Reproductive biology, growth and mortality of silver pomfret (*Pampus argenteus*) in Tarakan waters, North Kalimatan

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Abstract. Silver pomfret (*Pampus argenteus*) was a demersal fish of the family Stromateidae and high economical value. The fish was caught by the mini trawler. This research aims to study the reproductive biology, growth and mortality of silver pomfret in North Kalimantan. The research was conducted in January-November 2016 in Tarakan, North Kalimantan. The length of the silver pomfret was 9.5-32 cmFL, sex ratio between female and male was unbalanced (0.55:1). The peak of spawning season in January and August. The fecundity of silver pomfret ranges from 57,969 – 248,520 eggs and the spawning type was a multispawner. Length weight relationship was negative allometric. Length at first captured (Lc) was smaller than length at first matured (Lm). The Von Bertalanffy’s growth equation was $L_t = 36.6 (1 - e^{-0.51(t - 0.30274)})$. The natural mortality rate (M) of silver pomfret was smaller than fishing mortality rate (F).

1. Introduction
Tarakan waters in North Kalimantan is a part of WPPNRI 716 that highly potential in fisheries including small pelagic, demersal fish, prawn and crab. Silver pomfret (*Pampus argenteus*) a fish member from family Stromateidae, is one of mostly caught demersal fish in North Kalimantan waters. They are caught in mini trawl and gillnet using fishing vessel with capacity <10GT.

The species habitat is benthopelagic, sandy and muddy substrate with depth to 80 meters [White et al. 2013]. It has a wide distribution in Indo-West Pacific: Persian Gulf to Indonesia, in the North to Hokkaido, Japan. [1]. This fish are also found in Iranian waters of the northern Parsian Gulf and Oman Sea [2], Kuwait waters [3-4] and Korean waters [5]. Special characteristic of silver pomfret are body deep and very compressed, wrinkled patch of skin on head almost reaching pectoral-fin base, single dorsal fin, anterior dorsal and anal fins extended, 37–43 dorsal-fin rays; and silvery [1].

Even though fisheries resources are including renewable resources, but ever increasing fishing without restrictions or control of fishing effort can lead to depletion of these resources. Reproductive biology research on silver pomfret has been carried out in Kuwaiti waters [3-4] and parameters of population dynamics in Iranian waters [2] and Indonesia [6].

This research was aim to update the data and information on reproduction biology, growth and mortality of the Silver pomfret in Tarakan waters, North Kalimantan. It is hoped that the results of this investigation can be used as a basis for developing sustainable management policies for the Silver Pomfret’s fishery.
2. Material and methods

2.1 Data collection
Research on Silver pomfret (*P. argenteus*) was conducted in January to November 2016. A total of 2,274 samples of fish were collected from mini trawl and gill nets at landing site in Tarakan, North Kalimantan (Figure 1). Measurement of fish length using a measuring board with accuracy of 1.0 cm and a weight measured using a digital scale with a precision of 1.0 g. Female fish gonads are preserved in Gilson's solution, then conducted observations in the Biology Laboratory at Research Institute of Marine Fisheries, Jakarta.

![Figure 1](image)

Figure 1. Research sites in Tarakan waters, North Kalimantan

2.2 Data analysis
Analysis to determine the sex ratio of male and female can be obtained through equations [7]:

\[ X = \frac{\text{Male}}{\text{Female}} \]

where X is the sex ratio where J is the number of male and B is the number of female.

Spawning season of fish can be known through the composition of the gonad maturity stage and gonad maturity index from the data each month. Gonad maturity stages (GMS) were observed visually/macroscopically. Gonadosomatic index (GSI) was calculated [8]:

\[ \text{GSI} = \frac{\text{weight of gonad (g)}}{\text{weight of fish (g)}} \times 100\% \]

Fecundity is calculated by taking fish gonads that have reached mature (GMS III and IV). Measurement of the size of the diameter and the number of eggs carried out using a 10x10 microscope magnification. Fecundity is calculated gravimetrically [9]:

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

where F is fecundity where n is the number of eggs in sub sample (g), G is the weight of the gonad (g) and g is the weight of the sub sample (g).

