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School of Pharmacy (SF), Institut Teknologi Bandung

Preface

On behalf of the conference organizing committee, we are happy to present the Proceedings of the Third International Conference on Mathematics and Natural Sciences (ICMNS 2010). The organizing committee of the ICMNS 2010 is highly pleased to have nearly two hundreds full papers submitted to the Conference. The ICMNS's biannual event is organized jointly by the Faculty of Mathematics and Natural Sciences (FMIPA), the School of Life Sciences and Technology (SITH), and the School of Pharmacy (SF), Institut Teknologi Bandung. We are highly honored to host the event here in Bandung.

The aim of the ICMNS 2010 is to promote interdiciplinary researches in science and technology, to encourage the development of sciences and technologies for sustainable development, and to disseminate research in various fields of mathematics and natural sciences. The main theme of the ICMNS 2010 is "Science for Sustainable Development". The conference deals with mathematics and natural sciences to fundamental and applied researches, including nine scopes and topics that are health sciences, biosciences and biotechnology, environmental science, pharmaceutical science, physical sciences, material science, mathematics, computer and computational science, and earth and space sciences.

Finally, we would like to express our gratitude to Dean of FMIPA, Dean of SF, Dean of SITH, PT Chevron, PT Biofarma, and Indonesian Journal of Physics (IJP) for the financial support and thank the invited speakers as well as participants for their contribution in making the conference a success. As general chairperson, I highly appreciate the great efforts of the members of the organizing committee whose hard work really made it possible to have this conference.

Bandung, April 30, 2011

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Contents

Addendum

ACOUSTIC BACKSCATTER QUANTIFICATION OF SEABED USING MULTIBEAM ECHOSOUNDER INSTRUMENT

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Abstract. In Indonesia, the application of hydro acoustic technology such as multibeam echosounder (MBES) for bathymetry determination and sediment classification is very rare to be done due to information and application about the instrument is still limited. This paper describes the how to classify sediment using multibeam echosounder including bathymetric measurement. Data collection was carried out on 29 April until 30 May 2008 and 7-10 May 2008 in Malacca Strait using a Geomarin 1 research vessel belong to Marine Geological Institute (PPPGL). Acoustic data were obtained from a set of MBES SIMRAD EM 3000 instrument with operating frequency 300 kHz. The average backscattering obtained are as follows : −19,19 dB for sand, −19,54 dB for silty sand, −19,70 dB for clayey sand, −26,96 dB for clay and −21,89 dB for sandy clay. Sand has the highest backscattering strength value than other sediment. The factor causing different value of backscatter from sea bottom is grain size. This is the effective way to determine seabed.

Keywords: *multibeam echosounder, backscatter, seabed sediment.*

1 Introduction

Currently hydro acoustic technology needed for efficient and has a high resolution to obtain accurate data for the determination of bathymetry. In Indonesia as one of the utilization of multibeam bathymetry method of determination and classification of bottom substrate types are still very rarely done, because it is still the lack of knowledge and exploration of multibeam technology and this new tool. Hydro acoustic method will provide information about the value of backscattering from some type of bottom substrate. Backscattering value distribution of bottom sediment would be classified based on grain size and then mapped based on the type of base substrate in order to obtain the distribution patterns of bottom sediment.

Multibeam echosounder (MBES) is an instrument that use amount of beam arranged with the same frequency. Tansmitter and receivers beam composed with certain space (in degree), so that make possible acoustic transmission gives closeness as good as may be. Every transducer sender send acoustics pulse signal with characteristics or certain code, so that signal reflected from base only accepted by each transducer receivers.

According to Kagesten (2008) backscatter is the reflection of waves back to the direction they came from. By analyzing the amplitude of the returning sound wave it is possible to extract information about bottom structure and hardness, allowing for identification of bottom types. The bottom reflectivity properties depend on the hardness and the roughness of the seafloor surface. In simple terms a strong return signal indicates a hard surface (rocks, gravel), and a weak return signal indicates a soft surface (silt, mud).

