Measurement and analysis of TS-Frequency relationship on mackerel tuna (Euthynnus affinis) using bandwidth frequency

by Fauziyah Fauziyah

Measurement and analysis of TS-Frequency relationship on mackerel tuna (*Euthynnus affinis*) using bandwidth frequency

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Abstract. Mackerel tuna (*Euthynnus affinis*) is a pelagic fish from Scombridae family and one of the commercially important species. The fish is mostly found in the water column from the surface down to about 50 m. Mackerel tuna spread widely in the tropical and subtropical waters, including the Indian Ocean, Pacific, Mediterranean Sea, and Black Sea. Since the level of exploitation of this fish resource is relatively high, it is critical to have an accurate assessment on the status of the stock. In this paper we report and discuss the measurement results of the acoustic target strength (TS) of Mackerel tuna using acoustic broadband technique. A broadband technique was used to better characterized the basic TS-Frequency relationship of the target, and hence less bias in biomass estimation. Target Strength measurement was performed using SIMRAD EK-80 scientific acoustic instrument with frequency bandwidth 160-240 kHz and sound pulse was transmitted to the target with 1 CW pulse and 8 FM pulse. The fish was tethered and positioned directly below the acoustic transducer. The results of the measurements are presented in terms of TS-Frequency. It is found that the TS-F relationship fluctuates, where the highest TS value -54.64 ± 4.64 dB is in 190-200 kHz frequency interval.

1. Introduction

Mackerel tuna (*Euthynnus affinis*) is a pelagic fish from Scombridae family and one of the commercially important species which is not only favored by Indonesia's people but also several Asian countries [1, 2]. The fish is mostly found in the water column from the surface down to about 50 m and often caught using a purse seine fishing gear. The spread of mackerel tuna includes tropical and subtropical waters, including the Pacific, Indian, and Atlantic Oceans, the Mediterranean Sea and Black Sea [3]. Mackerel tuna is classified as epipelagic and as a predator that is able to live in water temperatures ranging from 18-29 ^{o}C at a young age the distribution is much in the bay waters to near the port and can live in groups with other species in large numbers and the adult size of this mackerel tuna is 33.1-65.2 cm [4] and the first size of gonads is 39.8 cm with a range of 40-65 cm [5].

One of Republic of Indonesia's Fisheries Management Areas (WPPNRI) in the Indian Ocean waters, is WPPNRI 573 with large pelagic potential reaching 505.941 ton/year [6]. Based on data reported by Nusantara Fisheries Port (PPN) in Palabuhanratu Bay (2016) the types of neritic tuna landed are bullet tuna (*Auxis rochei*), longtail tuna (*Thunnus tonggol*), frigate mackerel (*Auxis thazard*), and mackerel tuna (*Euthynnus affinis*). Mackerel tuna has a high vulnerability because most of those caught are juvenile, which is about 78% [7]. Male mackerel tuna first length of maturity is at size 45.6 cm and female mackerel tuna at a size 43.5 cm [8].

Hydroacoustic technology has been used in Indonesia to assess fish stock [9, 10]. In this paper we employed an acoustic broadband, which capable of measuring acoustic backscattering of an object (fish) in several frequency continuously and produce an acoustic spectrum. Broadband systems have several advantages, namely target size discrimination and more stable signal [11]. Furthermore, broadband signals are not only to distinguish between fish and other marine organisms, but also to identify the size and density of fish detected [12].

It is expected that this paper on the relationship between TS and frequency can be used as an initial reference for further research to improve fish stock assessment.

2. Methods

This research is part of the join research activities carried out by the Division of Acoustics and Marine Instrumentation of the Department of Marine Science and Technology with the Marine Fisheries Research Institute (BPPL) held on September 14-17, 2017 in the floating chart of BPPL in Palabuhanratu bay, Sukabumi, West Java. Data analysis carried out from October to June 2018 at MARITEK Laboratory of Acoustics and Marine Instrumentation Department of Marine Science and Technology FPIK IPB.

