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by Fauziyah Fauziyah

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Detection of bottom substrate type using single-beam echo sounder backscatter: case study in the East Coastal of Banyuasin

Fauziyah^{1*}, A I S Purwiyanto¹, F Agustriani¹, W A E Putri¹, M Liyani¹, R. Aryawati¹, E N Ningsih¹ and Y Suteja²

¹Marine Science Study Program, Faculty of Mathematics and Natural Sciences, Sriwijaya University, Indonesia

²Marine Science Department, Faculty of Marine Sciences and Fisheries, Udayana University, Indonesia

*E-mail: siti_fauziyah@yahoo.com

Abstract. This research was aimed to identify substrates type in the east part of the Banyuasin coastal waters using quantitative a backscatter data from single-beam echo-sounding. The SIMRAD EK-15 was used to classify the seafloor substrate types. The ground truth was required for calibrating the acoustic result. Wet sieving methods and Shepard's triangular diagram were used to analyze the ground truth samples. The acoustic data were filtered to extract the volume backscattering strength of bottom surface (SV) using Echoview 4.0. The data of bottom surface backscattering strength (SS) and SV were classified by using Hierarchical Cluster Method. Data of substrate type from the ground truth will be used as a guideline to classify the SS data to know the substrate type based on the SS characteristic which associated with various types of the bottom substrate. The results shown the single beam capability to distinguish the bottom substrate types, namely clayed sand with the SS value ranges from -47.29 to -46.32 dB), silt + sand + clay with the SS value ranges from -51.00 to -48.54 dB), clayed silt with the SS value ranges from -53.47 to -52.24 dB), and silty clay with the SS value ranges from -56.89 to -55.94 dB.

Keywords: bottom surface backscattering, single beam, echo sounder, substrate

1. Introduction

Information on a seafloor composition is very important for various fields of activity such as marine geology, marine biology, off-shore construction projects, coastal infrastructure building planning, environmental defense organizations, fishery management strategies and monitoring (Eleftherakis et al 2012, Costa et al 2013, de Pinho et al 2016, Montereale-Gavazzi et al 2018, Fauziyah et al 2018). In the terms of ecology, the seafloor is responsible for various processes that often affect the species spatial distribution and become the basic for interactions between ecosystems (Costa et al 2013) and used as the key indicators of 'Good Environmental Status' (Montereale-Gavazzi et al 2018). The substrate type of the seafloor in the Banyuasin Coastal Waters was one of the key factors for the shrimp abundance (Fauziyah et al 2019a) and the fish community stability (Fauziyah et al 2019b).

One method that the most cost-effective for detecting and mapping the coastal and marine resources was hydroacoustic (Manik 2015) and this method has developed become a standard

tool for the seafloor mapping and classification around the world (Bartholomä 2006). An approach of acoustic remote sensing techniques for classifying the sediments, in commonly use measurement equipment such as single beam echo sounder (H7nuna et al 2017, Amri-Simkooei et al 2011, Snellen et al 2011), s5t-beam sounder (Costa et al 2013, de Pinho et al 2016, Zakariya et al 2018), and multi-beam echo sounders (Eleftherakis et al 2012, Montereale-Gavazzi et al 2018, Harahap et al 2010). Whereas single beam echo sounder (SBES) acquire a single measurement per ping, the MBES (multi-beam echo sounders) can take up to 300 measurements per ping along a wide swath perpendicular to the direction of navigation. Despite the advantages of the MBES, the SBES is still extensively used. Methods that base the sediment classification on SBES measurements are consequently of high interest (Snellen et al 2011). The various advantages of SBES were: 1) low data volume and standardized procedures cause the data processing was more efficient; 2) the acquisition costs was comparatively low; 3) using multiple frequencies during one survey was very possible; 4) availability of water column backscatter and easy for processing; 5) on-axis calibration to scientist; 6) ready to use and comprehensive; and 7) relatively easy to be understood and operated (Anderson et al 2008).

The seafloor composition mapping was an ultimate goal of acoustical remote sensing techniques. Information about the seafloor composition was obtained from the shape and intensity of the received signal. To distinguish between different types of sediments can be identified from changes in form of echo received from one of sediment to another (Amri-Simkooei et al 2011). To produce information about the sediment type can be used the data combination between the echo form changes and ground truth knowledge from the different areas (Lied et al 2004). Direct estimation of target strength (TS) can't be done because of the SBES system doesn't provide information on target location, therefore when using the SBES system, the SS distribution must be estimated statistically (M2ik et al 2014). Based on the approach of acoustic remote sensing techniques, this research is aimed to identify and classify substrates type using quantitative SBES backscatter in part coastal waters of Banyuasin.

