Comparison between acoustic Target Strength of Yellowfin Tuna (Thunnus albacares) and Longtail Tuna (Thunnus tonggol)

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Abstract. Yellowfin Tuna (Thunnus albacares) and Longtail Tuna (Thunnus tonggol) are among the two commercially important fishes and highly migratory species, subject to be conserved by the convention on the law of the sea in Annex I of the 1982 Convention on the Law of the Sea (FAO, Fisheries Department 1994). Morphologically, T. albacares and T. tonggol have a striking difference, where the former has swim bladder while the latter has not. This paper comparing the result of acoustic target strength (TS) measurement of the two species using SIMRAD EY 60 scientific acoustic instrument. The in-situ measurement was conducted on each species for two different fish length. The fish is tethered using a monofilament string and the distance between the surface of the transducer to fish is ± 4 m. The result showed that the $\overline{TS}$ value of T. albacares1 (51.70 cm) is -40.46 dB and T. albacares2 (29.20 cm) is -43.70 dB, whereas T. tonggol1 (19.4 cm) is -46.53 dB and T. tonggol2 (17.1 cm) is -49.29 dB. Therefore, the presence of swim bladder made a difference on the measured mean $\overline{TS}$ between T. albacares and T. tonggol. While for the length of fish, is not always the case.

1. Introduction

T. albacares and T. tonggol are economically important Scombrid. T. albacares has an expensive price that makes fishermen very happy to catch this fish. Although the price is expensive the fish is still much to love it. This makes T. albacares has a high selling competitiveness [1]. While T. tonggol is a small tuna fish that is not less popular with T. albacares. This fish has a cheaper price compared to T. albacares, because of its smaller size. They are highly migratory species and widely distributed in tropical and subtropical waters around the world. The impact that fish are overfishing in various places. Overfishing is an adverse action for ecological sustainability and harmful to fishermen. Fishermen are losing money because they are depleting their catch. Consequently, fishermen have to sail farther to get more catches, but this also affects the cost that they have to spend to sail further. Therefore, it is necessary to study that fish. Hydroacoustic technology has one of the solutions, the solution is to know the TS (Target Strength) value of the fish. TS value is one of the important parameters to identify the fish density.

According to [2] TS is the ability of the target to reflect the sounds that hit it. Based on the domain used, TS is defined as the logarithm of the output between the intensity of the incoming sound about the target and multiplied by the number ten (10), as the following equation:
\[ TSi = 10 \log \frac{Ir}{Ii} \]  

\[ TSe = 10 \log \frac{Er}{Ei} \]  

where \( TSi \) is an intensity of target strength, \( Ir \) is the sound intensity of the target, \( Ii \) is the intensity of the target's reflected sound. \( TSe \) is the energy of target strength, \( Er \) is the sound energy of the target and \( Ei \) is the reflected energy at a distance of 1 m from the target.

\( T. \text{albacares} \) has a swim bladder, but \( T. \text{tonggol} \) has no swim blader. The swim bladder is an important organ that is squeezed by right and left ribs in the middle banging between the head and tail. Not all fish have swim bladder just like pelagic fish. Acoustically fish can be divided into two categories, with swim bladder fish and fish without swim bladder. Fish with swim bladder have a maximum TS value is not right on the dorsal aspect, while fish without swim bladder has maximum TS value right on the dorsal aspect.

The purpose of this research is to know the TS value of fish with swim bladder (Yellowfin Tuna, \( T. \text{albacares} \)) and without swim bladder (Longtail Tuna, \( T. \text{tonggol} \)) using Simrad EY 60 hydro acoustic instrument in Bagan Apung of Palabuhanratu Bay, Sukabumi, West Java, ID.

2. Method

This research was conducted on August 29, 2016 until September 2, 2016 using the tethered and in-situ method in Bagan Apung, Palabuhanratu Bay, Sukabumi, West Java. Processing of value data is done TS at Marine Acoustic and Instrumentation Laboratory, Department of Marine Science and Technology, Bogor Agricultural University.

The instrument used in this research is Simrad EY 60 hydro acoustic instrument with 38 kHz frequency, sphere ball (Tungsten 38.1 mm) with TS of -42.11 dB, GoPro Hero 4 underwater camera, Canon camera, rope, cold box, fish suture equipment, sewing meter, digital scales, analog scales, and monofilament. The software used to process data are Echoview, StatSoft Statistica 6, MS Office Word 2013 and MS Office Excel 2013. The materials used are Yellowfin Tuna (\( T. \text{albacares} \)) and Longtail Tuna (\( T. \text{tonggol} \)). The fish length is measured in terms of its Fork Length (FL) using the standard ruler. The same also applied for swim bladder (SB), it was measured in length.

