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Distribution of Fish Target Strength in Malang Rapat Seawater of Bintan Island, Kepulauan Riau Province

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Abstract

Malang Rapat is an area located in east Bintan Island. As a part of coastal communities, fisheries were the primary sector for public revenue in Malang Rapat. A qualified method is needed to determine the abundance and distribution of fish were required. Hydroacoustic technology is one method to solve this problem. This research aimed was to determine the value of fish target strength and to determine the pattern of fish distribution behavior in Malang Rapat, Kepulauan Riau Province, on September 23 and 24, 2016, using scientific echosounder Simrad EK15. The result indicated that fish target strength in Malang Rapat was -60 dB to -42 dB. This value was useful to estimate the length of fish ranged from 3 cm to 31 cm. The highest mean target strength based on depth was -48 dB at 10 m in the daytime and -52 dB at 3 m in the nighttime. The abundance of fish was found at night, precisely 3 meters from the surface of the water. The highest frequency appearance target strength range from -60 dB to -58 dB with 3.94 to 4.95 cm estimated fish length.

Keywords: Echosounder, Fish, Malang Rapat, Target Strength

1. Introduction

Malang Rapat is located part of the marine area of Bintan Island in the eastern part. This area is included in the Fisheries Management Area of the Republic of Indonesia (WPP RI) 711. These waters are also marine tourism spots for both local residents and areas outside of Bintan Island. The fisheries sector is the main livelihood for most Bintan coastal communities, where in 2016, there were 11669 fisheries households with fisheries production volume reaching 50022.21 tons (BPS Kabupaten Bintan, 2017). The size of the population who live in the field of capture fisheries requires accurate information for availability (stock), the characteristics of fisheries, and the distribution of fish resources so that further studies are needed in the fisheries sector using the hydroacoustic method.

Hydroacoustic generally learns about sound waves, and sound propagation in a water medium then receives and analyzes the characteristics of sound reflections that hit a target. When compared with other methods, the advantages of the hydroacoustic method for estimating fish abundance and distribution include the speed of information on fish abundance with a wide range of distances (Fauziyah *et al.*, 2010). High accuracy and accuracy compared to conventional methods, minimizing errors and deficiencies from fisheries statistical data because it can be done in real-time, in situ, and obtained data in the form of size, habitat, and fish stocks accurately (Manik, 2014).

Hydroacoustic instrument used in this study is Simrad EK15 because it can maintain and apply the single beam character to determine the distribution of fish from the water. Single beam Simrad EK15 only operates at a frequency of 200 kHz (Linlokken *et al.*, 2019). Quantitative echosounder development using Simrad EK15 can be used to measure the value of fish backscattering (Target Strength). Fish target strength is determined from the angle of acoustic wave arrival, fish length, and sonar frequency. Target strength information is useful for measuring fish stocks in waters. The target strength will increase as the object length increases (Manik *et al.*, 2017). The target strength value is also influenced by swimming bubbles, fish behavior, acoustic impedance, wavelength, beam pattern, species and swimming speed (MacLennan and Menz A, 1996).

Information on the abundance and distribution of fish, both spatially and temporally, is one thing that is needed by the community. Pelagic fish generally swim in large groups so that the existing information is able to provide accurate information on the location of abundant fish resources. Quantitative information about fish targets, such as the number of fish per unit volume, is an important requirement to know the value of target strength as a signal characteristic of fish targets (Simmonds and MacLennan, 2005). Therefore the purpose of this study is to determine the target strength value of pelagic fish and determine the pattern of fish distribution behavior in the waters of Malang Rapat in Kepulauan Riau Province.

2. Research Methods

2.1 Time and Location

The acoustic survey was conducted on 23 and 24 September 2016 in Malang Rapat Waters. Bintan Island waters in Kepulauan Riau Province at the coordinates of 1°2'58 "- 1°10'55" N and 104°36'57" - 104°40'30" E. The location of acoustic survey can be seen on the following map (Figure 1).

