Some biological stock indicators of red bigeye (*priacanthus macracanthus* cuvier, 1829) in Palabuhanratu waters, Indonesia

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**Abstract.** The potential of demersal fish resources in the waters of South Java is 7,902 tons with exploitation rates of 0.39. This low level of exploitation shows that increasing the utilization of this fish in South Java can still possible. The Red Bigeye fish (*Priacanthus macracanthus*), or Swanggi as known by local name is one of the economically valuable demersal fish from Family Priacanthidae. This study aims to examine several indicators of *Priacanthus macracanthus* biology stock as a basis for the sustainable management of this species. The research was conducted in February-December at PPN Palabuhanratu, Indonesia. The results showed that the spawning season takes place in May-July 2019. The sex ratio between male and female fish is balanced. The growth pattern is negative allometric with a value of $b = 2.7379$. Distribution of length ranges from 11.8 to 36.0 cm TL (total length) with an average of 23.32 cm TL. The average length of the first catch ($L_c$) was 21.58 cm, and the average length at first maturity ($L_m$) was 19.87 cm. The growth equation of Von Bertalanffy is $L(t) = 35.45 \left[1 - e^{-0.72(t - 0.8143)}\right]$. The fishing mortality rate is ($F = 1.52$), slightly greater than the natural mortality ($M = 1.40$), and the level of exploitation ($E$) is 0.52. The estimated spawning potential ratio (SPR) of this fish is 24%, which means slightly exceeding the optimum exploitation rate.

1. **Introduction**

Swanggi fish (*P. macracanthus*) has the international name Red Bigeye's fish. The local names in Indonesia are Swanggi, Cemaul Dasar, Mata Besar, Mata Goyang, Demang, Mangla and Broek Abah. The morphology of this fish is that the tip of the lower jaw when the mouth closed is above the midline of the body, while the front spines of the gill covers are long and reach or extend beyond the edge of the gill cover, forked caudal fins, silvery pink, dorsal, anal and pelvic fins with brown spots. Red Bigeye's fish habitat is marine, reef-associated, hard and soft substrate base at a water depth of 12-400 m. The distribution is Western Pacific: southern Japan to western Indonesia, the Arafura Sea and Australia [1]. The maximum length of *P. macracanthus* found in South Java, Indonesia reaches 34 cm, and spawning occurs twice a year, February / March and August / September [2].

The reg bigeye’s fish is marketed fresh and whole and also can be processed as surimi and sum-fog (a fermented Thai fish mince) [3]. It used to have a cheap selling price of Rp. 10.000 / kg, now the price has increased to Rp. 35.000 / kg. The people around West Java and Jakarta consumed this fish and the fish also one of the export commodities that are quite attractive [4] so there is ongoing exploitation of this fish.

The potential of demersal fish resources in the waters of the Java Straits (WPP 573) in 2016 is 7.92 tons with a utilization rate of 0.39 [5]. The Red Bigeye's fish (*P. macracanthus*) is an economically...
valuable demersal fish from the Priacanthidae family. The trend of swanggi fish production in South Java in 2005-2016 tends to increase from 320 tons (2005) to 1358 tons (2016) with an average increase of 79.43% [6]. Even though production continues to grow, it is necessary to make efforts to manage Swanggi fish in Palabuhanratu, South Java so that natural stocks can be sustainable.

The purposes of this study were to examine several indicators of Red Bigeye's fish biological stock, including spawning season, size structure and utilization rate. It is hoped that the results of this study will be used as input in the management of Red Bigeye's in Palabuhanratu, South Java so that this fish resources can be sustainably managed.

2. Material and Methods

2.1. Data collection
This research was conducted in February - December 2019 in the waters of Palabuhanratu, South Java (WPP 573) with fish sampling conducted at PPN Palabuhanratu, Sukabumi, West Java (Figure 1). The Red Bigeye's fish samples were collected from two different fishing gears, the handline, bottom longline and gill net. The handline used number 10-12 hooks with each rod used was around 40-65 hooks, bottom longline used number 6-8 hooks while the gill net mesh's size was \(1 \frac{3}{4} -3\) inch. Three of these gears were one-day fishing because the fishing ground is not far (about 3 miles from the landing site). The length of the sample was measured using a measuring board with an accuracy of 1.0 cm, and the weighed using a digital scale with an accuracy of 1.0 gram. The fishes were dissected after measured, using a dissecting set to observe the gonads.