TS measurements in the field were conducted using the tethered method. The first thing to do is wrapped-fish around with net using thin monofilament to contain the fish so that easy to handle. Then using the same monofilament, the fish was tethered at the end of the mouth (front), the fish's upper body (top), and the rear. Next put the ballast in the middle (bottom) as a ballast. Lower the target fish slowly so that the fish is not damaged. After reaching a depth of ± 4 meters below sea level, keep the angle of the fish so as not to carry the current by pulling and stretching the rope that has been installed at three points on the target fish before it is lowered. If the target fish angle is stable and visible on the echo sounder monitor, start recording what echosounder reads. The recording process was carried out for 5 to 10 minutes. If the target fish is unstable due to the current, pause the tape and pull the strap until the target fish reenter the main lobe echo sounder. After the recording is enough, stop the recording and raise the target fish back to the chart. Remove the sarong from the target fish. Repeat the process to the next target fish. After all the fish have been recorded, the field data measurement process has been completed.

Data processing is done using echoview software. The setting parameter used were: operating frequency 38.00 kHz, sound speed 1544.24 m/s, draft transducer 1.0 m, sample interval 0.000064 s, transmit power 300.0 W, pulse length 0.256 ms, transducer gain 23.250 dB, absorption coefficient 0.005304 dB/m, Sa correction -0.850 dB. *.raw files obtained using minor-axis beam width 8.680 °, major-axis beam width 8.730 °, two-way beam angle -18.00. The color display used is the color min -70.00 dB, color max -30.00 dB and color range 40.00 dB. Then integrate the cells that have been set, then record the target value on MS Office Excel. The upper and lower ranges was set 1.5 dB, for example, the value of TS -45 dB has a range of -43.5 dB up to -46.5 dB. The standard deviation value
was calculated using MS Office Excel and for normal distribution and mean value was obtained using Statistica software. The mean value of \( \overline{TS} \) obtained were then compare between \( T. albacares \) and \( T. tonggol \).

3. Results

3.1. Yellowfin Tuna (\( T. albacares \))

The normal distribution of \( \overline{TS} \) values \( T. albacares \) is shown in the graph (figure 1). Graphic of normal distribution have bar chart and line chart. The bar chart explained the number of occurrence of data. The line chart showed a picture of the data when it is spreading normally. The appearance of the first fish data more than the second fish, because the first fish was detected longer than the second fish. The first fish is detected longer because the water conditions are not supportive (fast current), consequently the fish is unstable and not in the main lobe.

![Figure 1. Normal distribution display assumption of the \( T. albacares \).](image)

The \( TS \) value of \( T. albacares_1 \) (51.70 cm) (figure 2a) in the range -43.48 dB to -37.52 dB. The \( TS \) value of \( T. albacares_1 \) based on that range is -40.46 dB ± 1.71. The \( T. albacares_2 \) (29.2 cm) (figure 2b) have \( TS \) values between -40.68 dB to -46.43 dB. The \( TS \) value of the \( T. albacares_2 \) is -43.70 dB ± 1.60. This indicates that the larger fish has a longer \( TS \) value.
3.2. Longtail Tuna ($T.\ tonggol$)

The $\overline{TS}$ values of $T.\ tonggol$ shows in the graph (figure 3). The graph be compose of the $\overline{TS}$ values and the frequency of the occurrence of the data. The frequency of occurrence of the data is indicated by the bar chart. The line chart is normal distribution assumption of the $T.\ tonggol$. Line chart is shapes of the Beta Distribution who shows the normal distribution data of TS values. That figure shows frequency of $T.\ tonggol_2$ have larger data be compared frequency of $T.\ tonggol_1$.

![Figure 3. Normal distribution display assumption of the $T.\ tonggol$.](image_url)

The $T.\ tonggol$ $\overline{TS}$ values shows in figure 4a and 4b. Figure 4a is graph of frequency distribution of $T.\ tonggol_1$ and figure 4b is graph of $T.\ tonggol_2$. The graph in figure 4a has a climax bar chart. Figure 4b have two climax bar chart. The two climax bar chart in figure 5b is not good, because the current so fast when measured data and position of fish is unstable. The position of fish are no on-axis and out from main lobe. On-axis is the position of fish to center of beam are at an angle of 180° (straight). On-axis position has a maximal beam, so the result of data is good. On-axis position on the fish with bladderless are precise on the dorsal aspect.

The $T.\ tonggol$ have a range of TS values between -52.45 dB to -43.77 dB. In the range, $\overline{TS}$ value of $T.\ tonggol_1$ is $-46.57$ dB ± 1.56 and $\overline{TS}$ value of $T.\ tonggol_2$ is $-49.29$ dB ± 1.78. The results indicate that the length of the fish affects the TS value.