2 Methods

Time and Research Location

Implementation of a survey conducted by the Geomarin 1 research vessel of Marine Geological Institute (PPPGL) ownership with two stages. First performed on April 29 until May 3, 2008. The second phase was held on 7-10 May 2008. Geographically located at the coordinates of 97o 30' 0"–98o 30' 0" East Longitude; 4o 40' 0"–5° 40' 0" South Latitude across the two districts of East Aceh and North Aceh, province of Nanggroe Aceh Darussalam. Map of study sites can be seen in Figure 1. The geology in this research area also has the potential mineral resources. The research area is the Basin of North Sumatra (North Sumatra Basin), which is one of the significant oil-producing basin in Indonesia. Analysis of subsurface conditions as information on matters relating to the existence of mineral resources (gas and oil) can not be separated from the initial information about the type of bottom sediment deposition environment such as in this study.

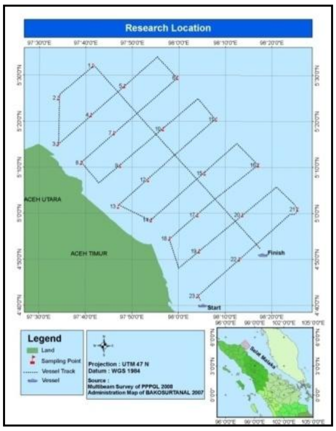

Figure 1. Research location

Data Processing

Depth measurement will be done in points that chosen for representing overall region that be mapped. In that points also done measurement for position determination. Place points were done measurement for position determination and depth is called sounding points.

Depth measurement points closeness depend on model scale that will be made. Depth measurement points present in depth measurement lines that called as sounding line. The position and depth of each point to be plotted into bathymetric maps or charts, while the value of the reflected waves describing the seabed profile and interpreted based on the type of bottom sediment. The speed of sound waves in the water column is influenced by changing salinity, pressure and temperature. Temperature and salinity affected by changes in depth, the greater the depth the greater the density. As a result of this density change will occur rapidly changing acoustic wave velocity (*c*). The calculation of travel time and direction of the beam angle of each staves determined from the phase difference measuring pulse multibeam echosounder. Depth (*h*) is calculated using the following equation:

– (1)

Sea water physical character likes temperature and salinity influenced by depth change, so that the density even also experience change with more increase the depth so the density ever greater. Effect of the density change is change so sound speed velocity will be changed. General equation for this formula is expanded by Medwin (1975), The equation is very simple but limited up to 1000 depth.

(2)

where :

c = sound speed (m/s)

t = temperature (^{o}C)

z = depth (m)

S = salinity ($^{o}/_{oo}$)

Acoustic survey carried out by using a Geomarin 1 research vessel of Marine Geological Institute (PPPGL). Placement of components should be in a safe and easy to operate. Multibeam echosounder placement position must be considered to avoid the occurrence of noise caused by ships, this is to get the best results. Intake of acoustic data using a device SIMRAD EM 3000. Multibeam echosounder SIMRAD SIMRAD EM 3000 is a product manufactured by Kongsberg of Norway. Multibeam echosounder SIMRAD this type is one important tool for mapping the shallow waters that are used to measure a lot of depth by using a transducer with high accuracy.

Tabel 1. Parameters of MBES

No.	Parameter	Operation Setting
1	Frequency	300 kHz
2	Source Level	215 dB re 1μPa/m
3	Power	0,6
4	Pulse Length	0,15 m/s
5	Beamwidth	$1{,}5^{o}$ x $1{,}5^{o}$
6	Number of Beam	127
7	Beam Spacing	$0{,}9^{o}$
8	Max Ping Rate	25/s
9	Min Range	0,3 m

Sonar Equation

Echo Level (*EL*) of backscattered signal from the seabed can be explain with sonar equation. (Urick,1983) :

(3)

Where : *SL* is Source Level ; *2TL* is Two Way Transmission Loss and

BTS is Bottom Target Strength

Transmission loss consist of :

1) Signal spherical spreading

(4)

2) Absorption loss

(5)

Total transmission loss (two-way) ;

(6)

Where :

R = distance (m)

= absorption coefficient (dB/m)

Bottom target strength (*BTS*) depend on the nature of the seabed reflection and wide from the base that reflects back a signal that has been scattered turn on every time. Therefore, to define the backscattering coefficient ( ) in dB/m^2, as a reflection of the value of bottom waters. The best equation to describe the change of angle BTS (incident angle) and depends on beam geometry and is the width of beam at normal incidence (φ = 0), beamwidth along the trajectory and the transmitted pulse length (τ).

