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Review : Seabed Detection Using Application Of Image Side Scan Sonar Instrument (Acoustic Signal)

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Abstract

The importance of knowing the method for seabed detection using side-scan sonar images with sonar instrument is a much-needed requirement right now. This kind of threat also requires frequent sonar surveys in such areas. These survey operations need specific procedures and special equipment to ensure survey correctness. In this paper describes the method of observation and retrieval of marine imagery data using an acoustic signal method, to determine a target based on the sea. Side scan sonar is an instrument consisting of single beam transducer on both sides. Side scan sonar (SSS) is a sonar development that is able to show in two-dimensional images of the seabed surface with seawater conditions and target targets simultaneously. The side scan sonar data processing is performed through geometric correction to establish the actual position of the image pixel, which consists of bottom tracking, slant-range correction, layback correction and radiometric correction performed for the backscatter intensity of the digital number assigned to each pixel including the Beam Angle Correction (BAC), Automatic Gain Control (AGC), Time Varied Gain (TVG), and Empirical Gain Normalization (EGN).

Keywords: Seabed detection, Side Scan Sonar (SSS), Acoustic signal.

1. Introduction

The seabed is part of the earth whose territory has not been explored in its entirety, whether its breadth, depth, or potential. Potential seafloor can be explored through several activities such as research, detection, sweeping, and determining objects located on the seabed. The acoustic signal has any function for: marine seismic, marine fisheries, determine the abundance of fish in marine fisheries (Lubis and Manik, 2017; Lubis and Wenang, 2016), Echo Processing and Identifying Surface and Bottom Layer (Lubis et al., 2016).

One of the effective and efficient methods used for marine exploration activities is using the Hydroacoustic method. This method is often used to investigate columns and bottom waters efficiently and accurately (Blondel 2009). Hydroacoustic utilizes sound waves capable of propagating to the seafloor and several layers beneath which are then reflected back and accepted as the echo from target detection (Lubis et al., 2017a; Lubis and Pujiyati, 2017). Seabed identification using sonar system with the acoustic signal from side scan sonar C MAX- CM2 instrument in Punggur sea in Riau Islands, Indonesia, with the acoustic method according to (Lubis et al., 2017a).

Side scan sonar is an instrument consisting of single beam transducer on both sides. Side scan sonar (SSS) is a sonar development that is able to show in two-dimensional images of the seabed surface with seabed surface conditions and targets simultaneously. Side scan of high-frequency sonar is routinely used in qualitative seabed mapping with the main purpose of determining the location of features and objects on the seabed (Lubis et al., 2017b).

Several outcomes (Scanning) can produce mosaics, geology and sedimentological features that are easily recognizable and interpreted qualitatively so as to provide information about the dynamics of the seafloor (Kenny et al., 2003). The advantage of the Sonar Scan side is being able to detect whatever is in the bottom of the waters so that shipwreck or other objects can be detected. This seafloor imaging technology provides a large area with high resolution. The greater the frequency value then the resulting data resolution will be higher but the coverage area is narrower (Chang et al., 2016). Generally research on side-sonar image scan is more directed to image processing, such as geometric correction on sonar side scan images (Dzieciuch et al., 2017), side scan sonar imagery and seabed geologic interpretation (Garcia et al. 2000), brightness and distance correction In side scan sonar image processing (Rhinelander, 2016).

2. Sonar Scan Side Data Correction

The correction done on the sonar side scan image is divided into two, namely geometric and radiometric correction to the image of sea floor data Side Scan Sonar (SSS). Geometric correction aims to establish the actual position in the sonar side scan pixel image, where as radiometrically is related to the intensity of back and digital numbers assigned to each pixel (Chavez *et al.,* 2002; Milkert and Fiedler, 2002).

Geometric correction is done in several processes namely bottom tracking, slant-range correction, and layback. The radiometric correction process is Beam Angle Correction (BAC), Automatic Gain Control (AGC), Empirical Gain Normalization (EGN), Time Varied Gain (TVG). The bottom tracking phase of correction is done on the track line by digitizing the first return area or first return to the seabed and entering the speed of sound in the water. The bottom tracking correction stage is shown in Figure 1.The Slant Range correction process is calculating the horizontal distance of an object on the seabed with the bottom of the sea under towfish. In this correction, an object is plotted to the left or right of towfish, so to obtain a slant range correction can be calculated using the phytagoras formula as follows (Fig 2).

$$a^2 = c^2 - b^2 \tag{1}$$

Where:
a = Slant range correction
b = High towfish to the seabed
c = Slant range

The result of applying this slant range correction will remove the blind zone from each datum and move to the representative position of the actual seabed and remap the pixel from its position visible to its true position by computing the return time and height of the sonar rides.