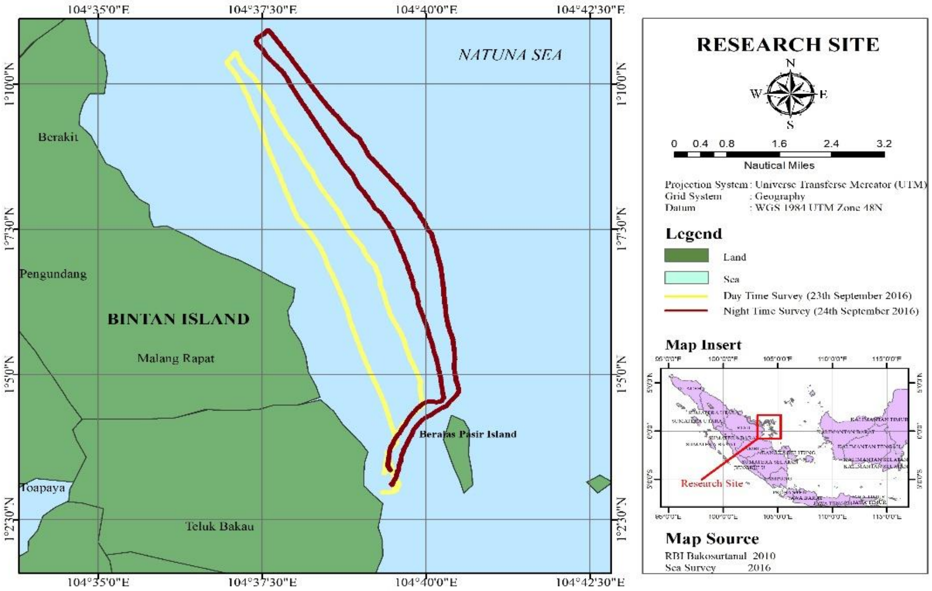

Fig. 1. Research Location

2.2 Data Collection

The calibration of the Simrad EK15 instrument was carried out before starting the hydroacoustic research, using a sphere measuring 38.01 mm, which is an isotropic reflector (Figure 2).

Fig. 2. Sphere Ball

Before conducting hydroacoustic research, the calibration of the Simrad EK15 instrument was first performed using an isotropic reflector sphere ball, which means being able to reflect an echo acoustic backscatter of the same size from all directions of the sphere ball. Sphere ball measuring 38.01 mm is placed in the water column then measured using echosounder for 3 minutes in a state of the still ball (Figure 3).

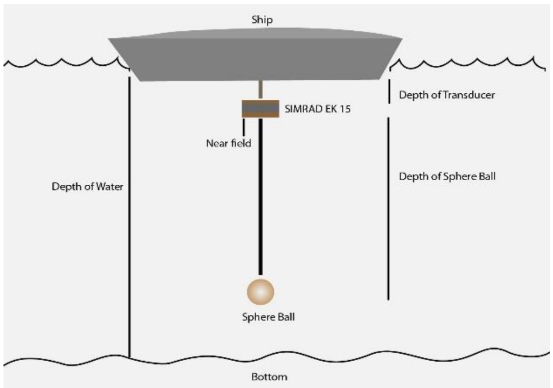

Fig. 3. Image Illustration to Callibration

After that, tracking can begin. This is done so that the parameters and specifications of the tools used are appropriate. Simrad EK15 echosounder is installed in the hull of the ship right in the water column with a depth of 80 cm from the surface. The ship used type 6 GT (Gross Tone) with a speed of 3 to 4 knots. The Simrad EK 15 transducer is set using a ping rate of 10 ping/s, a maximum pulse duration of 1.24 ms, and a pulse length of 0.128 ms capable of transmitting single beam verticles (Manik, 2015). The recording principle is that the transducer emits sound waves in the form of echo, then through the transmitter transducer, the echo propagates in the water medium and then will be reflected back when the echo hits a target which is then received by the transducer receiver (MacLennan and Simmonds, 1992).

2.3 Processing and Data Analysis

Acoustic data retrieval uses a horizontal alongshore tracking survey system (Figure 1). The form of tracking is carried out in accordance with the objectives of the study as a preliminary study covering the entire waters of Malang Rapat spatially and temporally. The process of recording data using the Simrad EK15 echosounder is activated during the process of sailing ships based on predetermined survey paths.