(6)

(7)

is the backscattering coefficient which shows the nature of reflection from the bottom waters. Backscattering coefficient depends on the angle (θ).

When $\theta = 0^o$, is constant.

When $0^o < \theta > 25^o$, changed linearly to changes in incidence angle (incident angle), the changes are random. When $\theta \geq 25^o$,

is not only determined by the angle of incidence (incident angle) but also depends on the roughness of the seabed

backscattering coefficient ( ) and the variation of angle is given by Lambert equation:

(8)

(Hammerstad, 2000)

3 Results

Sediment

Based on the analysis of particle size by sifting through sediment and pipette analysis with Buchanan in the method of Holme and McIntyre (1984) and sediment naming method based on Shepard (1954) then obtained the naming of the sediment as Table 2. At the study site were taken several types of sediments using gravity cores and van Veen grab from the results of laboratory analysis obtained 5 kinds of sediment on the ship trajectory.

Backscattering Strength Based on Sediment Types

Backscattering value of sediment obtained by matching the coordinates of sediment samples have been analyzed and the coordinates of bottom backscattering values, so that the backscattering values obtained for each type of sediment. The deeper waters of the tendency of the smaller backscattering value and composition of the sediment has the smallest grain size such as clay or sandy clay. Whereas in the more shallow waters or near the mainland distribution of backscattering values greater (Figure 2). Although the same type of sediment at the study site but the value can be different backscattering stength this is because the percentage composition of different sediment materials. so that the values of backscattering strength is different.

Table 2. Sediment percentage and backscattering strength of sediment

No. Sta.	**Sand (%)**	**Silt (%)**	**Clay (%)**	**Sediment**	**BS (dB)**	**Mean Diameter (mm)**
1	47,86	6,54	45,59	Clayey sand	-18,86	0,21
2	75,21	10,93	13,85	Sand	-19,45	0,12
3	2,77	18,30	78,92	Clay	-26,14	0,0041
4	67,32	7,92	24,74	Clayey sand	-17,47	0,137
5	59,76	21,40	18,83	Silty sand	-17,97	0,155
6	64,13	15,34	20,52	Clayey sand	-20,21	0,151

7	58,57	10,25	31,16	Clayey sand	-20,37	0,107
8	3,01	18,01	78,97	Clay	-28,19	0,0042
9	50,61	18,95	30,43	Clayey sand	-21,36	0,097
10	88,01	11,62	0,35	Sand	-18,95	0,127
11	52,89	19,70	27,40	Clayey sand	-20,67	0,106
12	67,14	14,43	18,42	Clayey sand	-19,62	0,149
13	75,97	21,13	2,88	Silty sand	-23,23	0,125
14	9,57	15,12	75,28	Clay	-25,38	0,0045
15	32,89	17,90	49,19	Sandy clay	-23,89	0,0039
16	63,90	17,77	18,32	Clayey sand	-20,09	0,117
17	64,12	18,43	17,43	Silty sand	-18,99	0,135
18	57,28	11,28	31,43	Clayey sand	-19,16	0,142
19	43,97	17,74	38,28	Clayey sand	-20,72	0,099
20	29,86	17,75	52,38	Sandy caly	-20,53	0,0058
21	82,29	7,79	9,91	Sand	-19,21	0,121
22	51,26	14,27	34,45	Clayey sand	-19,65	0,141

23	0,73	18,60	80,66	Clay	-29,19	0,0047

This indicates that the type of bottom sediment in the area has a larger grain size such as sand. It is caused by currents and waves as factors affecting the distribution of sediment in the bottom waters. Sediment distribution patterns in the research area overlaid with bathymetry as shown in Figure 2 is generally the pattern of distribution of sediment types of sand are on the more shallow waters than other sediments and clays are generally scattered in deeper waters. This is influenced by the grain size of sediment and flow pattern that carries sediment. Types of sediments that have a larger grain size tends to be in an area near the mainland and the more shallow waters. Sand is usually deposited on the ocean currents stronger than the silt and clay, and ocean current conditions are also going to show the condition of the seabed morphology.

