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Mapping of seabed target and TIN modeling using hydroacoustic methods in Piayu waters, Batam

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Abstract. Side Scan Sonar (SSS) is a marine survey equipment system that uses acoustic technology and instrument consisting of single beam transducer on both sides; this equipment system is a sensing strategy for recording seabed conditions by utilizing the nature of seabed media that is able to emit, reflect and / or absorb sound waves. This instrument can reach the bottom of the sea with a very far portion of the survey vessel. This research was conducted at Piayu waters, Batam, Indonesia with coordinates (Longitude of start: 104°6'38.83"E° and Latitude of start: 1°0'14.59"N; Longitude of the end: 104°6'57.78"E and Latitude of the end: 1°0'44.02"N) in May 2018. In this research, object detection is done by using the Hydroacoustic method as data acquisition and Triangulated Irregular Network (TIN) model as image data processing to display Scattering Volume (SV) value. Detected targets are more dominant that shows the sediment of sand using the methods. The SV value obtained is -90 dB which is the result of the detection of the sand object using the TIN model in the SSS image.

Key Words: Side Scan Sonar, hydroacoustic, TIN modeling, scattering volume (SV).

Introduction. Ocean depth measurements are performed faster using echo-sounding instruments. With this technique, the measurement can be done more quickly, and accurately, because the average sound velocity is 1500 m s^{-1} (Lubis et al 2018b, c). Side scan sonar is one of the acoustic instruments in the application of remote sensing science for underwater imaging and as a tangible form of technological development in the field of marine surveys today (Lubis et al 2017b; Kausarian et al 2017). Given the very limited reach and capability of the underwater visual application, sonar has been the preferred solution for seabed observations since its inception in the 1950s. This is done because there is still minim research on the detection of the underwater object using acoustic instruments (Greene et al 2018; Song et al 2019).

Side scan sonar (SSS) is an instrument consisting of a tilted transducer and a unit that can be used to provide underwater information which is interpreted and will produce images (Reed 2006; Charnila & Manik 2010; Lubis et al 2017a; Lubis et al 2018a). SSS has been used in bathymetry surveys using single-beam echo sounder as a depth information enhancement. The main parts of the sonar scanning side are basically transducers on tilted tow fish and a suitable solution for graphic image traces formed from echo traces depicting the state of the seabed in the form of sonography (Ye et al 2004; Langner et al 2009; Kaeser & Litts 2010).

The study of seabed texture is a fundamental requirement in terms of providing spatial information for planning and decision-making activities related to information on seabed conditions. This study was conducted in a marine area that has never been done before, to investigate and find out the texture of the seabed. This is important because a deeper introduction to the marine environment is essential in investigating the watershed. The application of geometric and radiometric correction is required to improve image quality. Imagery feedback signal processing and the quantification of seabed texture are important to support the interpretation of side scan side sonar data, both qualitatively and quantitatively, some of the morphology and basic physical characteristics of the waters.

The research in this paper aims to perform the qualitative and quantitative visualization and interpretation of the results of processing with SSS image correction and determine the acoustic value of the backscatter texture (texture behind acoustics) of the seabed on the Piayu waters, Batam Indonesia.

Material and Method

Time and location of the research. The research site is located on Piayu waters with coordinates (Longitude of start: 104°6'38.83"E° and Latitude of start: 1°0'14.59"N; Longitude of the end: 104°6'57.78"E and Latitude of the end: 1°0'44.02"N). The study has been done in May 2018. Geometry assumed on SSS can be seen in Figure 1, and the location of research can be seen in Figure 2.

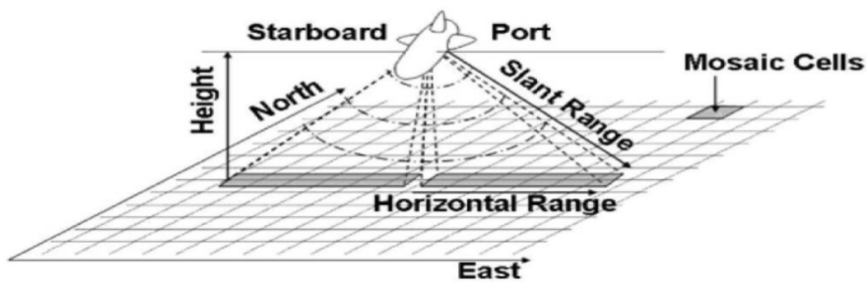


Figure 1. Geometry assumed on SSS.