Simrad EK15 echosounder is installed in the hull and is under the water column 80 cm from the surface. The ship used type 6 GT (Gross Tone) with a speed of 3-4 knots because it has an easier cruising range to do research in coastal areas which are shallow waters. The Simrad EK 15 transducer is set using a ping rate of 10 ping/s, a maximum pulse duration of 1.24 ms, and a pulse length of 0.128 ms capable of transmitting single beam verticles (Manik, 2015). The recording principle is that the transducer emits sound waves in the form of an echo using a time reference/time base to activate an electrical pulse with a certain frequency and time that triggers the transmitter to transmit electrical signals to the transducer (MacLennan and Simmonds, 1992). Transducers are used to convert electrical signals into acoustic sound waves. The echo propagating in a water medium will then be reflected back when echo hits a target and is received by the receiver and this weakened signal will be amplified using an amplifier.

2.4 Data Analysis

Environmental parameters greatly affect the speed of sound for propagation in the water column. The speed of sound is influenced by temperature, salinity, and depth (Helber *et al.*, 2010). Sound velocity information is used to determine the wavelength of water. Equation 1 is a sound velocity formula based on Del Grosso (1974)'s theory for 0 <T ° C <32 and 22 <ppt salinity <45 depth less than 1000 m. In this formula, T is the temperature (° C), S is salinity (‰), and z is depth (m).

$$c = 1449.2 + 4.6T - 0.055T^2 + 0.00029T^3 + (1.34 - 0.01T)(S - 35) + 0.016z \quad (1)$$

The measurement of the nearfield distance is done when calibrating the instrument using a sphere ball. Nearfield is a zone of unstable fluctuations emitted by transducers, so this zone is not ideal for hydroacoustic analysis (Simmonds and MacLennan, 2005). Equation 2 is used to determine the wavelength for information looking for nearfield values in equation 3.

$$\lambda = \frac{c}{f} \quad (2)$$

$$r = \frac{L^2}{\lambda} \quad (3)$$

Target Strength is the logarithmic value of the size of the energy reflected (Ir) by the target after the energy has hit it (Ii) in Equation 4 (Simmond and MacLennan, 2005).

$$TS = 10 \log \frac{I_r}{I_i} \quad (4)$$

The Target Strength (TS) value from equation 4 is used as a reference for estimating fish length (L) through equation 5 (Foote, 1987).

$$TS = 10 \log(L) - 71{,}9 \quad (5)$$

The threshold used in this study is -60 dB to -42 dB using Sv/ts scaling analysis. Sv/ts scaling is a method for estimating the density or density of a target (Manik and Nurkomala, 2016). This is because the backscatter value below -60 dB is the threshold for the plankton group (Simmonds and MacLennan 2005). The threshold is a threshold value for finding the optimal value according to the desired target (Parker-Setter *et al.,* 2009).

Data processing starts at a depth of 1 meter from the surface layer because, based on Equation (3), the nearfield value of Simrad EK15 is 0.34 meters. Source Level range as sound pressure at a distance of 1 meter from the transducer (Simmonds and MacLennan, 2005). Limitation of 1 meter from the bottom to avoid the influence of the backwater substrate scattering value.

3. Result and Discussion

3.1 Target Strength of Fish

The acoustic data acquisition results are visualized using an echogram display. Echograms provide information on the horizontal axis, the acoustic recording sequence based on the ping number, on the vertical axis, the depth of the results of the hydroacoustic acquisition, and scale bar for the size of the acoustic backscreens based on the echogram color. Target positions are marked with a red circle.

Condition of Malang Rapat sea based on the echogram in Figure 2 shows the top layer near surface layer is suspected to be nearfield area, the bottom layer is colored red and bottom is assumed to be the bottom of the water, and the yellow line is 1 meter threshold for surface and bottom layers. Fish target is at a depth of around 9 meters from the surface of the water. The mean Target Strength value on the red circle is -52 dB.

