Target strength measurement of Caroun croaker (*Johnius* sp.) and acoustic fish density estimation in Musi Estuary, South Sumatra

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**Abstract.** Caroun Croaker (*Johnius* sp.) is one of the dominant estuarine fish that has a reasonably high economic value. The target strength (TS) value measurement is essential in calculating the density of fish stocks using the hydroacoustic method. Target strength measurement of Caroun Croaker (*Johnius* sp.) and an acoustic survey in Musi Estuary Waters of South Sumatra Province was conducted in December 2019. The result of TS measurement will be used to estimate the acoustic density along the survey area. The TS measurement used the standard tethered method, tying placing the fish in a fixed cage, transmitting the acoustic pulse, and analyzing its return using the scientific acoustic instrument Biosonic DT-X 200 KHz. The fisheries acoustic survey was carried out in the area around the Musi estuary with a predetermined survey design. The results of the measurements have obtained the TS-length relationship, as $TS = 20 \log L - 78.79$ with determinant value of $R^2 = 0.67$ for fish length ranges from 18.1-23.3 cm, and an acoustic survey showed that the estimated stock density value was 286 kg/ha for the total surveyed area of 1.612 ha.

**Keywords:** acoustics, Caroun croaker, Musi Estuary, target strength

1. Introduction

Musi River is located in South Sumatra Province, Indonesia, and has a length of ± 700 km. It has many roles for fishery activities that can be developed, capturing fisheries, aquaculture, or fisheries processing. Musi River from upstream to downstream has 233 fish species [1]. Fish resources can be used as consumption fish or ornamental fish. Capture fisheries, fishing activities use various fishing gears, most traditional fishing gears produced by local fishermen.

The downstream of Musi River referred to as the Musi Estuary, has geographic characteristics bordering the Bangka Strait, so that it has a fluctuating salinity value because the tides of seawater influence it. Musi Estuary has an important role, namely as a care area, namely biodata, the fish foraging and sheltering and spawning some fish. Some fish in estuarine waters have migratory habits, and the structure of the fish community is influenced by season and time [2-3].

Fishery Management, one of which is a stock study. One method to determine the stock of fish resources is using the hydroacoustic method. A remote sensing method utilizes sound waves as an
intermediary emitted by equipment or an echo sounder to detect underwater objects, in this case, fish biodiversity. One thing that is fundamental in assessing fish stocks using the acoustic method is target strength (TS) measurement because the TS can represent differences in fish morphometric sizes. Therefore, we need a specific formula that can explain the relationship between acoustic parameters and fish biological parameters.

This research carried out the measurement and analysis of the target strength of Caroun croaker Fish (*Johnius* sp.), one of the dominant fish and has economic value in the Estuary area, and after obtaining the TS value formula, it will be further analyzed for the acoustic survey data. The results of this acoustic data processing will get the density or density value of fish in water, in this case, the Estuary, so that the current stock status values are generated which will be used as material for managing fisheries resources in an ecosystem, in this case, the Musi ecosystem so that fish resources remain sustainable. In this study, the focus is to examine the status of fish resource stocks in the downstream or Estuary of the Musi river.

2. Materials and methods

2.1. Study area

The research was conducted in the Musi Estuary waters, located in Sungsang Village, Banyuasin II Regency, Banyuasin District, South Sumatra Province, Indonesia, August-December 2019. The research location [4] and the acoustic track is presented in Figure 1.

![Figure 1. Acoustic track along the Musi Estuary, December 2019.](image-url)
2.2. Equipment and materials

The research equipment that is prepared to support field data collection activities include survey vessels (research vessels), Biosonic DTX split beam acoustic instruments with a frequency of 200 kHz, with a pulse length parameter setting of 0.3 m/s, ping rate 10 PPS (ping per second/sec), sampling rate 41667 Hz, Source Level/Sound Level 221.6 dB, and Threshold -70dB.

Measurement of target strength using the standard target strength test (TS) in Cage Experimental Setup in the form of iron ball with a thickness of 10 mm and a mesh diameter of 0.5 cm. The sample material used Cage for TS Measurement is Caroun croaker (*Johnius* sp.), a fish originating from the Musi Estuary. Tools and materials are presented in Figures 2, 3, and Tables 1, 2.