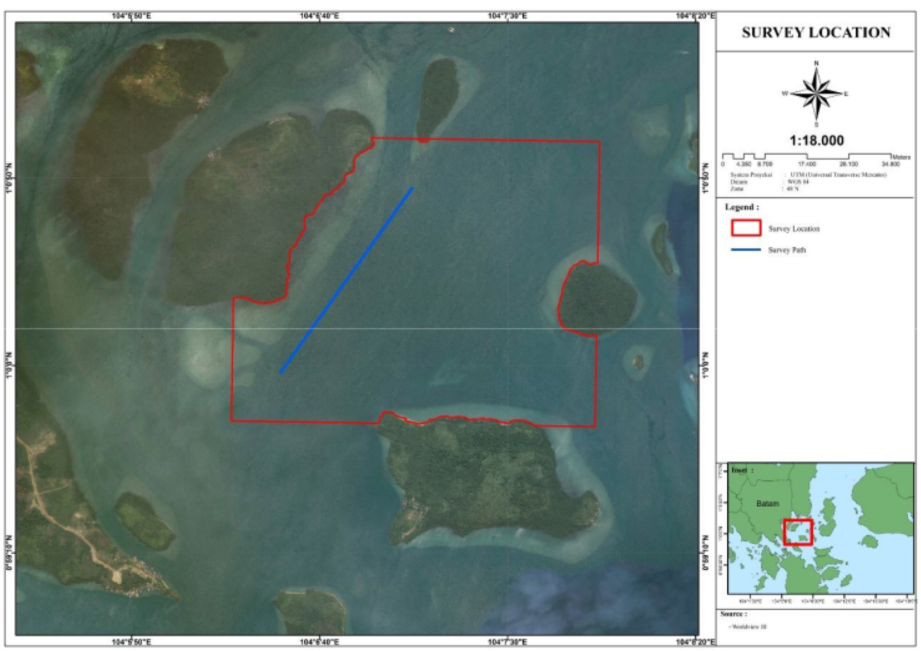


Figure 2. Research location in Piayu waters, Indonesia.

CM2 digital towfish. This research used the CM2 digital towfish instrument which combines operation on multiple frequencies, with two configuration options, DF (100 / 325 kHz) and EDF (325 / 780 kHz). The image of CM2 digital towfish instrument can be seen on Figure 3. This research used the highest resolution (Figure 4), with DF towfish they offer 325 kHz operation out to 150 m.

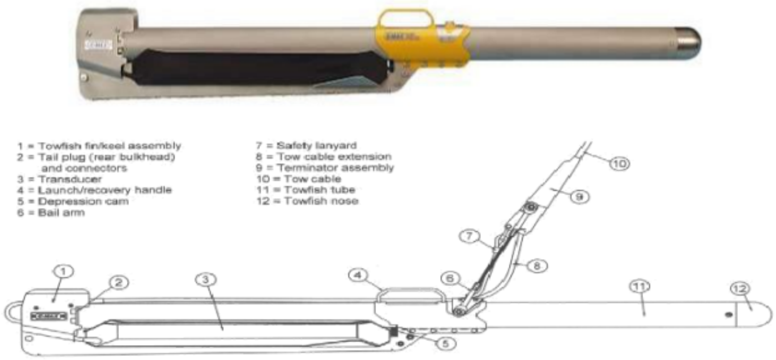


Figure 3. CM2 digital towfish instrument.

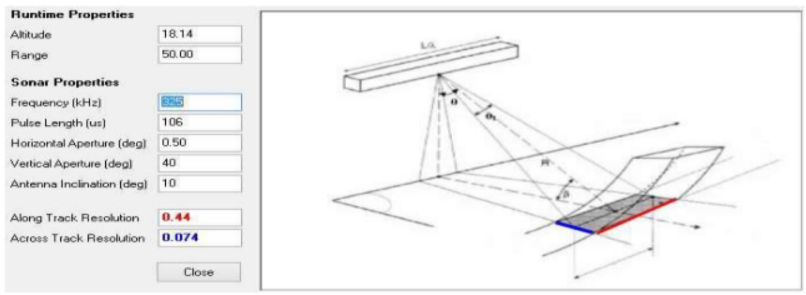


Figure 4. Resolution calculator of SSS survey.