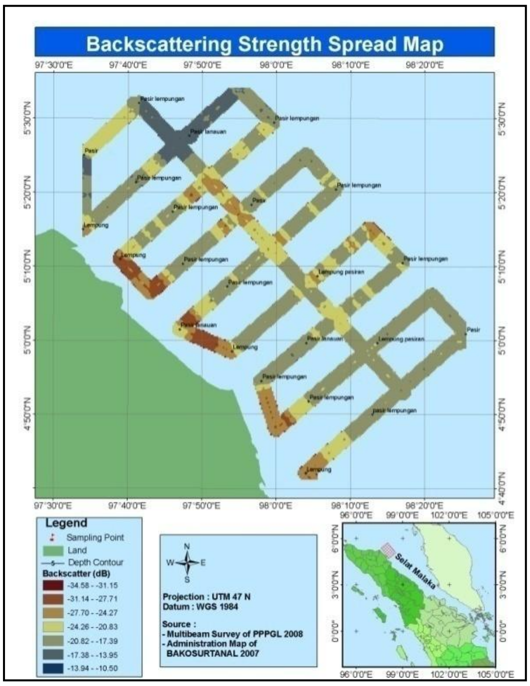

Fig. 2. Backscattering distribution overlay with bathymetric

Figure 2 is a bathymetric map overlaying sediments with values scattered along the path behind the ship as a whole with a depth of 5 meters contour interval. Russet dominate the area near the coast or inland to the interval value of backscattering -20,82 dB to -17,39 dB. Most likely the land area is dominated by sand sediment types that have a larger particle size compared to other sediment types. Coarse grained sediments such as sand will be deposited around the beach or coast while such fine-grained silt and clay deposited toward the deeper ocean. Bathymetric contours are relatively flat base substrate has a composition which tends to uniform compared with the basic morphology varying sediment composition is also diverse. It is influenced by factors that cause deposition of sediment, such as currents and waves.

The results showed the relationship between values scattered back to the sediment grain size is the larger grain size, the amount of backscatter was greater. The average backscattering value of existing sediment types on the location of the study are as follows sand (-19,19 dB), sandy silt (-19,54 dB), sandy clay (-19.707 dB), clay (-26,96 dB) and sandy clay (-21,89 dB).

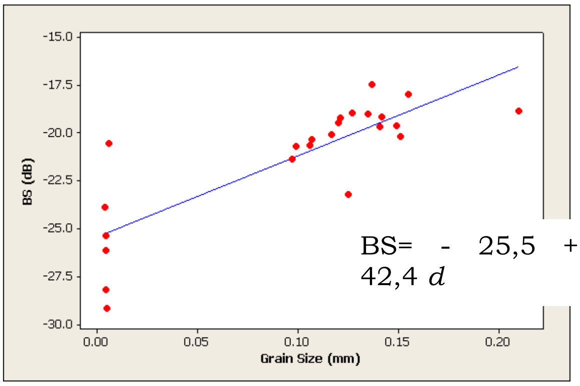

Figure 3. Backscattering strength scatter plot diagram. Grain size vs backscattering strength.

Table 2 and Figure 3 explains the relationship value of the backscattering strength of the sediment grain size. By using a scatter plot graph, obtained by linear regression equation as follows: $BS = 42{,}4d - 25{,}5$. Mean size [*d,* (mm)] and the variance (R^2) of 0,66. The sand has a grain size of 0,00625 to 2 mm, silt has range of grain size between 0,0039 to 0,00625 mm, while clay has the smallest particle size that is less than 0,0039 mm.

Each sediment backscattering values among the sites were plotted into a graph based on grain size as shown in Figure 3. So for this type of sediment such as sand silt, sandy silt, silt clay and clayey silt is the combination of these three types of sediment. Naming the type of sediment depending on the percentage composition of the dominant constituent bottom waters. From all types of samples obtained from the field, determined from the average value of each sediment backscattering. Retrieved proportional relationship between grain size and value of backscattering strength, the larger the grain size, the value of backscattering will be greater and vice versa. These results obtained from the comparison of grain size and value of backscattering.

Backscattering strength values can not be considered the same in all aquatic locations using different tools and specifications. Several studies about the value of backscattering by using different instruments obtained value of each different backscattering although the water same type of bottom substrate. High frequency and using a short pulse length then it will get high resolution but lower penetration power due to absorption of sea water medium is proportional to the frequency used.