![Figure 1. Map of research and fishing areas for Red Bigeye's fish in Palabuhanratu, South Java.](image)

2.2. Data Analysis
Composition of gonad maturity stages (GMS) was observed visually every month by looking at changes in gonad morphology with the criteria for GMS I (immature), GMS II (development), GMS III (mature) and GMS IV (spawned). We calculate the Gonad Somatic Index (GSI) according to [7]:

\[
GSI = \frac{\text{weight of gona} \text{d (g)}}{\text{weight of fish (g)}} \times 100.
\]

The sex ratio of male and female was analyzed using equations [8]:

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

where \(X\) is the sex ratio, \(M\) is the number of males, and \(F\) is the number of females. The fish length and weight relationship can be determined using the equation:

\[
W = aL^b.
\]

where \(W\) is the weight (g) of fish, with \(L\) is the fork length (mm) of fish, \(a\) and \(b\) are weight growth coefficients. The estimation of length at first captured (Lc) was using the logistic curve between the fish length (X-axis) and the number of fish (Y-axis). The length at
first maturity ($L_m$) was analyzed using [9] equation: $m = X_k + \frac{X}{z} - \{X \sum p_i\},$

$$\text{anti log} \left[ m \pm 1.96 \sqrt{X^2 \sum \left( \frac{p_i x_{qi}}{n_i - 1} \right)} \right]$$

where: $m = \log$ of fish length at first maturity; $X_k = \log$ of median at first maturity of 100%; $X = \log$ of median; $P_i = \text{proportion of mature fish at class-i}$ where $p_i = r_i / n_i$; $n_i = \text{number of mature fish at class-i}$; $q_i = 1 - p_i$.

Growth parameters ($L_\infty$ and $K$) were estimated using the ELEFAN method in the TropFishR package using the R software program [10]. We estimate the growth parameters using the von Bertalanffy growth model [11]: $L(t) = (1 - e^{-K(t-t_0)})$ where $L(t)$ = the length at age t (fork length); $L_{\infty}$ = the asymptotic length; $t_0$ = the theoretical age at zero-length; $K$ = the growth coefficient.

The total mortality ($Z$) was calculated by: $Z = M + F$. Natural mortality ($M$) was estimated by the empirical equation method [12]:

$$M = -0.152 - 0.279 \times \ln L_{\infty} + 0.6543 \times \ln K = 0.463 \times \ln T,$$

where $M = \text{natural mortality per year}$; $L_{\infty} = \text{asymptotic length}$; $K = \text{the growth coefficient}$; $T = \text{average annual temperature (Â°C)}$. The formula for Fishing mortality ($F$) was: $F = Z - M$ and for exploitation rate ($E$) was: $E = F / Z$ [12].

The estimated spawning potential ratio (SPR) was analyzed using long data (Length based SPR) [13]. The data included in the SPR analysis were fish length, asymptotic length value ($L_{\infty}$), the value of $M / K$ division yield, 50% value of gonad ripe ($L_m 50\%$) and 95% value of cooked gonads ($L_m 95\%$).

3. Results and Discussion

3.1. Spawning Season

The monthly composition of GMS and GSI provided information for spawning season of the species. The composition of the maturity stage of male and female in the observation from February to December 2019 consists of stages I to IV. Matured males were found in February, May and June while matured females in February, May, June and July (Figure 2).

![Figure 2](image_url). GMS of males and females of Red Bigeye's fish in Palabuhanratu - South Java, 2019.

The GSI ranged from 0.34 to 4.38, with an average of 1.72. The lowest value was in December at 0.34 and the highest in May at 4.38. (Figure 3).
Based on the information on the composition of the GMS and GSI, the Red Bigeye's spawning season assumed to occurs in May-July. The results of this study were almost the same as those of [14] that the Red Bigeye's fish spawning season in the same area occurs twice a year, June-July and December-January. In contrast to the results of research by [15] in Labuhan waters, Banten, the spawning season occurred in March and September. The differences in spawning seasons in several water locations can be caused by differences in growth, food availability and environmental water conditions such as temperature [16].