The length at first captured \( (L) \) was estimated by the logistic curve between the fish length (X-axis) and the number of fish (Y-axis). The fish length and weight relationship can be determined using the equation [7]:

\[ W = aL^b \]

where W is the weight (g) of fish, L is the fork length (mm) of fish, a and b are weight growth coefficients.

The growth parameters \( (L, L) \) were analyzed by metode *Electronic Length-Frequency Analysis-I* (ELEFAN-I) and *FAO-ICLARM Stock Assessment Tools-II* (FiSAT-II) and \( t_0 \) was obtained by the equation of Pauly [10]:

\[ \log(t_0) = -0.3922 - 0.2752 \log L_{\infty} + 1.038 \log K. \]

The growth parameters were estimated by the Von Bertalanffy growth model [11].
L(t) = L_\infty (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]:
\[
\ln M = -0.152 - 0.279 \times \ln L_\infty + 0.6543 \times \ln K + 0.463 \times \ln T,
\]
where \( M \) = natural mortality per year; \( L_\infty \) = the asymptotic length; \( K \) = the growth coefficient; \( T \) = average annual temperature (°C). Fishing mortality (F) was determined by the formula: \( F = Z - M \).

Exploitation rate (E) was measured by the formula [12]:
\[
E = F/Z.
\]

3. Results and discussion

3.1 Sex ratio

The number of males was 131 and 235 of females and the sex ratio of silver pomfret in Tarakan waters was 0.55 : 1 in favour of females. Monthly observations show that the sex ratio of males and females is significantly different at the 95% confidence level (\( X^2 \) value > \( X^2 \) table) which means that the sex ratio of male and female silver pomfret is unbalanced (1 ≠ 1) (Chi square, \( P = 0.05 \)) and dominated by female fish (Table 1). Another research results of silver pomfret by Almatar et al. [4] in Kuwaiti waters is dominated by male fish. According to Bal & Rao [13], the imbalance in the sex ratio of fish is influenced by eating habits and spawning or migration of each type of fish.

Table 1. Sex ratio of silver pomfret (P. argenteus) in Tarakan water, North Kalimantan.

| Month    | Male | Female | Total | Sex ratio (M:F) | \( X^2 \) value | \( X^2 \) tab |
|----------|------|--------|-------|----------------|-----------------|--------------|
| January  | 3    | 17     | 20    | 0.17:1.0       | 14.90           | 3.84         |
| February | 32   | 38     | 70    | 0.84:1.0       | 35.25           | 3.84         |
| March    | 38   | 57     | 95    | 0.67:1.0       | 49.40           | 3.84         |
| April    | 18   | 22     | 40    | 0.81:1.0       | 20.20           | 3.84         |
| May      | 0    | 15     | 15    | 0.00:1.0       | 15.00           | 3.84         |
| June     | 7    | 30     | 37    | 0.23:1.0       | 25.65           | 3.84         |
| July     | -    | -      | -     | -              | -               | -            |
| August   | 23   | 2      | 25    | 11.5:1.0       | 21.32           | 3.84         |
| September| 8    | 12     | 20    | 0.66:1.0       | 10.4            | 3.84         |
| October  | 2    | 22     | 24    | 0.09:1.0       | 20.33           | 3.84         |
| November | 0    | 20     | 20    | 0.00:1.0       | 20.00           | 3.84         |
| Total    | 131  | 235    | 366   | 0.55:1.0       | 197.77          | 3.84         |

3.2 Spawning season

Figure 2 shows the composition of the gonad maturity stage (GMS) in each month. The composition of GMS of silver pomfret (P. argenteus) which is mature on females (GMS III and IV) was found in January - September and GMS IV is dominant in January. The range of Gonad maturity index (GSI) of this species between 0.02 to 11.95 with an average of 6.81. The highest average GSI in January was 5.25 and August was 3.27 while the lowest GSI in November was 0.84 (Figure 2). Based on the data of GMS and GSI, spawning season of silver pomfret predicted to occur from January to September and the peak of spawning season for these fish species are predicted to occur in January and August.

This study shows that the results of the study are almost the same as those of Almatar et al. [4] and Dadzie et al. [3], the spawning season of silver pomfret in Kuwaiti waters begins in May to October.
and the peaks season predicted to occur in May and August. Abu-Hakima et al. [14] reported that the silver pomfret spawning season occurs in March - August. In order to keep the sustainability of the silver pomfret resource in Tarakan with fisheries management option by reducing catch during the peak of spawning season (January and August).