Side scan sonar image interpretation. There are two stages in SSS image processing, namely real-time processing and post-processing. Real-time processing aims to provide corrections during imaging while post-processing aims to improve understanding of an object through interpretation (Zhao et al 2018). The purpose of quantitative interpretation is to define the relationship between the position of the ship, the position of towfish and the position of the object to obtain horizontal and vertical quantities (Zheng & Tian 2018). Horizontal quantities include the value of the position of the object when the trajectory of towfish parallel to the trajectory of the ship or when the trajectory with angular towfish and vertical magnitudes include the height of the object from the seabed as well as the depth of the object (Prada et al 2008).

Data collection. The acquisition of SSS data was performed using the fisherman ship (16 meters long and 6.5 meters wide). The tool used is C-MAX CM2 side scan sonar with 325 kHz frequency. Sound waves are transmitted by the transducer to the column toward the water. This sound signal will be reflected by the object and the seabed and then received by the receiver which is then displayed in the form of images that describe the condition of the surface of the seabed. Data flow diagram SSS in the Piayu waters can be seen in Figure 5.

Slant range correction. Data collection from various sonar systems will result in areas that have darker or lighter shades. Time Varied Gains (TVG) is done but often this is not enough, depending on the system and the type of the base substrate. Beam angle correction is done to correct the variation of beam intensity. If not done will result in striped data that reduces the backscatter variation in all cases. Figure 6 is a description of the slant range correction, assuming a flat ocean surface. R is the slant range ct/2 the sonar distance to the target/point on the seabed, c is the speed of sound in m s^{-1}, t time in seconds, and h is the sonar height of the seabed. So the illustration of slant range correction can be seen on Figure 6.

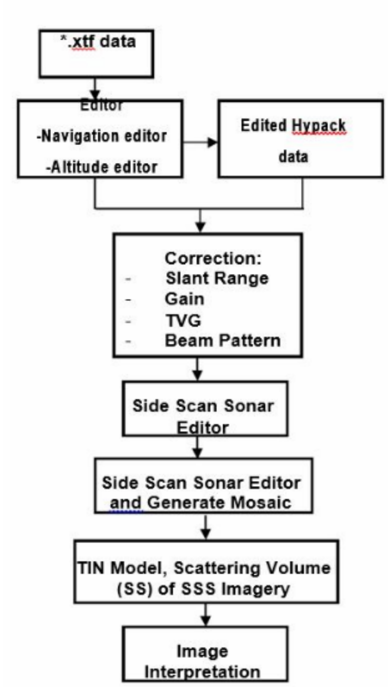


Figure 5. Data flow diagram side scan sonar (SSS).

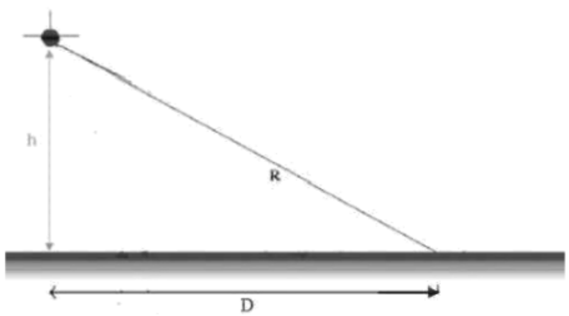
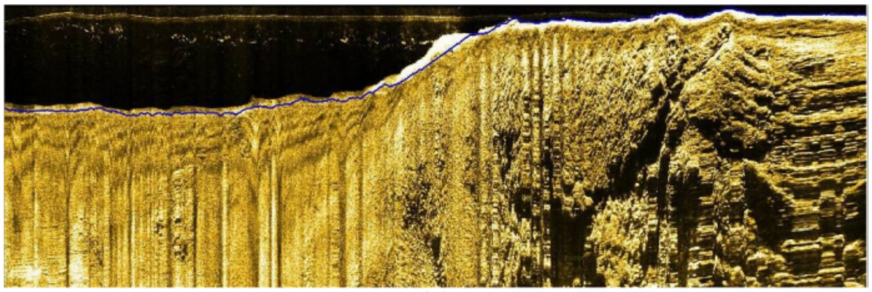
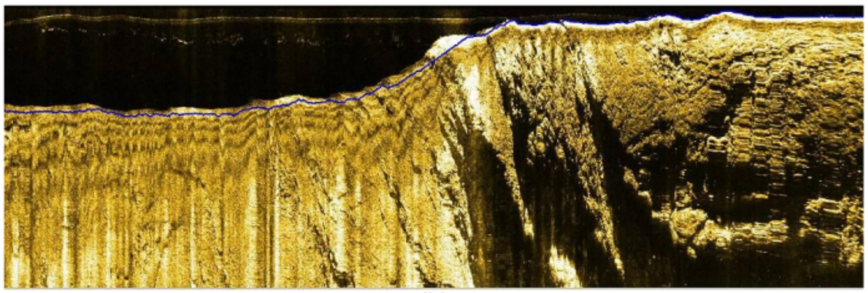


