Spawning potential ratio (SPR) of Sulphur Goatfish (*Upeneus sulphureus*): biological basis for demersal fishery management in Java Sea

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Abstract. Goatfish is one of the most dominant demersal-fish species currently caught by local fishermen in North-Coast of East Java and Madura using modified Danish-Seine. This research aimed to investigate species diversity goatfish and spawning potential ratio (SPR) of most representative species, *U. sulphureus*. Identification was completed through morphometric and meristic investigation. A total of 2,550 fish were sub-sampled from catches for length-frequency analysis, length at first maturity (*Lₘ*), length-weight relationship and SPR. The results showed that there were five species within catches, being: *U. sulphureus*, *U. moluccensis*, *U. tragula*, *U. sundaicus*, and *P. heptacanthus*. Length-weight followed cubic formula with *Wₜ = 0.0159 * Lt³⁻¹²⁴ (p< 0.05; r² = 0.92). Female length-at-first mature was reached at 11.67 cm Fork-Length, with total female biomass in the sample 6.5 kg. Total biomass was 93.1 kg, hence the SPR was < 7%. The minimum value of SPR while maintaining stock at good parent stock was >20%. From these results, it was very clear that demersal fishery in North-Coast of East Java, represented by *U. sulphureus* is unsustainable. Management measure, either size or effort limitation should be implemented, otherwise, the stock will soon collapse.

1. Introduction

North coast included in Fisheries Management Area 712 found various types of demersal fish the main target in fishing activity and have a potential of 320,432 tons in 2016 (Ministerial Regulation of Marine Affairs and Fisheries of the Republic Indonesia Number 71/KEPMEN-KP/2015). Demersal fish caught are dominated by goatfish which are the main target in capture fisheries. The utilization of goatfish in the North Coast has been going on for a long time and contributed significantly to the fisheries sector. High market demand for Sulphur goatfish causes the intensity of fishing to increase. Sulfur goatfish exploitation is danish seine.

Danish seine is a traditional fishing gear that maintained by fishermen on the North Coast of Java. Catching fish with danish seine is a technological engineering that is adjusted to catch fish that live on the bottom of the water. Danish seine is sweeping the bottom water so that it can damage the bottom water and the fish caught consists of various sizes. If the catch is dominated by fish that are too small, it will result in growth overfishing, the fish caught are mostly ripe gonads, overfishing
recruitment will occur [1]. Danish seine includes on the category of prohibited fishing gear in Ministerial Regulation of Marine Affairs and Fisheries of the Republic Indonesia Number 2/PERMEN-KP/2015 and it is Ministerial Regulation of Marine Affairs and Fisheries of Republic Indonesia Number 71/PERMEN/2016.

Conservation of sulfur goatfish resources must be maintained to remain sustainable stock of goatfish. The utilization of goatfish on the North coast requires information related to stock assessments to determine the effect of fishing activities. The stock status of sulfur goatfish assessed using the Spawning Potential Ratio (SPR) method, which is an index of the relative reproduction rate of exploitation resources [2].

2. Materials and methods

The study was carried out at the Landing Port Brondong, Lamongan, and Lekok, Pasuruan in January-March 2019. Fish identification is observing and recognizing morphological makers based on species identification guidelines body-color, the color of the dorsal fin, the color of the caudal fin, barbel and number of mid-lateral using the book Carpenter and Niem 2001a and Fish base. Length data is taken by measuring Fork Length using a ruler with an accuracy of 0.1 cm as much as 2,550 samples. Gonadal surgery is cutting the rectum toward the abdomen to the operculum vertically, continued toward the surface of the lateral line of 300 samples. Weigh of body and gonad using analytical scales with an accuracy of 0.01 gram.

Gonad Maturity Level By Holden dan Rait (1974) in [3], GML I (immature), GML II (maturing), GML III (maturing ripe), GML IV (ripe) and GML V (spent).

| Stage | Condition      | Remarks                                      |
|-------|----------------|----------------------------------------------|
| I     | Immature       | Ovaries and testes are approximately 1/3 the length of the body cavity. Clear reddish ovaries. Whitish testes. Egg is invisible with the naked eye. |
| II    | Developing     | The ovaries and testes about ½ length of the body cavity, clear or whitish tested, more or less symmetrical. Eggs not visible to the naked eye. |
| III   | Ripening       | Ovaries and testes approximately 2/3 length of the body cavity. Ovaries are reddish yellow and egg white begins to appear. Whitish testes of beige. No egg is translucent or clear |
| IV    | Ripe or Fully Mature | Ovaries and testes 2/3 fully body cavity. The ovaries are pink or orange with blood vessels visible on the surface. Visible eggs are ripe and translucent. Whitish or creamy and soft testes. |
| V     | Spent          | The ovaries and testes contract to approximately ½ body cavity. Ovaries contain leftover eggs. |