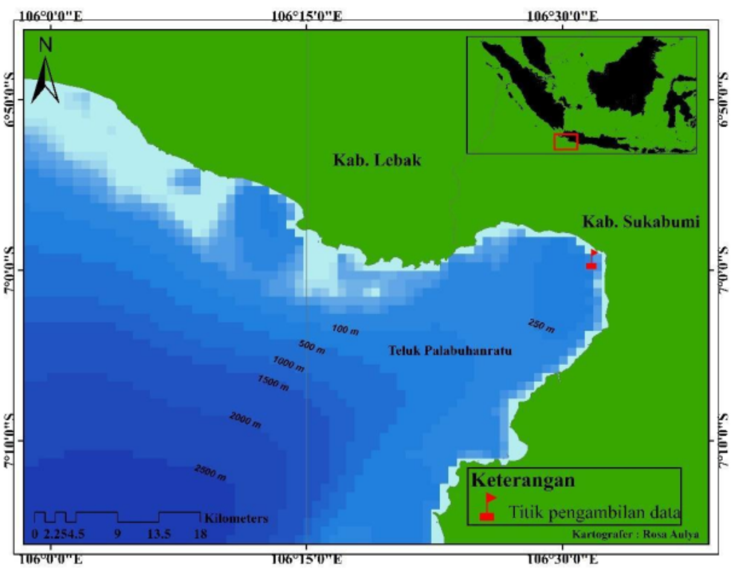

Figure 1. Map of study sites

The fish used in this study is mackerel tuna (*Euthynnus affinis*), with fork length 26 cm and 274.6 grams in weight, Echoview 7.1 software, Microsoft office (Ms. Word and Ms. Excel), Minitab 16 software are used to process the measured TS data.

2.1. *Acoustic Data Collection Method*

This research was conducted in situ, directly using fish cages tethered to a floating platform (Figure 2) to determine the value of TS fish. The dimension of a floating platform is 8.50 m by 8.50 m and with height of 2.50 m. The setting parameters of acoustic instrument is provided in Table 1. The calibration was carried out first using a standard tungsten ball (WC) with a diameter of 38.1 mm [13] before taking measurements. Tethered method was used, where the fish was tied using a monofilament rope and placed perpendicular to the weighted transducer, to collect the TS data.

Table 1. Setting parameters SIMRAD EK-80 Scientific Echosounder

Parameters	Value
Temperature (°C)	29.3
Salinity (psu)	32.7
Sound Speed (m/s)	1542
Near Field (m)	1.867

In this study the depth of the transducer was placed at 0.2 m from the surface of the water, so that the fish was positioned at a depth of 2-4 m from the transducer and the weight was at a depth of 1 m below the fish. The fish is attached with a monofilament rope that has been knotted according to the size of the fish and then tied to the dorsal, also the tip of the mouth and the tail so that it stays in a horizontal position.

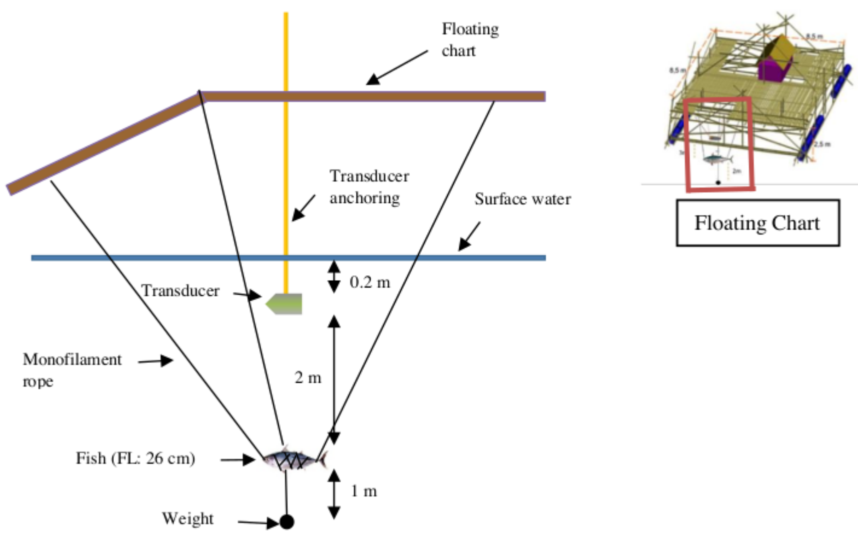

Figure 2. Data retrieval scheme on the floating platform

2.2. *Acoustic Data Processing*

The flowchart of acoustic data processing is presented in Figure 3. To obtain the average value of TS, the following equation [14] was used.

$$TS = 10\log ts\ ;\ ts = 10^{\frac{TS}{10}}\ ;\ \overline{ts} = \sum \frac{ts}{n}\ ;\ \overline{TS} = 10\log \overline{ts}$$

Notes:
TS : *Target strength* (dB)
ts : *Target strength* linear
$\overline{ts}$: *Target strength* average linear
$\overline{TS}$: *Target strength* average (dB)
n : amount of data

Data distribution of the appearance of TS values obtained from echograms is save in Microsoft Excel on different sheets for easy processing. After that the data is sorted from the smallest to the largest. FM pulse analysis is done by transferring data from Microsoft Excel to Minitab 16. Analysis of FM pulses and CW pulses is carried out with a frequency of 190-200 kHz (FM), a frequency of 200 kHz (CW), and a frequency of 200-240 kHz (FM). Then the three frequencies are displayed using a 3D-line graph, the ranges TS value on the x axis and the frequency of the band on the y axis. The average TS value in FM pulses (160-240 kHz) and CW pulse (200 kHz) are displayed using scatter graph, the average TS value on the x axis and the frequency of the band on the y axis.