**Figure 2.** Gonad maturity stage and gonad somatic index of silver pomfret (*P. argenteus*) in Tarakan waters, North Kalimantan.

### 3.3 Fecundity

Fecundity of silver pomfret was from 57,969 to 248,520 number of eggs. The results of this study are smaller than the research results by Dadzie et al. [3] of 28,995 - 455,661 eggs and Abu Hakima et al. [14] 765,675 – 2,537,744 eggs, which means the potential reproduction of silver pomfret in Tarakan waters is relatively high. Based on the egg diameter analysis (GMS 4) of the silver pomfret, it ranges from 0.24 - 1.39 mm (Figure 3). These results are not different from the results of Almatar et al. [4] that the diameter of the egg ranges from 0.2 to 1.1 mm. It is suspected that this type of spawning is multiple spawners, where spawning is done more than once a year. Dadzie et al. [3] said Silver pomfret in Kuwait waters spawned when a GSI value <6% and oocyte size <0.7 mm.

**Figure 3.** Eggs diameter of silver pomfret (*P. argenteus*) in Tarakan water, North Kalimantan, 2016.

### 3.4 Length frequency

Distribution of length frequency of silver pomfret was from 9.5-32.0 cmFL with the average of 17.489 cmFL with the highest mode at 18 cmFL from 2,274 samples of fish. The length distribution of male is almost the same as the female. The range of fish length of male from 10.0-28.0 cm with an average of 17.76 cm and female from 10.0-27.5 cm with an average of 18.54 cm (Figure 4). The fish weight
between 37.0 – 770.0 gr with an average of 211.58 gr. The results of this study are not significantly different from the research results by Parsa et al. [16] that the length distribution of silver pomfret in the waters of the Persian Gulf and the Oman Sea is 10 - 32 cm and weighs 35 - 1075 gr. Carpenter & Niem [17] said that the maximum standard length of a silver pomfret was 60 cm and generally found with the length 30 cm.

**Figure 4.** Distribution of length frequency all, male and female of silver pomfret (*P. argenteus*) in Tarakan water, North Kalimantan, 2016.

3.5 The length at first captured (Lc) and the length at first maturity (Lm)
The length at first captured (Lc) of silver pomfret with mini trawl and gill nets was 16.91 cmFL and the length at first maturity using logistic curve methods (Lm) was 20 cmFL (Figure 5). Lc value from this research bigger then the previous results in the same sampling sites (Lc=15.90 cm) [6], and in the Persian Gulf was 10.1 cm [16], but smaller than the research result in east of China Sea (Lc = 17.0 cm) [19]. Lm value from this research bigger then the previous results in the same sampling sites (Lm=15.98 cm) [6]. The length at first captured smaller than the length at first maturity, therefore most of the fish caught have not yet spawned. In order to keep the sustainability of the resource by applying minimum legal size should be conducted on the fishery by allowing mininum catch size at Lm size or bigger (Lm = 20 cm).

**Figure 5.** The length at first captured (Lc) and the length at first maturity (Lm) of Silver pomfret (*P. argenteus*) In Tarakan waters, North Kalimantan, 2016.

3.6 Length and weight relationship
Length and weight relationship of silver pomfret (*P. argenteus*) with the 1.792 sampel of fish obtained value \( a = 0.0474, \ b = 2.855 \) and \( R^2 = 0.9358 \), then the equation of the length-weight relationship is W
= 0.0474L^{2.855}. Based on the t test obtained \( t_{\text{value}} > t_{\text{table}} \) which means that the growth pattern of silver pomfret is allometric negative (Figure 6). The results of this study are the same as those of Karim et al. [20] that the length-weight relationship of silver pomfret in the waters of Bengal Bay, Bangladesh is negative allometric, while the results of the study by Parsa et al. [16] and Muhammadkhani & Shirang [18] in the Oman waters that the length-weight relationship is positive allometric. The differences in the length-weight relationship of fish in various waters are the period of the year and the level of gonad maturity [13], sexual dimorphism [14] and research sampling procedures including fish sample size and the range of fish length.

![Figure 6](image)

**Figure 6.** Length-weight relationship of silver pomfret (\( P. \ argenteus \)) in Tarakan waters, North Kalimantan 2016.