Figure 6. Slant range correction (Blondel 2009).

Results and Discussion. Modelling on raw data is done to know the features of the seabed that are on the port and the starboard on the image of the SSS. Figure 7 shows the view from the left side of the seabed to find out the sediment. From the Figure 7 it can be known is a sand sediment. Figure 7a is raw data modelling of port imagery, and Figure 7b is raw data modelling of starboard imagery, and it can be seen there is a bit of obstacle, which is likely to be the object of the seabed in the form of coral reefs or rocks. The results of the SSS image on the left side display the seabed sediments shown as brown objects, which are the appearance of material or sediments located on the seabed. In data processing, SSS must have mosaic and tracklines to see the condition of the survey. It is also necessary to assist in the broad identification of targets, in order to process the seabed feature analysis more quickly and precisely, by recording the position of the identified target through visual analysis (Figure 8).



(a)



(b)

Figure 7. Raw data modelling of port imagery (a), and starboard imagery (b).

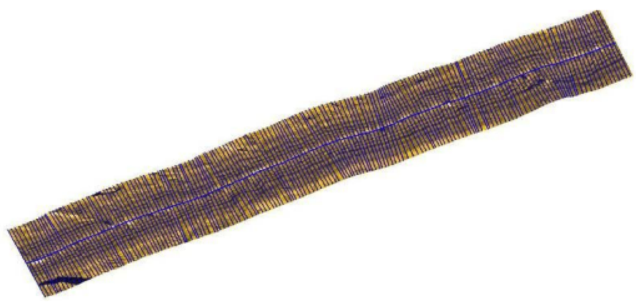


Figure 8. Mosaic and tracklines of SSS imagery.

In Figure 8 the results of the data SSS Scan View section is the part that displays the seabed sediment from both sides. It can be seen that the brown image is the appearance of material or sediment located on the seabed while the black section indicates the area where data was not taken by the SSS.

3D Triangulated Irregular Network (TIN) modelling. Basically, the TIN model in the object identification is using a relative coordinate system in which at a certain point coordinate will be determined by the size of the object. The results of the TIN model on track 1D with a mosaic station (Ms) have a size on the cross-section that is along the cross-section line (Mcs) (Figure 9).

Results of data processing using TIN model can be seen in Figure 10. In the processing and model performed in this study, the result of the 3D TIN model by not deleting boundary, and deleting boundary, can be seen in Figures 10 and 11 respectively.

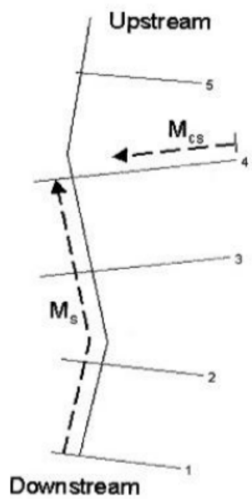
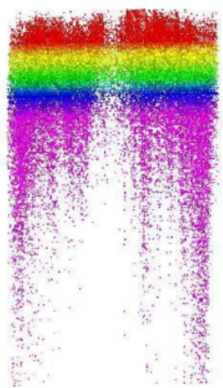
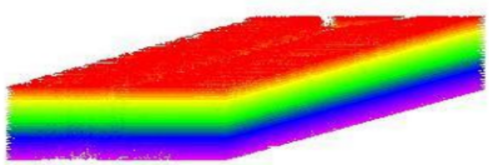


Figure 9. 1D stream representation in SSS imagery TIN modelling.