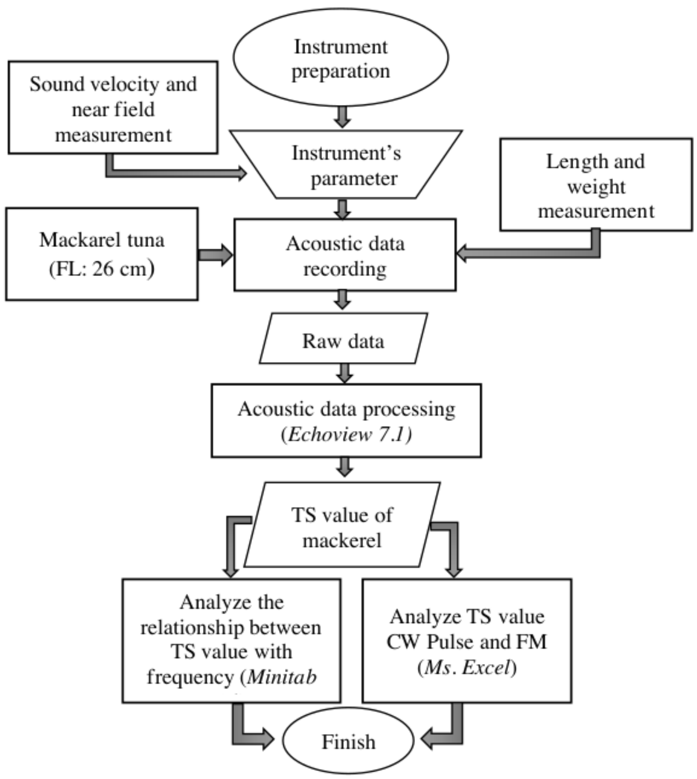

Figure 3. Flowchart data collection and processing

3. Result and Discussion

3.1. Distribution of TS Value

The distribution of the target strength (TS) value of mackerel tuna (*Euthynnus affinis*) at frequency of 160-240 kHz is presented in the form of a bar diagram, which shows the number of occurrences of data and the normal model distribution of data is overlay on top of bar diagram (Figure 4).

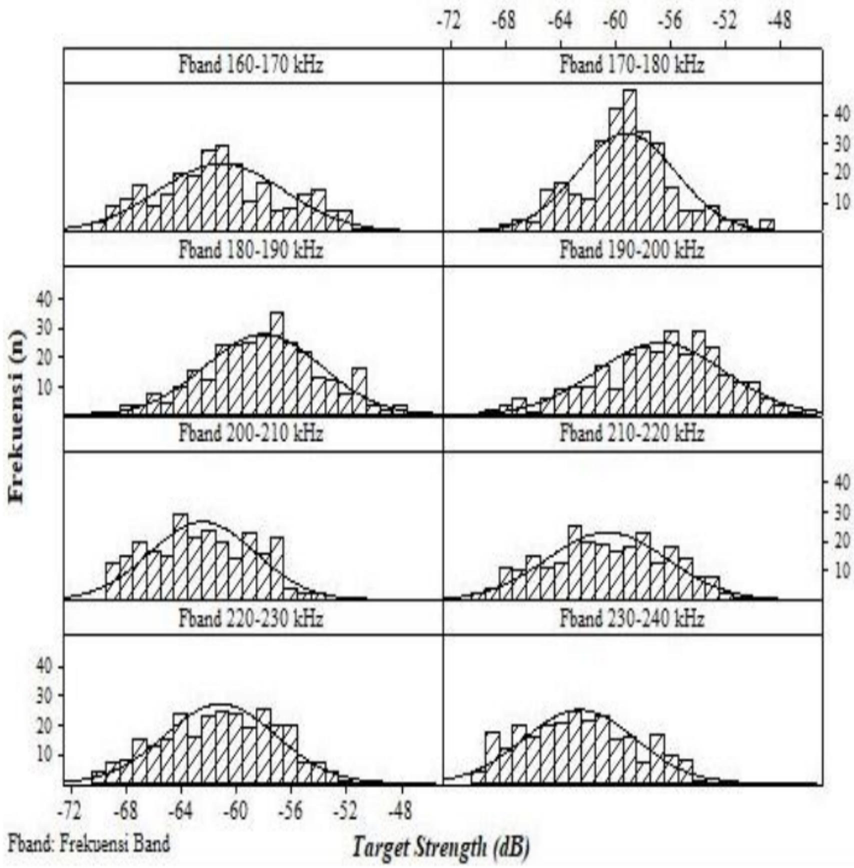

Figure 4. Distribution of TS value in the frequency band 160-240 kHz with 10 kHz interval and normal distribution model