Blind Zone is the area that is in the middle of the sonar side scan image with low backscatter intensity. The width of the blind zone will correspond to the distance between the seafloor and the sensor. Thus, the intensity of the sound waves contained in the blind zone will be affected by noise on the sensor and suspended particles in the water (Burguera and Oliver 2016) Layback correction is a measure of the horizontal distance from the position of the GPS antenna installed on the vessel against towfish position drawn behind the boat. The actual position of towfish can be known through the calculation of layback (Fig 3).

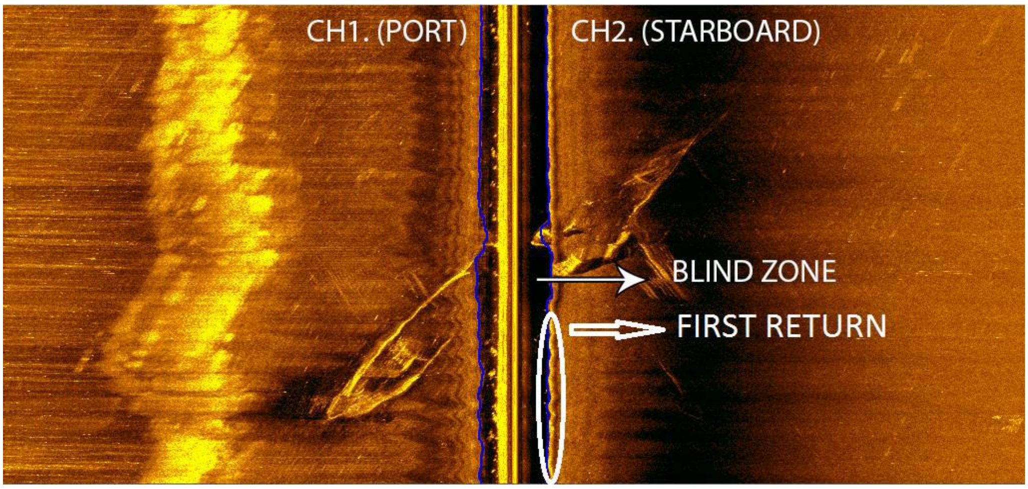

Fig. 1. Area First Return (Geometric correction)

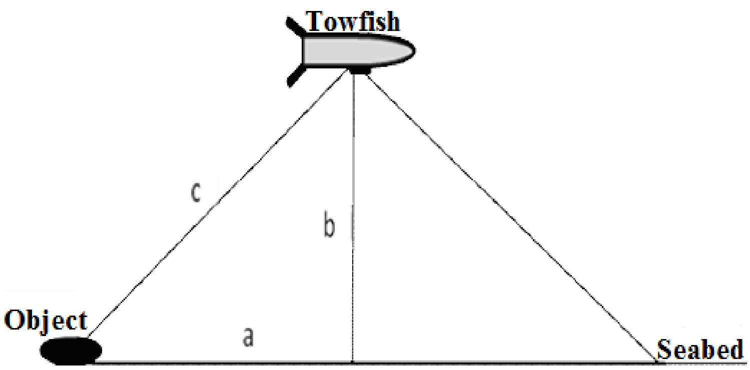

Fig. 2. Slant Range Correction Plan

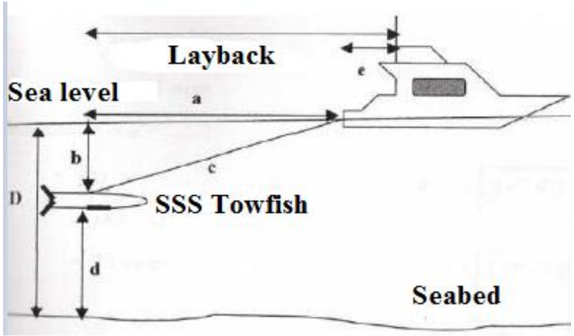

Fig. 3. Layback correction calculation scheme

The horizontal distance from the antenna to towfish can be calculated by summing the horizontal distance from the stern to the towfish with the antenna distance to the stern of the vessel, where a = horizontal distance from the stern of the vessel to the towfish, b = the depth of the towfish from the sea surface, c = towcable length, d = Towfish from the seabed, and e = The horizontal distance from the GPS antenna to the stern of the vessel. Time Varying Gain Correction (TVG) is performed on sonar side-scan data processing because the sonar system will produce beam coverage areas that have darker or lighter shades depending on the seabed texture type, so we get the equation:

$$a = \sqrt{c^2 - b^2} \quad (2)$$

$$\text{Layback} = a + e \quad (3)$$

In addition, it needs correction beam angle to correct the variation of beam intensity emitted towfish to the seabed. The overall backscatter energy variation is controlled by the return angle. The further away from the towfish, the energy will be reduced so that it takes correction beam angle on the sonar side-scan data processing. Fig 4 shows Characteristics of beam patterns of sonar side scan devices having radiant sonar intensity relative to different directions (Hsueh, 2007). This beam pattern will produce strong enough noise at low slope angle beam (Urick 1967).

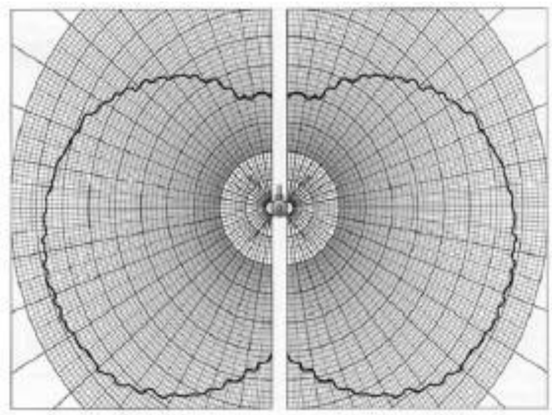

Fig. 4. General Beam pattern on Side Sonar scan instrument

The Empirical Gain Normalization (EGN) correction stage is performed for normalized gain so that the backscatter sonar output is independent of the angle and can build normalized mosaics, providing good contrast and brightness to the sonar side scan data, followed by Automatic Gain Control correction to normalize the reflection Of the sonar so as not to be affected by the geometry of the seabed.

3. Calculation of Object Length

The long calculation is intended to find out how long an object located at the bottom of the sea that is seen from the image of side scan sonar. The trick is to compare the length of an object and the distance between fix in side scan sonar image with the distance between fix field, so we get the equation:

$$S_1' = \frac{S_1 . S_2'}{S_2} \quad (4)$$

Where:

S1 '= The length of the object in the field
S1 = Distance between the fiks in the field (meters)
S2 '= The length of the object in the image
S2 = The distance between the fixes in the side scan sonar image (meter)

4. Calculation of Object Width

The width calculation is intended to find out how wide an object is in the field. The trick is the same as to find the length of the object, and we get the equation:

$$l_1 = \frac{L_1 . l_2}{L_2} \quad (5)$$

Where:

L_1 = Width of between fix in field (meter)
l_1 = Width of object in field
L_2 = Width of between fix in side scan sonar image (meter)
l_2 = The width of the object in the image

5. Acoustic Impedance and Reflection Coefficient

In principle to calculate acoustic impedance can be seen in Fig 4, which shows the state of a medium against sound waves and then reflects back. Acoustic impedance Z and reflection coefficient R are used to determine how big/ strong the value of the reflection of an object. The sea bottom acoustic impedance is a property that rules the backscattering strength, together with other sediment features such as slope and roughness. In this sense, SONAR devices can be used to measure the backscattering strength of a material lay up on the sea bottom and estimate the aforementioned sediment features.

This is generally referred to as the acoustic impedance, and in the linear regime, this is independent of the amplitude of pressure fluctuation. This paper is concerned with the linear absorptive properties of a range of aperture geometries with bias flow in the presence of seabed incident waves.