(a)

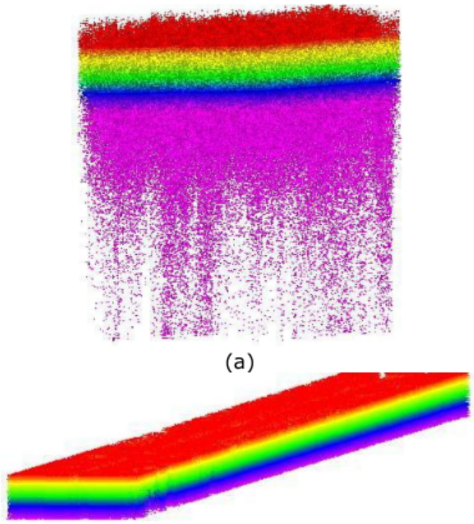


(b)

Figure 10. (a) 3D TIN modelling; (b) 3D countour of TIN model not removing the boundary.

The result of the SSS data in the form of 3D TIN is done by not removing the boundary. The results in Figure 10 are the layers of the data that have been taken, with the interpretation that the red colour is the top and the purple colour is the bottom. Figure 11 is the result of the SSS image data in the form of 3D TIN has done the process of its delineate boundary. These results are the layers of the data that have been retrieved (SSS images). Red is the top and purple is the bottom. SV values obtained from the calculated TIN modelling can be seen in Figure 12 with the result of object detection all in the dominant state is the sand object in Piayu waters, Batam, Indonesia. The scattering volume (SV) value obtained is -90 dB which is the result of the detection of the sand object using the TIN model in the SSS image. This SV value was obtained by using the RoxAnn seabed classification that had been done by previous researchers (Hasan et al

2014). Different SV values can be caused by the different instruments used and the power and frequency of the research tools (Hasan et al 2012). This research only shows the results of SV by not classifying objects, because it uses a side scan sonar instrument which is very different compared to instruments such as multibeam echosounder. In the study of Prokhorov & Sushchenko (2015) the results clearly show a difference with the SV value,(which shows the SV value of -65 dB on sand objects using SSS image.



(a)

(b)

Figure 11. (a) 3D TIN modelling; (b) 3D countour of TIN model removing the boundary.

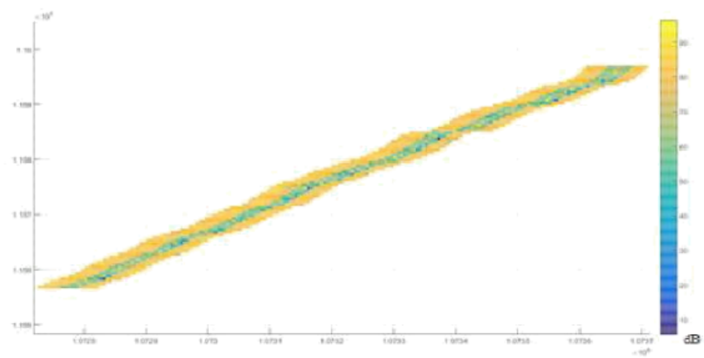


Figure 12. Scattering volume (SV) value of TIN modelling from SSS imagery.

Conclusions. Based on this study, the mapping of seabed targets and TIN modeling using hydroacoustic obtained good results for analyzing the difference in images produced using the TIN model to eliminate boundaries and not erase borders. The detected target is more dominant, showing sand deposits in the bottom of the Piayu Sea waters, Batam, Indonesia which are seen by the results of the SV value classification. Visually the TIN model used in this study can produce a smoother and more logical appearance of seabed objects. The results of this study can be used as references for determining SV values in shallow waters in Indonesia. Future studies can be carried out in different places and with a different map and scales to determine the most appropriate interpolation method in detecting seabed objects using Side Scan Sonar (SSS) imagery.

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