3.2. Analysis of Target Strength-Frequency on FM Pulses

The broadband system allows acoustic backscattering to be measured continuously over a frequency range and more information is obtained so that it can be used for target spectral characterization [15]. The distribution of average backscattering at each frequency interval is shown in Table 2.

Table 2. Average TS value (dB) of Mackerel tuna

F band (kHz)	Average TS (dB)	Std	Amount of TS
160-170	-58.68	±4.58	265
170-180	-57.64	±3.57	300
180-190	-56.05	±4.21	294
190-200	-54.64	±4.64	289
200-210	-60.71	±3.86	258
210-220	-58.60	±4.36	253
220-230	-59.39	±4.05	278
230-240	-60.77	±4.04	257

The average TS value of mackerel tuna with the highest value is found in the 190-200 kHz frequency band, that is -54.64 dB ±4.64 and the lowest average TS value of mackerel tuna is found in the band frequency of 230-240 kHz which is -60.77 dB ±4.04. The average TS value can be converted to the average length of fish. The strength of the target strength of tuna fish also depends on the length of the fish and the swim bladder.

3.3. Analysis of Target Strengths on CW and FM Pulses

SIMRAD EK-80 can be configured to emit FM pulses, CW pulses, or a combination of these two pulses. At CW pulses the effective pulse duration is the total energy in sending pulses depending on maximum strength. On FM pulses, the total energy in the delivery of the autocorrelation signal depends on the maximum strength of the signal transmission [16]. The distribution of occurrence of interval values of TS pulses CW and FM is shown in Figure 5. CW pulses are transmitted at a band frequency of 200 kHz while FM pulses are transmitted at a band frequency of 160-240 kHz with an interval of 10 kHz, and the example taken is the band frequency from 190 to 200 kHz and 200-210 kHz.

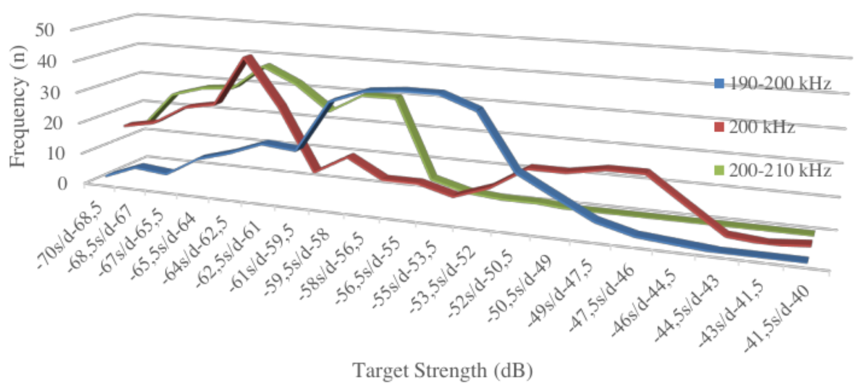

Figure 5. Distribution of the TS value in CW and FM pulses

The highest frequency distribution of TS is in the band frequency of 190-200 kHz (FM) which is -56.5 to -53.5 dB and the lowest is in the band frequency of 200 kHz (CW) which is -64 to -62.5 dB. FM pulses are able to identify objects better [16]. Frequencies of 18, 38, 70, 120, and 200 kHz commonly used in fisheries acoustic surveys [17, 14], but the frequency of 38 and 200 kHz is usually used to detect fish that have swim bladder.

The distribution of the average TS value on CW pulses and FM pulses (Figure 6) shows that the average values in the band frequency of 160-240 kHz are -57.82 dB ±4.60. At 200 kHz band frequency is -52.64 dB ±7.54.