2. Materials and Methods

2.1. Study location

The study location was the east part of the Banyuasin coastal waters (Fig. 1). A field survey was conducted in September 2017.

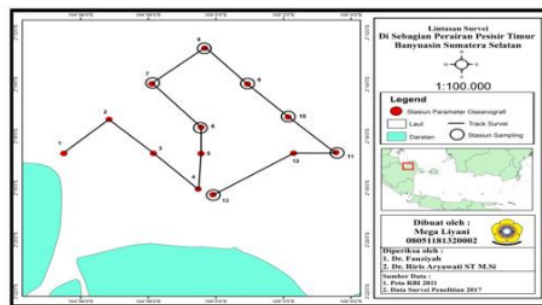


Figure 1. Study location and cruise track.

2.2. Acoustic Sampling

Acoustic sampling was carried for 3 days using a mixed survey design consisting of parallel and series. (Fig.1). The total ESDU (Elementary Sampling Distance Unit) used was 13 ESDU with a total distance of 24.05 nmi or 44.603 km and a distance of 1 ESDU of 1.85 nmi or 3.431 km.

Acoustic sampling was performed by means of SIMRAD EK-15 (a scientific single beam echosounder) operating at 200 kHz. Acoustic data were recorded at a constant speed of 5 knot. To minimize the effect of noise in order to produce a good recording quality, the transducer was mounted on the center right side of the ship at a depth of 1 meter below the sea water surface. And specifically at the sediment sampling location, recording acoustic data was carried out for approximately 1 hour.

2.3. Sediment sampling

Groundtruth knowledge was required for calibrating the acoustic classification results. This information was collected from the sediment sampling that undertaken at the track lines of acoustic survey. This line track as the principal test location to associate between the backscatter data and the seafloor substrate types.

The samples were collected using Ekman Grab (15 x 15 cm) based on the stratified random sampling method. In relation to the acoustic sampling, ground truthing was carried out to identify the seafloor substrate types at 7 station points based on conditions in the field that allowed for sampling and their closeness to the track lines of acoustic survey (Fig. 1). In order to verify the acoustic sampling results, the sediment sampling was attempted just below the transducer then the sample was put into a plastic bag, labeled and sealed (Hamuna et al 2017, Zakariya et al 2018). For further analysis, the samples were taken to the laboratory and substrate texture will be used as in situ data and comparative data from the acoustic data (Fauziyah et al 2018, Hamuna et al 2017).

2.4. Sediment and Acoustic Data Analysis

The wet sieving technique was used to determine the size grains of the sediment from the sediment samples that have been obtained (Haris et al 2018). Substrate texture analysis was based on the Shepard's triangular diagram for samples containing silt, clay and sand (Costa et al 2013, Fauziyah et al 2018, Ningsih et al 2013).

To extract the volume backscattering strength of bottom surface (SV), the acoustic data obtained at 200 kHz were filtered using Echoview 4.0. The SV data obtained consists of backscattering value from the first reflection (E1) and the second reflection (E2). In this study, the SV value used was the E1 value (Hamuna et al 2017). The E1 value was processed using the threshold range from -50.00 dB to 0 dB (Fauziyah et al 2018, Hamuna et al 2017, Pujiyati et al 2010). The Elementary Sampling Unit (ESU) used in the data processing to find out the SV value was 100 pings (Hamuna et al 2017). The integration thickness of the E1 value was 0.15 meters which was adjusted to the grab sampling (15 x 15 cm).

Data processing was done at the peak intensity value or the maximum value of the raw SV on each ping. This value was considered the Sv value that produced by the bottom substrate (Pujiyati et al 2010). This study also used the backscattering strength of bottom surface (SS)

as the acoustic parameters of the bottom surface for further analysis.

Formulations that explain the relationship between the raw bottom backscattering strength (Ss) and the raw SV value of the bottom echo (S_{VB}) (Manik et al 2006, Manik 2011) as:

$$S_{VB} = \frac{Ss \Phi}{\Psi \left(\frac{c\tau}{2}\right)} \quad (1)$$

where, S_{VB} = the raw SV value for the seafloor echo (not averaged)

Ss = the raw backscattering strength for the seafloor

Φ = instantaneous equivalent beam angle for surface scattering

Ψ = equivalent beam angle for volume scattering

c = sound speed (m/s)

τ = the pulse width (ms).

At the seafloor echo peak, integration value $\Phi \cong \Psi$ therefore equation becomes:

$$Ss = \left(\frac{c\tau}{2}\right) S_{VB} \quad (2)$$

$$SS = 10 \log \left(\frac{c\tau}{2}\right) + S_{VB} \quad (3)$$

$$SS = 10 \log Ss \quad (4)$$

2.5. Clustering

This study used an unsupervised classification method namely class assignments were only based on the data distribution and then associated with ground truthing. The hierarchical cluster method was utilized to identify any similarities between group of acoustic sampling sites based on the E1 and SS value. This result was displayed in the dendogram.