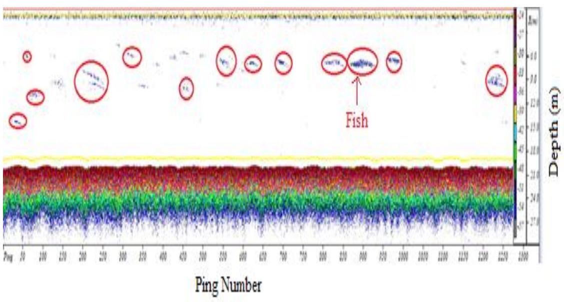

Fig. 2. Echogram in daytime

The results of acoustic acquisitions at night are visualized based on Figure 3. At night it is seen that in the target water column are scattered individually. The water column gives a mean Target Strength value of -55 dB. This indicates that the upper layer is dominated by small fish.

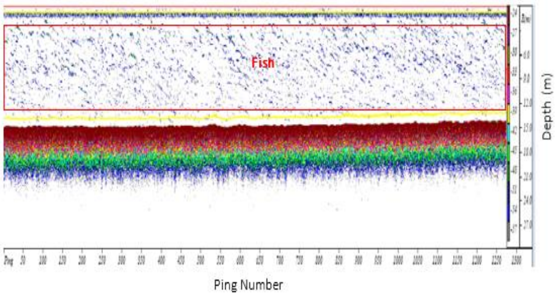

Fig. 3. Echogram in nighttime

The results of echograms at night showed more fish distribution compared with the daytime. Schooling of fish is formed at sunrise and spreads at sunset (Brehmer *et al.,* 2007). The existence of zooplankton is very high at night compared to daytime (Kaltenberg and Bird, 2009). This invites anchovy as consumers to rise to the surface to find zooplankton. Besides that, another important reason why fish do not do schooling at night is a form of fish adaptation that allows them to reduce or avoid the pressure of night predators based on their prey choice on non-visual cues, such as lateral lines and smell (Pavlov and Kasumyan, 1990).

3.2 Percentage of Target Strength

The percentage composition of the frequency of occurrence of the Target Strength value in Figure 5 uses the percentage of frequencies for each total occurrence during the day and night. The range of -60 to -58 dB gives the highest percentage of frequency of occurrence both in the day and night. During the day, the frequency of occurrence is dominated in the range of -60 to -54 dB and -46 to -44 dB while at night, the range is -54 to -46 dB and -44 to -42 dB.

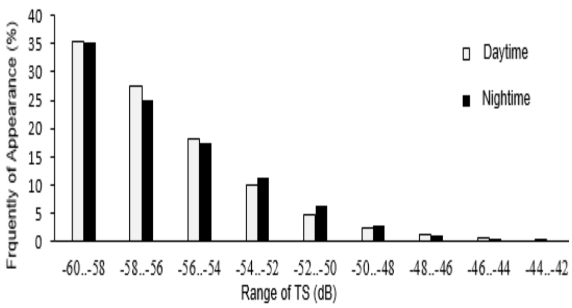

Fig. 4. Graphic percentage of the frequency of occurrence of TS

The percentage graph of the frequency of occurrence of the Target Strength range shows that the Target Strength range during the day is narrower than at night. This is presumably due to the daily vertical migration carried out by pelagic fish from the lower layer to the upper layer to find or fulfill their physiological needs (Wudianto *et al.,* 2005).

3.3 Estimated Fish Length

Estimating the length of the object based on the value of the Target Strength using Equation (5). Fish that are in Malang Rapat waters are thought to have a type of open swimming bubble or physostome. In Table 1, the results of the Target Strength (TS) values can be used to estimate the length of the fish.