3.2. Sex ratio
The sex ratio of the Red Bigeye's fish (P. macracanthus) was 0.60:1.00 with 220 male fishes and 241 female fishes. Based on the results of the analysis with the chi-square test ($\chi^2$), the sex ratio of $P. macracanthus$ is balanced ($\chi^2$ value $> \chi^2$ tab), which means that the population of male and female fishes in nature is the same so that the species can maintain their survival. This result was the same as the results of research by [17] on the P. tayenus species that the sex ratio of $P. macracanthus$ was balanced. [18] stated that fish stocks could be maintained in nature if the sex ratio was balanced, or at least there are more females fish. The result from a monthly observation showed the sex ratio between male and female fishes were not significantly different, except for February, June, August and October (Table 1).

**Table 1.** The sex ratio of Red Bigeye's fish ($P. macracanthus$) in Palabuhanratu - South Java, 2019.

| Month | Males | Females | Total | Sex ratio (M:F) | $\chi^2$ value | $\chi^2$ tab |
|-------|-------|---------|-------|----------------|---------------|--------------|
| Feb   | 45    | 75      | 120   | 0.60:1.00      | 7.50*         | 3.84         |
| May   | 17    | 17      | 34    | 1.00:1.00      | 1.20          | 3.84         |
| Jun   | 37    | 25      | 62    | 1.48:1.00      | 32.16*        | 3.84         |
| Jul   | 15    | 19      | 34    | 0.78:1.00      | 0.47          | 3.84         |
| Aug   | 46    | 19      | 65    | 2.42:1.00      | 11.22*        | 3.84         |
| Oct   | 28    | 47      | 75    | 0.59:1.00      | 4.81*         | 3.84         |
| Nov   | 27    | 37      | 64    | 0.72:1.00      | 1.56          | 3.84         |
| Dec   | 5     | 2       | 7     | 2.50:1.00      | 1.29          | 3.84         |
| Polled| 220   | 241     | 461   | 0.60:1.00      | 0.96          | 3.84         |

* Confident level 95%
3.3. Length-weight relation
The relationship between the length and weight of *P. macracanthus* regardless of sex are negative allometric with a value of $b = 2.7379$ and a correlation value ($R^2$) of 0.955, which means that the length increase of *P. macracanthus* is faster than the weight gain. This result is the same [19][20][21][22] that the growth pattern of *P. macracanthus* was negative allometric. Several factors that differentiate the length-weight connection are sex, age, time and location of fishing, the aquatic environment and food availability [23] (Figure 4).

![Figure 4. Length-weight relation of Red Bigeye's fish in Palabuhanratu - South Java, 2019.](image)

$$W = 0.0312L^{2.7378}$$

$$R^2 = 0.9555$$

3.4. Fish length distribution
The length distribution of *P. macracanthus* caught in bottom gill nets, handline and longlines without distinguishing sex from the total number of fish samples of 3,729 fish ranged from 11.8 - 36.0 cm TL with an average of 23.32 cm TL (Figure 5) and weight varies from 77 - 484 gr with an average of 205 gr. [1] mentioned that *P. macracanthus* found reached 33 cm.

![Figure 5. Fish length distribution of Red Bigeye's fish in Palabuhanratu - South Java, 2019.](image)

3.5. The average of length at first capture ($L_c$) and length at first maturity ($L_m$)
The average of length at first capture ($L_c$) of *P. macracanthus* in Palabuhanratu caught by gill nets ($L_c = 12.27$ cm) was smaller than bottom longlines ($L_c = 21.64$ cm) and handline ($L_c = 24.37$ cm) (Table 2). The average of length at first maturity ($L_m$) using the Udupa method was 19.87 cm. This value was smaller than the results of the study by [14, 17] each of 21.9 cm and 24.5 cm, respectively. The $L_c$ of *P. macracanthus* caught using gill nets is smaller than the $L_m$ ($L_c < L_m$), while the $L_c$ caught using longline and handline fishing gear is greater than $L_m$ ($L_c > L_m$). This result shows that the use of hand line and
bottom longline fishing gear is more selective than gill nets so that the fish are caught after at the size after spawning, and the availability of *P. macracanthus* stocks is sustainable.