2.6. Calibration

The classification system based on empirical relationships between acoustic parameters and the sediment properties needs to be calibrated. Calibration method consists of direct or indirect calibration methods (Penrose et al 2005). This study used an indirect method was that of applying the acoustic data classification base on the hierarchical cluster method, as well as using groundtruth to provide the meaning of the acoustic cluster. Based on the compatibility between the acoustic cluster and the sediment cluster, the substrate type can be determined. The stepwise multiple regression model were developed to examine relationships between the sedimen fraaction and SS value.

3. Results

3.1. Hydroacoustic

To quantify the spatial distribution of sedimentary properties and bathymetry in the sampling locations were used hydroacoustic measurements. At the sampling location, Banyuasin Coastal Water was a shallow coastal, with minimum depth of 2,8 m and maximum depth of 8 m (Table 1). The E1 values ranged from -12,91 dB to -2.34 dB and the SS value ranged from -

56.89 dB to -46.32 dB.

Table 1. Acoustic bottom backscattering strength from each acoustic sampling in Banyuasin Costal Water.

Station	Depth (m)	E1 (dB)	SS (dB)
1	3.5	-9.49	-53.47
2	3.59	-2.99	-46.97
3	5.67	-6.16	-50.14
4	3.74	-2.51	-46.49
5	5.17	-4.56	-48.54
6	7.25	-2.34	-46.32
7	2.8	-8.26	-52.24
8	7.78	-5.25	-49.23
9	8	-7.02	-51.00
10	4.9	-11.96	-55.94
11	3.9	-12.91	-56.89
12	5.93	-8.52	-52.50
13	4.3	-3.31	-47.29

The first analysis was to use the backscattering value (E1 and SS) and apply the hierarchical cluster method to create the acoustic data classification (Fig. 2). The results identified four unique clusters of stations, i.e., Cluster A containing the stations 2, 4, 6, 13, Cluster B containing the stations 3, 5, 8, 8, Cluster C containing the stations 10, 11 and Cluster D containing the stations 1, 7, 12. The SS interval value for cluster A ranged between -47.29 dB and -46.32 dB, cluster B ranged between -51.00 dB and -48.54 dB, cluster C ranged between -53.47 dB and -52.24 dB, and cluster D ranged between -56.89 dB and -55.94 dB. This clusters can revealed the substrate types. The results of classification cluster (Fig. 2) would be compared with the classification result of seafloor substrate (Fig. 4).

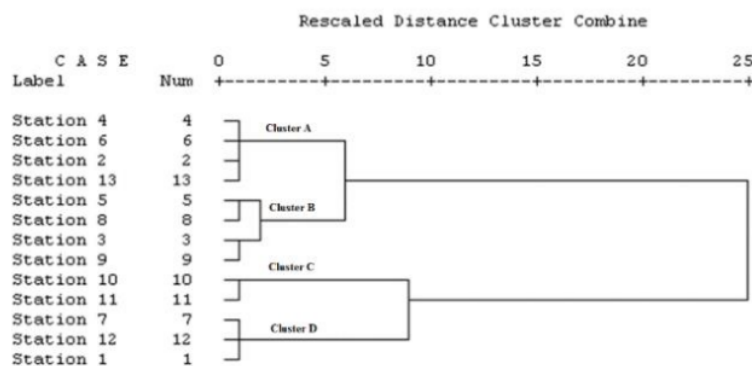


Figure 2. Cluster analysis dendrogram of the acoustic data.

3.2. Substrate types based on ground truth

Based on the substrate compositions (Fig. 3), the classification method was used to generate a set of substrate classes typifying the ground truth area (Fig. 4). Using a Shepard's triangular diagram, meaningful substrate type can now also be distinguished.

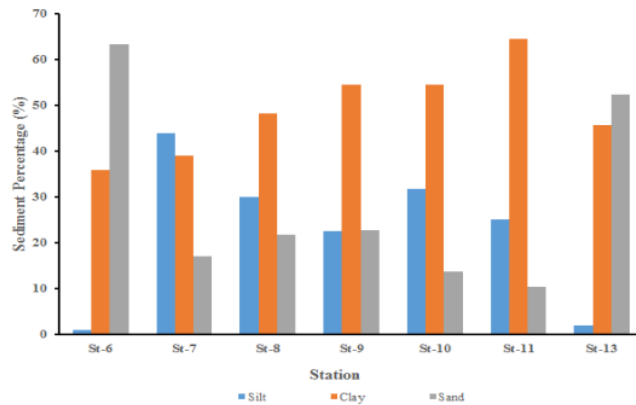


Figure 3. The Sediment percentage based on ground truth in Banyuasin Coastal Water.

