Fishing Ground

The fishing ground area in Madura Strait was around 10 miles from the port and was in the Fisheries Management Area (FMA) 712. This FMA was mainly part of Java Sea. Fishermen in Paiton conduct a one-time fishing operation. The coordinate for fishing ground was 113°26'30'' - 113°34' longitude and 07°29' – 07°38' latitude.

3.2 Fishing Unit

The fishing gears operated in Probolinggo waters landed in Paiton was dominated by purse seine with a total of 95 purse seiners. The size of fishing vessels was dominated by purse seiners with capacity of 10-20 GT with 93 vessels and only 2 fishing vessels with a capacity of 20-30 GT.

3.3 Sampling

The sampling of Indian mackerel ($R. kanagurta$) was conducted at the end of January 2016 until the beginning of May 2017. The sampling time was based on the Java calendar used by Paiton fishermen at the beginning of each month and the end of the month. Fish sampling was done randomly to obtain variation of fish sizes. Total sample from eight times sampling (Table 1) was 960 fish or 120 fish every sampling. From 120 fish samples taken of each sampling, for about 60 fish were measured to the biological aspect.

3.4 Environmental factors

Environmental factors to be assessed were water temperature and salinity which were taken in the time of data collection. The temperature and salinity in Probolinggo waters ranged from 27°-33 °C and 25-28 ppm respectively during study in January 2017-May 2017 (Table 1). These sea surface condition in Propolinggo waters was in accordance with data mentioned by Nadjid et al., [12]. The general temperatures in Indonesian waters ranged from 27 °C – 33 °C. The temperature is suitable for marine life. Temperature data used to estimate natural mortality was 30°C. The average salinity of sea level
during the study was about 26.4 ppm. The surface salinity is a well-known parameter and its variations can describe the overall mass of water circulation of the Java Sea [12]. They added that the distribution of salinity in Madura Strait waters varied between 26 - 30 ppm, with an average of 27.8 ppm. The relationship of the salinity parameter data influences the biological process and directly affects the life of the organism, such as affecting the growth rate and the amount of food consumed [13].

Table 1. Temperature and Salinity in Probolinggo waters during study (2017)

| No | Date        | Temperature (°C) | Salinity (ppm) |
|----|-------------|------------------|----------------|
| 1  | 29 January  | 27               | 26             |
| 2  | 01 February | 33               | -              |
| 3  | 21 February | 31               | 26             |
| 4  | 09 March    | 28               | 25             |
| 5  | 29 March    | 32               | -              |
| 6  | 02 April    | 29               | -              |
| 7  | 30 April    | 28               | 27             |
| 8  | 03 May      | 32               | 28             |

3.5 Biological Aspects of Fish

3.5.1 Sex Ratio. The sex ratio between female and male Indian mackerel (R. kanagurta) was 1 : 1.19 with percentage of 45.63 % female and 54.38 % male (Figure 1).

![Sex Ratio Graph](image)

**Figure 1.** The proportion of sex ratio of Indian mackerel (R. kanagurta) in Probolinggo waters.

Sex ratio is the comparison of a male fish with a female fish in a given population where comparison 1: 1 that is 50 % a male and 50 % a female fish are the condition of the ideal to maintain population [5].

3.5.2 Gonad Mature Level. Having seen the proportion of gonad mature fish based on maturity level of gonads, it can be said that most of the fish were caught in immature stage because the samples were dominated by fish in GML 1 and 2 (Figure 2). In contrast, the fish which is categorized as in mature stage when the fish is in GML 3, 4, and 5.

Figure 2 shows that in every month Indian mackerel is dominated by GML 1 and 2. Immature fish as many as 438 fish or 91.3% and mature fish is only 42 fish or 8.8%. According to Syahrini et al., [14] the highest breeding of Indian mackerel fish occurred in April.
3.5.3 Gonado Somatic Index. Value of gonado somatic index (GSI) in eight samples fluctuated and ranged from the lowest 0.0079 in sample eight taken in 3rd May 2017 to the highest 0.679 in sample seven taken in 2nd April 2017 (Figure 3). The value of GSI will increase until it reaches the maximum range when it will spawn, then it will drop back quickly during spawning takes place until completion [5].

3.5.4 Length and Weight Relationship. Length and weight relationship of Indian mackerel (R. kanagurta) was illustrated by equation \( W = 0.007275 L^{3.15} \) with a value of \( r^2 \) square as 0.9948 which meant that the growth length strongly affected the growth weight of fish (Figure 4).

Analysis of T-test showed that the value of T-count (3.80) was higher than that of T-table (1.96). This informed that the b value was significant different. The result also shows a b value is 3.15. This means that length and weight relationship of Indian mackerel is allometric positive. This is in accordance with the statement of Syahriani et al., [13] for Indian mackerel was allometric positive.
3.5.5 Length at First Mature (Lm). Length at first mature (Lm) data analysis were separated between female and male. Result illustrated that Lm of female and male fish was 22.47 cm and 22.85 cm respectively (figure 5 and 6).

**Figure 5.** Lm of female Indian mackerel (*R. kanagurta*) in Probolinggo waters

Lm size of female fish was a bit bigger than that of male. This is thought to be due to growth length (based on growth patterns) of male of Indian mackerel was faster than that of female fish. Size of Indian mackerel below 20 cm has not been seen any development of gonads [15].
3.5.6 Length At First Capture (Lc). The results of length at first capture (Lc) size of Indian mackerel (R. kanagurta) analysis was 17.02 cm (Figure 7). This result was in accordance with data about Lc size of Indian mackerel in Kendal waters. It was about 17 cm [16]. Compare to Lm size, both female and male, it showed that the size Lc was much lower than that of Lm. This condition informed that the fish was mostly caught before mature. Hence the size of the captured fish must be increased in order to let more matured fish to spawn before captured. Otherwise the decline of Indian mackerel stock will occur in short time.

3.5.7 Growth Parameters. Length data analysis using Fisat II obtained that values of length infinity (L∞) and growth rate (K) were 23.4 cm and 1.03 per year respectively. While value of t0 calculated by Pauly equation [11] was -0.165 year. Therefore the growth equation of von Bertalanffy of Indian mackerel (R. kanagurta) was Lt = 23.40 (1 - e^{-1.03(t + 0.165)}) (Figure 8).
Figure 8. Growth Length Curve of Indian mackerel (*R. kanagurta*) in Probolinggo waters

4 Conclusion

Comparison of sex ratio of male and female fish was 1:1.19. The total gonad maturity level (GML) of mature fish was 42 fish or 8.8% while immature was as much as 438 fish or 91.3%. The smallest value of GSI occurred in the eighth sampling month with the value of 0.0079 while the largest average value occurred in the seventh sampling with a value of 0.6792. Length and weight relationship fish was allometric positive with an equation of \( W = 0.0007275L^{3.15} \). The \( L_m \) values of male and female were 22.85 cm and 22.47 cm respectively. While Lc value of fish was 17.02 cm.

Growth parameters values of Indian mackerel (*R. kanagurta*) were \( L_\infty = 23.40 \) cm, \( K = 1.03 \) per year, and \( t_0 = -0.17 \) with the equation \( Lt = 23.4 \left( 1 - e^{-1.03(t + 0.165)} \right) \). Based on GML and Lc values, it can be concluded that the Indian mackerel resource in Probolinggo waters was mostly caught before mature.

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