**Table 2.** The average of length at first capture (Lc) of Red Bigeye's fish in Palabuhanratu, 2019.

| Fishing gear    | Lc       |
|-----------------|----------|
| Gillnets        | 12.27 cm |
| Bottom longlines| 21.64 cm |
| Handlines       | 24.37 cm |

3.6. Population Parameters Estimation

The results of population dynamics analysis for *P. macracanthus* showed that the value of asymptotic length (L∞), growth rate (K), and t0 was 35.45 cm, 0.72/year, and is 0.8143/year respectively. Result for Von Bertalanffy growth function for the same species is $L(t) = 35.45 \left[1 - e^{0.72(t - 0.8143)}\right]$ (Table 3). [11] stated that the value of K> 0.5 then the growth rate is faster, otherwise if the value of K < 0.5 then the growth rate is slow. The K value from this study and several research locations including Palabuhanratu (Indonesia), Java Sea (Indonesia), Malaysia, and the South China Sea is a fast-growth except for Taiwan which has a slow growth rate. The asymptotic length value from this study was greater than of the Java Sea, Taiwan and the South China Sea, but smaller than in Malaysian waters. Environmental conditions and genetic variations were thought to be the main cause of the differences in asymptotic length values for each location [2, 24].

**Table 3.** The value of growth parameters estimated of Red Bigeye's fish in Palabuhanratu, 2019.

| Location                | Year of sampling | K (per year) | L∞ (cm) | t0      | Source                  |
|-------------------------|------------------|--------------|---------|---------|-------------------------|
| South Java (indonesia)  | 2019             | 0.72         | 35.45   | -0.8143 | This study              |
| South Java (indonesia)  | 2016             | 1.38         | 35.37   | -0.21   | [2]                     |
| Java Sea (Indonesia)    | 1978-1979        | 1.15         | 23.00   |         | [25]                    |
| North Coast of Java (Indonesia) | 1980 | 1.36         | 26.7    |         | [19]                    |
| Malaysia                | 1997             | 1.30         | 37.0    |         | [26]                    |
| North central (taiwan)  | 2006             | 0.46         | 27.37   | -0.9140 | [27]                    |
| Beibu Gulf (South China Sea) | 2011-2015  | 0.70         | 29.1    |         | [28]                    |

The fishing mortality rate of Red Bigeye's fish (F = 1.52 per year) was slightly higher than the natural mortality rate (M = 1.40 per year) while the exploitation rate (E) was 0.52. [29] states that the optimum level of exploitation is at E = 0.5. The estimated spawning potential ratio of this fish was 24% (Table 4). According to [30], the SPR value of 20% is the minimum threshold, and the 40% value is the target reference point. Based on the E and SPR value, the utilization of Red Bigeye's fish in Palabuhanratu, South Java slightly exceeds optimum or experiencing full exploitation.

**Table 4.** The value of population parameters of Red Bigeye's fish in Palabuhanratu - South Java, 2019.

| Population parameters                                | Unit | value |
|------------------------------------------------------|------|-------|
| The total mortality (Z)                              | year | 2.92  |
| Natural mortality (M)                                | year | 1.40  |
| Fishing mortality (F)                                | year | 1.52  |
| Exploitation rate (E)                                | year | 0.52  |
| Spawning potential ratio (SPR)                       | %    | 24.0  |
4. Conclusions

The spawning season of Red Bigeye's fish (*P. macracanthus*) lasts from May to July. The use of hand line and bottom longline fishing gear is more selective than gill nets. The fishermen can catch *P. macracanthus* at a minimum size of 19 cm. The Von Bertalanffy growth function of *P. macracanthus* is 

\[ L(t) = 35.45 \left[ 1 - e^{-0.72(t-0.8145)} \right] \]

Utilization of *P. macracanthus* in Palabuhanratu, South Java is slightly higher than optimum or is fully exploited.

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