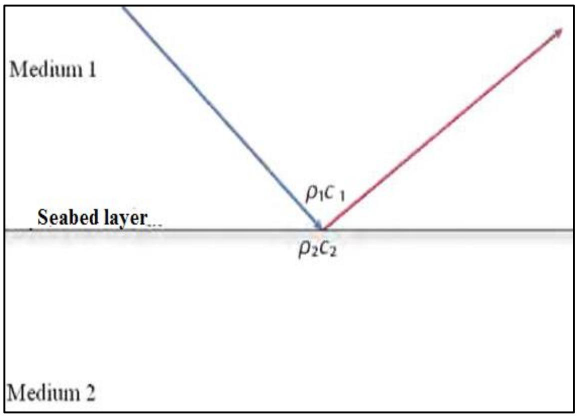

Fig. 5. General Beam pattern on Side Sonar scan instrument

Based on data ρ and c referring to Lurton (2002) can be calculated impedance value, reflection coefficient. This is done because the substrate type is known through the grab sample. The impedance value, the reflection coefficient can be calculated by equation (6), (7) below:

$$Z = \rho \times c \qquad (6)$$

$$R = \frac{Z1-Z2}{Z1+Z2} \qquad (7)$$

Where:

Z_1 = Acoustic impedance of medium 1
Z_2 = Acoustic impedance of medium 2,
ρ = Mass type (kg / m^3)
C = Sound speed (m / s).
R = Reflection Coefficient

The acoustic impedance is the ability of a material to be passed by acoustic waves. The acoustic impedance can be used to define the reflection coefficient, R is the measurement of the strength of the reflection by acoustic waves.

Acoustic backscatter that is reflected back to the sonar side scan transducer from the seabed is recorded for a certain period of time for a ping resulting in a time series data counter-amplitude. The backscatter of this amplitude can indirectly describe the object as well as the surface of the ocean floor reflecting the acoustic waves of the transducer. The backscatter values explain the response of the seafloor at the frequency used and for the specific conditions of the ensonification region (Blondel 2009). Sample figure of result backscatter can be seen in Fig 6.

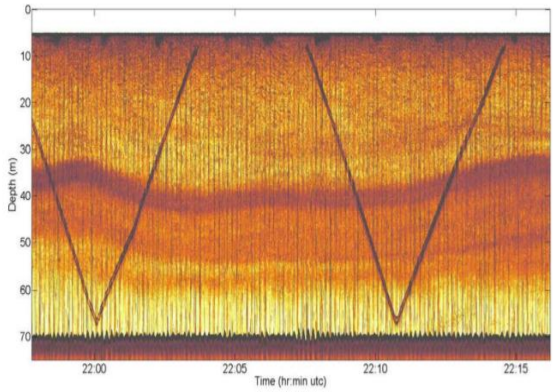

Fig. 6. Acoustic backscatter image.

The higher the amplitude value the more rough or hard a target is detected. Similarly, the smaller the amplitude value, the level of roughness or violence of an object decreases. In addition to the roughness factor and roughness of an object, the sound frequency in the tool used and the grazing angle of the acoustic pulse can also be a factor affecting the value of backscatter in the bottom waters (Burczynski, 2002). Sample figure of sound velocity can be seen in Fig 7.

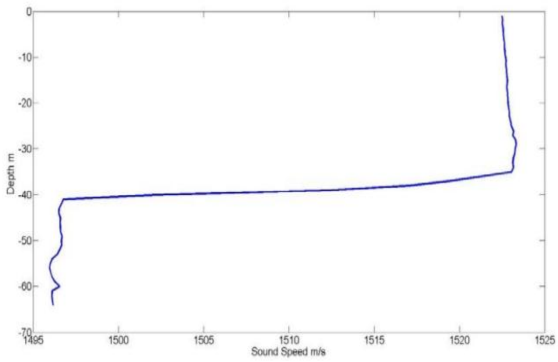

Fig. 7. Sample of Sound Velocity Figure.

6. Baseline Substrate Sample Analysis of Seabed

Sampling process of the substrate is done by using grab sampler equipment, then substrate sample will be taken to the laboratory to be analyzed texture of its substrate type. The method used to determine the type of bed-based substrate is by measuring the large diameter of the substrate grain (s), the substrate is saturated, before sieving the substrate sample is dissolved with hydrogen peroxide (H2O2) to remove the organic matter contained therein Dried with an oven and weighed with an analytical scale, after the substrate sample was weighed and then dissolved (immersed) in water, to separate each grain size from 0.063 s / d 8.00 mm diameter sieves based on Wenworth (1922).

The sieve yield of each diameter was dried by means of a driven, and each diameter was measured by weight with an analytical scale, the remaining sieving results in the sludge were accommodated in a residual pan and by the pipette method. Based on the diameter of the grains and the weight percentage of the substrate components are clay depth (diameter <0.004 mm), mud (diameter 0.004 - 0.063), sand (diameter 0.063 - 2.00 mm) and gravel (2-8 mm).

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