In Table 3 are visible even when the instrument using the same frequency but the value of backscatter can also be different because it is influenced by the fast wave propagation in the medium of water, pulse length, depth and beam angle also affect the value of backscattering. If the angle is perpendicular to the transducer then stormed the value behind it will get stronger. Beam angle in this study can not be written because the data can be extracted from multibeam sounding record does not specifically incident angle of the beam, only to record the coordinates of the position (longitude and latitude) and backscattering strength values.

Table 3. Comparison of some experiment using hydro acoustic and backscattering strength of sea bottom substrate.

Experiment	**Location**	**Instrument**	**Frequency.**	**BS (dB)**
Manik *et al.* (2006)	Southern Java Sea	Quantitative Echosounder	120 kHz	Sand : -18,3 Silt : -23,4 Silty clay :-31
Siemes *et al.* (2007)	Mediteranian Sea	MBES Simrad EM 3000D	300 kHz	Silty clay : -33,2 Clay :-30,1 Clayey silt :-27,9
Kagesten (2008)	Storgrundet Gulf of Bothnia	Simrad EM 3002D	300 kHz	Sand : -14,1 Silt : -17,4 Clay : -25

Present data (2010)	Malacca Strait	MBES Simrad EM 3000	300 kHz	Sand : -19,19 Clay : -26,96 Sandy clay : -21,89

The results of this study, for determination of sediment classification can not be used for all acoustic instruments. Determination of sediment types by observing the backscatter values can only be used on the instrument and the same specifications as those used in this study so beneficial to facilitate the determination of the basic substrate waters by observing the backscatter value alone without taking basic sediment samples. Very effective for a wide area and require a relatively short time.

Overlaying between backscatter and bathymetric data of sediment sampling as well as ground truth the actual field conditions is a very effective way to determine the composition of the basic structure of the waters. This method is relatively easier to be understood by observers who are not familiar with the backscatter data. Lack of basic classification based on the backscatter and bathymetry data is extremely difficult to perform the classification process with direct observations without basic sediment sampling, because the grain size can not be directly associated with backscattering values for all types of sediment without studying the bathymetric data. Interpretation manually will require a lot of time (time consuming) for classification on large areas but would be very efficient in a smaller study area, such as sedimentation in the port area or the development of offshore construction. Identification of bottom sediment with sediment grain size could potentially occur because of pollutants from the mainland such as (mud and silt), so with the use of backscatter and mapping of bottom sediment can be used to estimate the extent of distribution of sediment pollutants.

4 Summary

The average value of backscattering strength (*BS*) types of bottom sediment by using a multibeam echosounder SIMRAD EM 3000 from highest to low is -19,19 dB for sand, -19,54 dB for silty sand, -19,70 dB for clayey sand, -26,96 dB for clay and -21,89 dB for sandy clay. Sand has the highest backscatter values than others and the lowest is clay.

Backscattering strength difference value basic sediment types are examined in this study is highly dependent on grain size, because the classification of types of sediment taken is based on grain size. There is a directly proportional relationship between sediment grain size and the backscattering strength. Sediment that has the largest grain size has the largest value of backscattering strength and vice versa. In addition to grain size, some things that affect the difference in the value of backscattering strength of the seabed objects are the porosity, roughness, surface sediments and sediment volume heterogeneity.

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References

[1] Buchanan JB. 1984. Sediment Analysis *in*: Holme NA. and McIntyre, editors. *Methods for the Study of Marine Benthos*. Second Edition. Blackwell Scientific Publication. Oxford. 41 – 65 pp.

[2] Hammerstad E. 2000. *Backscattering and Seabed Image Reflectivity*. EM Technical Note. http://www.kongsberg.com [June 15, 2010].

[3] Kagesten G. 2008. *Geological Seafloor Mapping with Backscatter Data from A Multibeam Echosounder*. Department of Earth Science, Gothenburg University. 38 pp.

[4] Manik HM, Furusawa M, Amakazu K. 20006. Measurement of Sea Bottom Surface Backscattering Strength by Quantitative Echo Sounder. *Fisheries Science* 72 : 503-512.

[5] Medwin H, Clay.1998. *Fundamentals of Acoustical Oceanography*. Academic Press. London. 707 pp.

[6] Siemes K, Mirjam S, Simons DG, Hermand JP. 2009. Using MBES Backscatter Strength Measurements for Assesing A Shallow Water Soft Sediment Environment. *IEEE*: 4244-2523.