Table 1. Estimated fish length against Target Strength

TS (dB)	Estimated Fish Length (cm) TS=20Log(L)-71,90	Frequently Occurance of TS (Daytime)	Frequently Occurance of TS (Nighttime)
-60 to -58	3,94 to 4,95	144.116	291.888
-58 to -56	4,95 to 6,24	111.775	207.154
-56 to -54	6,24 to 7,85	73.543	144.382
-54 to -52	7,85 to 9,89	40.260	93.931
-52 to -50	9,89 to 12,45	19.532	52.873
-50 to -48	12,45 to 15,67	9.537	24.127
-48 to -46	15,67 to 19,72	4.907	9.953
-46 to -44	19,72 to 24,83	2.843	3.406
-44 to -42	24,83 to 31,26	1.616	1.294

The highest frequency of occurrence of target strength values based on Table 1 is -60 to -58 dB occurring at night, with estimated fish length measurements ranging from 3.94 to 4.95 cm. Malang Rapat waters have a typical fish that is usually obtained by fishermen, namely the bilis or the common name of anchovy (*Stolephorus* sp.). Bilis are fish that have a size of 3 to 11 cm. In addition to bilis there are pelagic fish that are predominantly in Bintan Regency, namely selar fish (*Atule mate*) measuring 17 to 30 cm (Zahra *et al.,* 2019). Research Arkham *et al.,* (2015) in the seagrass ecosystem of Malang Rapat waters there are mackerel (*Rastrelliger kanagurta*) measuring 15 to 20 cm, tamban fish (*Clupea fimbriata*) and lambai fish (*Siganus doliatus*) measuring 15 to 25 cm, bruised fish (*Siganus guttatus*) measuring 20 to 35 cm.

The prior studies before this research has been done is 13% increase in the number of fish detected during the night owing to an increase in the detection of small fish compared with large fish that are detected less often (Goulon *et al*., 2018).

3.4 Mean Target Strength for Depth

The graph of changes in the mean Target Strength value to depth can be seen in Figure 6. The graph value during the day shows the variation in the mean Target Strength value as the water depth increases. At a depth of 10 m, the highest value is -48 dB. Whereas at night, the mean Target Strength value does not change significantly as water depth increases. The highest value is at a depth of 3 m, which is -52 dB.

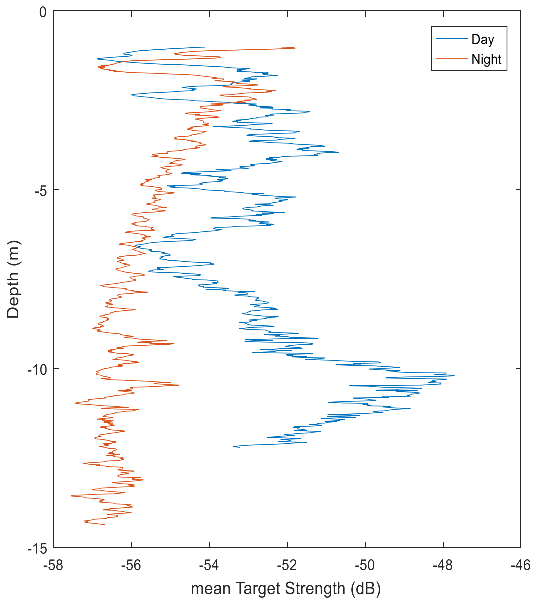

Fig. 5. Graphic of mean target strength for depth

The mean Target Strength value decreases with increasing depth, this shows the distribution of fish more near the surface of the water, as well as proving the intensity of light is very influential on the distribution of fish. During the day, there are fluctuations in the mean Target Strength value as the depth increases. This behavior is suspected because fish near the surface of the water are planktivorous, ie, organisms that eat phytoplankton and zooplankton (Ward *et al.*, 2008). Vertical zooplankton migration is highly dependent on changes in the environment, light intensity, and the presence of predators (Brierley, 2014). This affects fish distribution and causes fish distribution fluctuations.

4. Conclusion

Distribution of Target Strength value of fish in Malang Rapat sea of the Kepulauan Riau province is -60 dB to -42 dB. This shows the distribution of various fish sizes ranging from 3 cm to 31 cm. The highest Mean Target Strength during the day is -48 dB at a depth of 10 m while at night it is -52 dB at a depth of 3 m. Fish behavior patterns in Malang Rapat sea shows that fish are found at night at a depth of 3 meters from the surface of the water with frequencies appearing in the range of -60 dB to -58 dB with an estimated fish length of 3.94 to 4.95 cm.

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