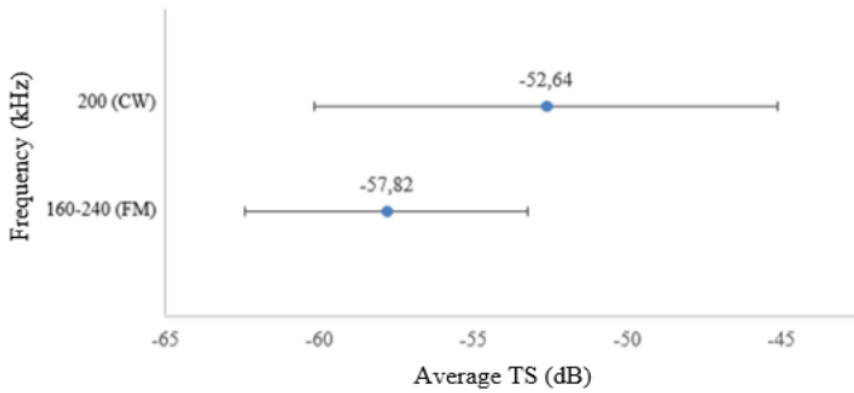

Figure 6. Average TS value of mackerel tuna on FM and CW pulses

The average TS value on the FM pulse band frequency of 160-240 kHz has 5.18 dB lower than the frequency band frequency of 200 kHz CW. The CW pulse measures only one frequency, whereas the FM pulse measures the band frequency range 160-240 kHz. CW pulses have a narrower band than FM pulses [18], and CW pulses have a high-quality factor (Q) or a ratio of the bandwidth to half the power of the middle frequency (f_c), compare to FM pulses which has a lower quality factor (Q).

4. Conclusion

The average TS value in the range of 160-240 kHz frequency is found to be fluctuated, where the highest average TS value is obtained at the frequency interval of 190-200 kHz (-54.64 dB ±4.46 dB) and the lowest averages value at the frequency interval of 230-240 kHz (-60.77 dB ±4.04 dB). The range of TS values on CW pulses varies and has a high standard deviation value, whereas the FM pulses has relatively small variation.

References

[1] Hafiludin H 2011 *J. Kel. 4* 1-10.
[2] Hapsari T D, 2014. *AQUASAINS J. Ilm. Per. Sum. Perair*. 131-138.
[3] Collete B B and Nauen C E 1983 *FAO Species Catalogue* 2 (Rome: FAO) pp 27-37.
[4] Widodo A A, Satria F and Sadiyah L 2014 *J.l Kebija. Perikan. Indo*. **6** 23-28
[5] Fishbase 2018 *Ikan Tongkol Komo (Euthynnus affinis)* Available on: http://fishbase.org
[6] Ma'mun A, Priatna A, Hidayat T and Nurulludin N 2017 *J. Pen. Per. Indo*. **23** p-ISSN: 0853-5884 e-ISSN: 2502-6542.
[7] Suryaman E 2017. Pengelolaan perikanan tuna neritik dengan pendekatan ekosistem (Studi kasus: Perairan teluk palabuhanratu, kabupaten sukabumi, jawa barat) [skripsi]. Bogor (ID): Institut Pertanian Bogor.
[8] Masuswo R and Widodo A A 2016 *BAWAL* **8** 57-63
[9] Ma'mun A, Manik H M and Hestirianoto T 2013 *J. Tek. Per. Kel.* **4** 173-83
[10] Kurnia M, Sudirman and Nelwan A 2016 *J. Per. Un. Gadjah Mada* **18** 7-13
[11] Simpson P K and Denny G F 2001 *A comparison of broadband and narrowband fisheries sonar systems. Report No.: SFS-01-01* (National Science Foundation awar Nr. 9961318).
[12] Lee W, Lavery A C and Stanton T K 2012 *The J. of Ac. Soc. of America* **131** 4461-75
[13] Stanton T K and Chu D 2008 . *J. Acoust. Soc. Am.* **124** 128-36.
[14] Simmonds E J and MacLennan D N 2005 *Fisheries acoustic: theory and practice 2nd Edition* (Oxford, UK: Blackwell Science) p 437

[15] Lavery A C, Bassert C, Lawson G L and Jach J M 2017 *ICES J. Marsci.* **74** 2262-75
[16] Demer D A, Andersen L N, Bassett C, Berger L, Chu D, Condiotty J, Cutter Jr G R, Hutton B, Korneliussen R, Le Bouffant N et al. 2017 *ICES Cooperative Research Report* No. 336 (Denmark: International Council for the Exploration of the Sea) p 69
[17] Korneliussen R J, Heggeland Y, Macaulay G J, Patel D, Johnsen Eand Eliassen I K 2016 *ELSEVIER* **17** 187-205
[18] Demer D A, Berger L, Bernasconi M, Bethke E, Bosell K, Chu D, Domokos R, et al. 2015 *ICES Cooperative Reasearch Report. No. 326* (Denmark: International Council for the Exploration of the Sea) p 130.

Note:

This paper is worth publishing with minor revision

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