![Acoustic Instrument and Cage for TS Measurement](image)

**Figure 2.** Acoustic instrument (a) and Cage for TS measurement (b) [4].

![Method of Length Measurement](image)

**Figure 3.** Method of length measurement for Caroun croaker (*Johnius* sp.) [5].

2.3. Research procedure

2.3.1. Calibration

Calibration is carried out to see to what extent the value produced by the Split-beam echo sounder acoustic instrument produces a backscatter value in this case, the target strength (TS). The calibration used standard method, where the sphere ball is tethered. The sphere used is made of Tungsten Carbide material with a diameter of 36.4 mm, with a standard TS value following the characteristics of sound speed obtained from salinity, temperature, and depth parameters.
2.3.2. Target strength measurement and acoustic tracking survey

TS measurement is done by placing the test fish in the waring and sounding/recording the data, then doing morphological parameters such as length, weight, and length of the swim bladder. The acoustic survey was carried out around the Musi Estuary waters by placing an acoustic device beside the ship. Then the selected tracking path is in the form of a Zigzag or cross. The shipping speed during the second survey was 3.8 knots.

2.3.3. Data analysis

Data analysis using echoview 5.0 software with a threshold setting of -70 dB, horizontal grid distance based on time (0.2 minutes), vertical grid separation (0.2 meters) to obtain the TS value, after that the data is converted into an ASCII file, Image Process The analysis on the echoview program is presented in Figure 4.

![Figure 4. TS analysis on echoview 5 software.](image)

The results of the ASCII file that have been obtained are then analyzed using Microsoft Excel software. A statistical analysis of the relationship between the morphometric parameters is carried out, namely the length of the fish ($L$). In this case, the total length ($TL$) is used, and the TS of the fish is carried out to obtain a constant value ($c$) in the long relationship formula. Fish ($L$) and fish target strength ($TS$) specifically for each target fish/sample. The TS formula used the equation [6]:

$$TS = 10 \log(tbs)$$

$$TS = 20 \log L + c$$

Analysis for the fish density from survey data with the equation [6]:

$$TS = SV 10 \log \rho$$

Where:

- $TS$ = Target strength (dB)
- $tbs$ = Back scattering cross section (TS in linear value)
- $c$ = Constant
- $SV$ = Scattering volume (dB)
- $\rho$ = Density
Estimation of fish length values is obtained using the TS equation obtained previously and the coefficient of determination is also computed. The weight value of the fish can be calculated using the length ($L$) and weight ($W$) relationship [7]:

$$W = aL^b$$

(4)

The equation of length and weight [8]:

$$Wt = a \sum n_i \left( \frac{(L_i + \frac{\Delta L}{2})^b - (L_i - \frac{\Delta L}{2})^b}{((b+1)\Delta L)} \right)$$

(5)

Where:
- $Wt$ = Total weight (g)
- $L$ = Length frequency (cm)
- $Li$ = Median value (cm)
- $ni$ = Total individual
- $a$, $b$ = constant

Further calculations after obtaining the TS value, density, estimated length, and weight will calculate the estimated biomass value for the density of fish stocks by calculating the total area of the area that has been surveyed.

$$\text{Stock Density} = \frac{\text{Total length (kg)}}{\text{Total area (ha)}}$$

(6)

In addition to the estimated value of fish stocks based on their size composition, the analysis results are also presented in a density distribution map for each ESDU using QGIS software.

3. Results and discussion

3.1. Relationship length and fish target strength value

The data result from measurement Length, Weight, TS, swim-bladder was presented in Table 1. In calculating the TS value, the results of the correction value of the sphere ball 0.36 dB have been calculated. The relationship between the logarithm of fish length and TS is presented in Figure 5.

| No | Total Length (cm) | Weight (gr) | TS (dB) | Length of Swim-bladder (cm) | n ping | Constant |
|----|-------------------|-------------|---------|-----------------------------|--------|----------|
| 1  | 18.1              | 40.1        | -57.32  | 0.91                        | 1329   | -89.32   |
| 2  | 18.8              | 39.5        | -63.54  | 0.82                        | 843    | -86.64   |
| 3  | 19.7              | 52.9        | -64.94  | 0.84                        | 1014   | -83.34   |
| 4  | 20.5              | 58.2        | -56.33  | 1.01                        | 1615   | -80.54   |
| 5  | 20.8              | 58.1        | -51.44  | 1.16                        | 2491   | -79.51   |
| 6  | 21.5              | 50.8        | -46.44  | 1.01                        | 1654   | -77.18   |
| 7  | 22.0              | 71.6        | -44.02  | 1.06                        | 1952   | -75.56   |
| 8  | 22.7              | 72.5        | -50.82  | 0.71                        | 1457   | -73.35   |
| 9  | 23.3              | 79.4        | -41.77  | 1.04                        | 1840   | -71.51   |
Figure 5. Graph of $TS$ and Log $L$ relationship of Caroun croaker fish ($Johnius$ sp.).