Length frequency distribution analyzed using fork length data and presented in a bar graph with 1 cm of interval class. Length and weight relationship used to determine fish growth and condition factor, can be calculated using the calculation:

\[ W = a \times L^b \]

Keterangan:
- \( W \) = Weight (gr)
- \( L \) = Lenght (cm)
- \( a \) = Intercept
- \( b \) = Slope

Length at first capture (Lc) is estimated the length of fish caught by 50% based on Lc value, it can be calculated using the following calculation [4]:

\[ SL = \frac{1}{\text{1+exp}(51-52+L)} \]
Keterangan:
SL = logistic curves
S1 = a
S1&S2 = Constanta
S2 = b

Length at first mature (Lm) is using to estimate the length of first-time gonad matured using logistic formula model, assuming its length where 50% of all individuals are sexually mature (L50) [5]:

\[ P = \frac{1}{1+e^{r(L-L_{50})}} \]

Keterangan:
P = fraction interval class of mature
1 = maximal value of gonad maturity
e = 2.718
r = slope
L = interval class
Lm = length at first mature

Spawning potential ratio provides a conservation strategy to maintain the reproduction of a stock that is useful in preventing overfishing recruitment. SPR method is commonly used in the management of fish resources. It can be used to define a reference point for data-poor fisheries. The SPR value is calculated based on [6] equation as follows:

\[ SPR = \frac{SSBR_r}{SSBR_{r=0}} \times 100 \]

Where:
SPR = Spawning Potential Ratio of fish (%)
SSBR_r = Spawning stock biomass at exploitation (kg)
SSBR_{r=0} = Spawning stock biomass un-exploitation (kg)

The limits of the SPR values used as the basis for the management of fish resources (Goodyear, 1989) in [6]:
1.1 SPR < 20% = Decreasing of fish population
2.1 20% ≤ SPR > 30% = Sustainable of fish population
3.1 SPR ≥ 35% = Increasing of fish population

3. Result and Discussion
3.1 Identification
During January-March 20192 genus (5 species) were identified which were landed in Landing Por Brondong, Lamongan, and Lekok, Pasuruan. Goatfish that have been identified are *Upeneus* and *Parupeneus*, a sentence of: *U. sulphurous*, *U. sundaicus*, *U. moluccensis*, *U. tragula*, and *P. heptacanthus*. Mullidae family has an elongated and compressed body, the main character has 2 long barbells.

1) *Upeneus sulphureus* (Cuvier, 1829)
*U. sulphureus* has a moderately elongate and compressed body. The local name of this fish in Brondong is Rambangan fish. Dorsal fin is reddish bronze with silvery-white underside and peritoneum is brownish yellow. Two yellow midlateral extends from the back end of the operculum to the end of the base tail. The dorsal fin has two blackish yellow lines with the tip of the black mark (Figure 1).

2) *Upeneus sundaicus* (Bleeker, 1855)
*U. sundaicus* has a moderately elongate and compressed body. The local name of this fish in Lekok is Black Goatfish. The dorsal fin is dark bronze with a silvery-white underside, the peritoneum is brownish yellow. Brownish-yellow midlateral line that extends from the back upper eye to the front of
the base tail. Besides, three dark zone markings, one under each dorsal fin and one in the anterior of the base tail (Figure 1).

3) *Upeneus moluccensis* (Bleeker, 1855)

*U. moluccensis* has moderately elongate and compressed. The local name in Brondong is Kamojan fish. The dorsal fin is pink with silvery-white underside, the peritoneum is brownish. The yellow midlateral line extends from the top eye to the front base upper tail (Figure 1).

4) *Upeneus tragula* (Richardson, 1846)

*U. tragula* has a moderately elongate and compressed body. The local name in Brondong is Red Rambangan fish. The dorsal fin is reddish pink with silvery white underside, the peritoneum is whitish. Reddish spots over the body from the head to base tail (Figure 1).

5) *Parupeneus heptacanthus* (Lacepede, 1802)

*P. heptacanthus* has a moderately elongate and compressed body. The local name of this fish in Brondong is Lepetan fish. The dorsal fin is reddish with yellow underside and peritoneum is whitish (Figure 1).