![Figure 4. TS-frequency data distribution of $T.\ tonggol$.](image_url)
3.3. Relations of the TS and Fork Length

Data of *T. albacares* and *T. tonggol* shows in table 1. The data plotted at 3rd quadrant. This data is result of measurement in the field and data processing. The relationship graph for TS values and Fork Length (figure 5), TS values in x axis and Fork Length in y axis. First *T. albacares* point at 51.70 cm, -40.46 dB. Second *T. albacares* point at 29.20 cm, -46.70 dB. The two points are connected to the linear line. The *T. albacares* line named α1. Then, First *T. tonggol* point at 19.40 cm, -46.53 dB. Second *T. tonggol* point at 17.10 cm, -49.29 dB. The first and second points of *T. tonggol* are connected to the linear line. The *T. tonggol* line named α2. The lines of *T. albacares* and *T. tonggol* are drawn lines to intersect. The intersection of the two lines is the equilibrium point. The equilibrium of TS values is 20.80 cm, -44.93 dB. Estimated at 20.80 cm fork length, both fish species have the same TS value, as an ecological strategy. Ecological strategy is the ability of the fish to cluster.

|                      | FL (cm) | SB (cm) | TS min (dB) | TS max (dB) | TS (mean) (dB) | Stdev |
|----------------------|---------|---------|-------------|-------------|----------------|-------|
| *T. albacares* 1     | 51.70   | 8.40    | -43.48      | -37.52      | -40.46 ± 1.70  |       |
| *T. albacares* 2     | 29.20   | 4.00    | -46.43      | -40.68      | -43.70 ± 1.60  |       |
| *T. tonggol* 1       | 19.40   | -       | -49.11      | -37.77      | -46.57 ± 1.56  |       |
| *T. tonggol* 2       | 17.10   | -       | -52.45      | -46.43      | -49.29 ± 1.78  |       |

Note: FL = Fork Length, SB = Swim Bladder, TS = Target Strength, Stdev = Standard Deviation

4. Discussion

Figure 4 shows the difference in TS values occurring between two *T. albacares* due to FL differences and the presence of swim bladder. TS values in fish with swim bladder were greater than TS values without swim bladder [2]. The larger the size of the fish, the greater the value of TS obtained. In accordance with the research [3] obtained data indicating that the longer the size of fish TS value obtained greater. This shows that the size of the fish and the value of TS are directly proportional. The presence of swim bladder in the target fish (Yellowfin Tuna) seems to affect the sensitivity to the TS value. In the study, [4] obtained the results that the value of TS fish with swim bladder is greater than fish without swim bladder (Catfish).

Swim bladder serves as a regulator of hydrodynamics, to regulate the pressure generated by the surrounding waters. However, it also serves as a reflector and a resonator of the incoming sound waves. The swim bladder, which contained gas/membrane and meat around it, creates a strong contrast or high impedance that play important factor in the reflection of the incoming sound. It almost incompressible liquid. Gas is easier to move than liquid. If there is no central organ, external pressure waves will reflect back into the air, following the smallest path of resistance. In other words, the incoming sound energy will be reflected back from the rigid membrane at the entrance of the internal organ. The function of the swim bladder is the floating organ regulates the gas circulation, the balance regulator when swimming vertically, oscillating organ, and as a reflector of hydroacoustic force [5], [6], [7], [8]. The working mechanism of swim bladder applies the Law of Newton II, the Law of Archimedes and the Law of Bernoulli simultaneously [8, 9, 10]. The action given due to contraction/relaxation of the swim bladder membrane causes a floating/drowning reaction with a distance certain (vertical), proportional to the increasing/decreasing air volume (Newton and Archimedes Laws synergies) [8].

For *T. tonggol* which does not have swim bladder make target fish is not too sensitive to TS value. According to [11], the main factors affecting the value and characteristics of the target strength of fish are the frequency of sound used, the shape and length of the fish body, the fish body structure and the
physical parameters and the orientation and behavior of the fish. This factor is a general trend. According to [12] that for a particular fish species (with a particular anatomy) and wavelength (frequency) there is a close relationship between the target strength (equivalent cross section) and the size of the fish; larger fish have greater target strength.

5. Conclusion
In situ TS measurement for Yellowfin Tuna (T. albacares) and Longtail Tuna (T. tonggol) has been conducted with different FL. The presence of swim bladder made a difference on the measured mean $\overline{TS}$ between T. Albacares and T. Tonggol. While for the length of fish, is not always the case.

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