The $TS$-$L$ equation for Caroun croaker with a length range of 18.1-23.3 cm is obtained as follows:

$$TS = 20 \log(L) - 79.66$$ (7)

Variations in $TS$ were detected in the range (-65.30) - (-42.13) dB with a body length of 18.1-23.3 cm. Based on Figure 5, the coefficient of determination ($R^2$) is obtained at 0.667. It means the formation of the $TS$ value is influenced by the length of the fish by 66.7%, while the rest is influenced by other factors not examined in this study. Furthermore, the correlation coefficient ($r$) is 0.81, which means that there is a strong relationship between the body length of the Caroun croaker and the formation of its $TS$ value. Previous $TS$ research for weed fish produced the $TS$ = $20 \log L - 67.35$ equation using an acoustic instrument with a frequency of 70 and 120 kHz [8].

In general, based on the results of observations and measurements for the body length does not entirely affect the formation of the $TS$ value. The swim-bladder contributed 89% of the formation of the backscatter value ($TS$) [9].

3.2. Acoustic survey analysis

Estimation of fish stocks in the Musi River is carried out using surveys or acoustic surveys. Measurements generate $TS$ and $SV$ values. The $SV$ value is generated from the previously determined $TS$ equation. Furthermore, the value of $SV$ is used to calculate fish biomass.

3.2.1. Fish density

Fish density value is the individual density value in volume units ($m^3$). Density values of fish to depth are presented in Figure 6, and a spatial map of density distribution is presented in Figure 7.

Figure 6. Fish density and its relation with depth in the study area.
The density distribution in Figure 6 shows that the density increases in areas that are not too deep, namely at 2-3 meters. Likewise, the spatial map shows where the most significant fish habitat is in more expansive river areas.

Fish density in Figure 7 is obtained in the range 0.1 - 3 ind/m$^3$. This value is smaller compared to the author's previous research [10], which is an average of 20 ind/m$^3$. This occurs due to differences in transect locations and decreased water quality for more than five years.

### 3.2.2. Estimated fish length based on TS values

The value of fish length can be calculated from the TS equation that has been obtained previously for the upstream Musi River presented in the graph in Figure 8.

Based on the graph, the most detected TS value is at a TS value of -62, which is equivalent to a length of 7.6 cm, which means that the Musi estuary waters in December are classified as having a fish size that is not too large.
3.2.3. Fish biomass density

Based on the calculation results, it was found that the total area of the downstream Musi River was surveyed was approximately 1612 ha. Total area is used to determine the fish biomass density. Average fish biomass density is 286 kg/ha. Fish biomass density value is presented in Table 2.

Table 2. Fish biomass density in Musi Estuary.

| TS Value (dB) | -58 | -57 | -56 | -55 | -54 | -53 | -52 | -51 | -50 | -49 | -48 | -47 | -46 | -45 | Total |
|---------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-------|
| Length (cm)   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |       |
| Weight (gr)   |     |     |     |     |     |     |     |     |     |     |     |     |     |     |       |
| Individual Composition (%) |     |     |     |     |     |     |     |     |     |     |     |     |     |     |       |
| Density (kg/ha) |     |     |     |     |     |     |     |     |     |     |     |     |     |     |       |
|               | 12  | 14  | 15  | 17  | 19  | 22  | 24  | 27  | 30  | 34  | 38  | 43  | 48  | 54  |       |
|               | 24  | 31  | 40  | 52  | 67  | 87  | 113 | 146 | 190 | 246 | 320 | 415 | 538 | 699 |       |
|               | 73  | 5   | 6   | 2   | 4   | 3   | 2   | 1   | 1   | 1   | 0   | 1   | 1   | 1   | 100   |
|               | 43  | 11  | 20  | 10  | 21  | 22  | 21  | 9   | 12  | 15  | 0   | 26  | 33  | 43  | 286   |

Figure 8 Estimated fish length from TS value in Musi Estuary.

Fish potential production, namely the potential of water to produce resources calculated using Leger-Huet's method based on the calculation of the macrozoobenthic [11]. The downstream part of Musi River has potential for fish production is 1118 kg/ha [1]. Therefore, the value of stock density produced by the acoustic method is reasonable because it is smaller than its water production potential value. Based on research, the water quality of the downstream Musi River waters is a temperature of 26-29 °C [1]. Temperature is an essential factor in the continuity of biological and chemical processes in water, such as the life and reproduction of aquatic organisms.

Dissolved oxygen levels are still above 2 mg/l, indicating that the waters are still suitable for supporting fish life [1]. The level of dissolved oxygen in waters of at least 2 mg/l is sufficient to support aquatic organisms' lives, typically provided with no toxic compounds in these waters [12].

4. Conclusion

Target strength versus fish length relationship for Caroun croaker fish (*Johnius* sp.) is TS= 20 LOG L-79.66. Fish biomass density is 286 kg/ha, and the fish is vertically distributed at a depth of 2 to 3 m.
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