3.7 Estimation of Growth Parameter (\( L_{\infty}, K, t_0 \))

Estimation of growth parameters using the ELEFAN-I method in the FiSAT II package Pauly [12] obtained asymptotic length (\( L_{\infty} \)) of silver pomfret was 36.6 cm and growth coefficient (K) was 0.51 per year and theoretical age at the time when the length of the fish is zero (= to) was -0.3027 per year. Thus the growth equation von Bertalanffy of silver pomfret is \( L_t = 36.6(1-e^{-0.51(t+0.3027)}) \) (Figure 7).

![Figure 7](image)

**Figure 7.** Von Bertalanffy’s growth equation curve and catch curve according to length measurement of silver pomfret (\( P. \ argenteus \)) in Tarakan waters, North Kalimantan 2016.
In this study, the estimated value of asymptotic length (L∞) of silver pomfret is bigger than the estimated value of L∞ in the waters of Persian Gulf (Kuwait), Java sea (Indonesia), Korea, Bengal Gulf and Oman sea [26,27,28,29, and 30 and 16] but smaller than the estimated L∞ value in Gujrat waters, India and Bengal Bay, Bangladesh [31]. This K value also experienced differences in several sampling sites (Table 1). Differences in growth parameters (L∞ and K) in several waters are suspected due to biological and physical-chemical factors at the time of fishing [12], data from research used for various analytical methods obtained by different fishing methods such as trawl, purse seine, handline and gillnet [32], environmental conditions (temperature differences), variations in fishing intensity, errors at sampling, genetic structure of each fish species, disease and food availability [33,34]

Table 2. Estimation parameters of growth of P. argenteus in several different waters.

| Location                      | L∞ (cmFL) | K (per year) | t₀ | Source                                |
|-------------------------------|-----------|--------------|----|---------------------------------------|
| Persian Gulf (Kuwait)         | 32,5      | 0,55         |    | Morgan (1985) [18]                    |
| Java sea (Indonesia)          | 32,5      | 0,95         |    | Dwiponggo et al. (1986) [19]          |
| Korea                         | 33,6      | 0,26         |    | Lee et al. (1992) [20]                |
| Benggala Gulf                 | 28,0      | 0,63         |    | Mustafa (1993) [21]                   |
| Benggala Gulf                 | 28,9      | 0,53         |    | Mutafa (1999) [22]                    |
| Gujrat, India                 | 39,5      | 0,75         |    | Khan (2000) [23]                      |
| North Kalimantan (Indonesia)  | 37,28     | 0,52         | -0,07 | Prihatinningis et al. (2015) [6]     |
| Persian Gulf & Oman Sea       | 32,55     | 0,30         | -0,54 | Parsa et al. (2017) [10]              |
| Bay of Bengal, Bangladesh     | 54,6      | 0,39         | -0,44 | Karim et al. (2018) [12]              |
| North Kalimantan (Indonesia)  | 36,6      | 0,51         | -0,30 | This research                         |

3.8 Mortality and exploitation rate

Based on the analysis of the total mortality (Z) of silver pomfret was 4.22 per year. The average annual temperature in Celebes Sea waters was 29°C, then if it is included in Pauly's empirical equation (1980), the natural mortality (M) was 1.11 per year and the fishing mortality (F) was 3.12 per year. (Figure 8)

The value of fishing mortality (F) of silver pomfret bigger than the natural mortality (M). This shows that the fish stocks exploitations are not optimum. Gulland [35], states that the optimum fish stock is when fishing mortality value equal to its natural mortality. According to Gulland ([36]), if the exploitation ratio is above 0.5, then the fish stocks are considered endangered or over-exploited. In this results, the exploitation rate of silver pomfret (E) was 0.73 per year. It shows that P. argenteus fish stocks in Tarakan waters, North Kalimantan have exceeded the optimum (over exploitation).
Figure 8. Length Converted Catch curve is linearly based on the length composition of silver fompret (P. argenteus) in Tarakan water, North Kalimantan, 2016.

4. Conclusions
In order to keep the sustainability of the resource, management by applying minimum legal size should be conducted on the fishery by allowing minimum catch size at Lm size or bigger. Other actions that can be measured are reducing catch during the peak of spawning season (January and August) and lower the fishing effort to 46% of the current situation.

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