![Figure 1](image-url.com) A. *Upeneus sulphureus*; B. *Upeneus sundaicus*; C. *Upeneus oluccensis*; D. *Upeneus tragula*; E. *Parupeneus heptacanthus*

A length frequency distribution is many sulfur goatfish in each length class which is calculated per unit length. Based on statistical calculations, the highest frequency length is 750 at an interval class of 11-12 cm (Figure 2).
Based on research [2] in Tegal, the length of the sulfur goatfish is 9.5 cm in March and April. Besides the research of the study (Beck and Sudrajat, 1978) in Coast Java, the length of sulfur goatfish is 8-15.8 cm and length in 20 cm never founded on coast Java. The difference in size and number of fish in waters caused by differences in growth, gonad first mature, life span and new species in the population. The same species living in different locations have different growth due to internal and external factors that affect fish growth [8].

Length weight distribution of Sulphur goatfish is used to determine the size composition. Differences in size and weight of sulfur goatfish related to some factors such as food, water quality, age, and sex. This is due to the influence of the selectivity level of danish seine to used get sulfur goatfish. Based on the result of the above research, length weight relationship and length frequency relationship are interrelated. Length distribution will affect the result of length weight relationships.

Length weight relationship analysis of sulfur goatfish obtained \( R^2 \) is of 0.921 while the value of regression result breached 3.124 ± 0.018. Based on the t-test of b value, the value of \( t_{\text{count}} \) was 6.869 while the table value of 5% was 1.961. It can be concluded that the \( t_{\text{count}} > t_{\text{table}} \) means the growth of sulfur goatfish is positive allometry, where the weight is faster than length because \( b > 3 \) (Figure 3).
Length and weight research about sulfur goatfish conducted in Brondong, Lamongan [9] showed that growth of sulfur goatfish is allometric negative with b value 2.224 and $R^2$ is 0.700. The difference value of b occurs in different location and time collection. Ecological factors include seasonality, water quality, temperature, ph, salinity, geographical position, and sampling techniques. While biological factors include gonad development, habits, growth phase and gender [10].

Gonad Maturity Level (GML) Analysis during the study 300 samples was identified with 141 male and 159 female. The result showed that as many 79 male is immature and 62 male mature, while as many 59 female immature and 100 female mature. Maturity level of male sulphur goatfish in GML 1 was 30%, GML 2 was 24%, GML 3 was 30%, GML 4 was 14%, and GML 5 was 1%. While the maturity level of female sulphur goatfish in GML 1 was 18%, GML 2 was 19%, GML 3 was 31%, GML 4 was 28% and GML 5 is 3% (Figure 4).
Gonad Maturity Level can provide condition of gonad maturity fish immature or mature. Through the knowledge about GML can obtain that fish spawned [1]. Temperatur condition in the tropic area above 21°C allow the process of gonad ripening and spawning to take place throughout the year (Tuwo and Nessa, 1992 in Hartati, 2006).

Length at first mature of sulphur goatfish reach 12.33 ± 0.040 cm (GML III-V), while Lm female sulphur goatfish is 11.67 ± 0.108 cm. Length at first capture of sulphur goatfish is 11.20 ± 0.077 cm. Based on Lm and Lc value, it can be shown that the Lm higher than Lc, so the size of the fish is immature. It can be concluded that Danish seine that operated in North Coast classified as unsustainable fishing gear because the landed fish at a size not feasible to catch and it can be said that stock of sulfur goatfish is overfishing.

The result of the SPR analysis obtained the SPR value of sulfur goatfish in the North Java sea is 7% (SPR < 10%). This shows that the criteria for the condition of sulfur goatfish are overfishing, sulfur goatfish caught using Danish seine have a smaller size compared with Lm. This is due to the heavy exploitation and Danish seine sweeps the bottom of the water. For the potential of sulfur goatfish to remain sustainable, efforts were made to increase the stock of sulfur goatfish by not catching fish too small and increase the mesh size of danish seine so immature fish could can growth and reduce the mortality of small fish. SPR will be increased by 30% at length 11.70 cm.

**Figure 4.** Proportion of Gonad Maturity Level Male and Female of Sulphur Goatfish (*Upeneus sulphureus*) on January-March 2019
Based on research conducted in Tegal, Central Java, the value of sulfur goatfish was 11%. Conclusion to avoid the extinction of fish stocks can be done by increasing Lc so SPR value will increase as well. Increasing SPR value is expected to increase the availability of fish stock [12].

4. Conclusion
Identify of goatfish founded 5 species and 2 genus, *U. sulphureus*, *U. sundaicus*, *U. moluccensis*, *U. tragula*, and *P. heptacanthus*. The condition factor of sulfur goatfish is allometric negative and the highest frequency is 750 in interval 11-12 cm. The result SPR analysis of sulfur goatfish is 7%, shows that sulfur goatfish in overfishing condition. Restoration of sulfur goatfish can be done by increasing the mesh size so that immature fish not caught.

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