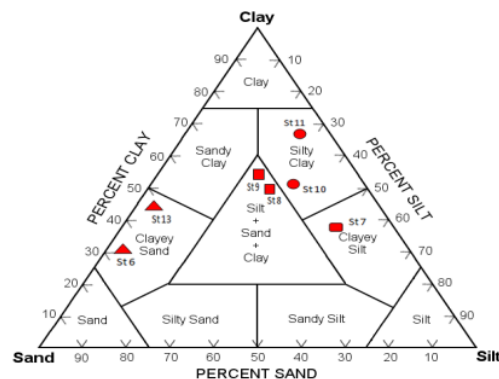


Figure 4. Shepard's triangular diagram of the sediment data.

Figure 4 shown that the substrate type in the ground truth area is divided into four cluster, i.e., silty clay (station 10, station 11), silt-sand-clay (station 8, station 9), clayed silt (station 7) and clayed sand (station 6, station 13).

3.3. Acoustic classification based on ground truth

The percentage distribution of sediment compositions indicate the presence of four bottom substrate types: silty clay, silt-sand-clay, clayed silt, and clayed sand (Fig. 4). This results used to assign meaning of the acoustic classes. The acoustic classes obtained by matching the ground truth classes has been analyzed, so that the SS value are obtained for each substrate

type (Table 2). The results show the interval value of SS for clayed sand ranged between -47.29 dB and -46.32 dB, the type of silt+sand+clay ranged between -51.00 dB and -48.54 dB, clayed silt ranged between -53.47dB and -52.24dB, as well as ranged between -56.89 dB and -55.94 dB for silty clay.

Table 2. The classification of the SS and substrate type in Banyuasin Costal Water.

Clustering Station		Substrate Tipe ²
Acoustic data ¹	Sediment data ²	
Cluster A: Station: 6, 4, 2, 13 SS: -47.29 to -46.32 dB	Cluster A: Station :6, 13	Clayed sand
Cluster B: Station: 5, 8, 3, 9 SS : -51.00 to -48.54 dB	Cluster B: Station: 8, 9	Silt + sand + Clay
Cluster C: Station: 7, 12, 1 SS: -53.47 to -52.24dB	Cluster C: Station: 7	Clayed Silt
Cluster D: Station: 10, 11 SS: -56.89 to -55.94 dB	Cluster D: Station: 10, 11	Silty Clay

¹ : Hierarchical Cluster Method

² : Shepard's triangular diagram

The substrate type of clayed sand has the highest SS value than silt+sand+clay, clayed silt and silty clay. This results indicates that the sand percentage as a factor causing different value of the bottom surface backscatter strength. The multiple regression resulting by adding stepwise substrate fraction parameters in the model are given in Table 3. The contribution of sand percentage to the model is significant ($P < 0.05$) and helps to explain 70% of the variance in SS value to sand percentage (adj. $R^2 = 0,70$). Conversely, the percentage of clay and silt does not have a contribution to the model. There was a positive correlation between the SS value and the sand percentage of bottom substrate.

Table 3. Results of stepwise multiple regressions for the effect of SS value on sediment fraction

Dependent Variable	Intercept (β_0)	β_i			Adj. R^2
		Sand	Clay	Silt	
SS value	-56.2	0.17*	NS	NS	0.70

* : Significant level $p < 0.05$;

NS : Not Significant

4. Discussion

This study found the SS value, in decibels (dB) ranges from -55.94 to -47.29 dB. The high decibels (Zakariya et al 2018) shown coarse particles because the rough surface will reflect sound waves, while low decibels shown a soft surface because some sound waves are being absorbed.

In this study, the acoustic classification was generally in accordance with the sediment sampling. Acoustic class A was associated with the clayed sand, class B comprised combinations of sand, silt and sand, and class C associated with the clayed silt and class D associated with the silty clay. According to the stepwise multiple regression, the sand fraction

is a key factor affecting the SS value. The higher the sand fraction, the higher the SS value. Thus, the most important influences on the acoustic classification (Ellingsen et al 2002, Collins and Lacroix 1997) were the seafloor roughness and the density difference between the water and the seafloor material. The grain size and porosity were the best descriptors of surface properties (Preston et al 1999).

There was a strong correlation between the SS values and the seafloor substrate type (Haris et al 2015, Kloser et al 2010) as well as a very strongly positive correlation between the SS value and the sand percentage (Fauziyah et al 2018). The value of roughness, hardness, and grain size for the sand substrate greater than the substrate type of clayed sand and clay (Hamuna et al 2017, Ningsih et al 2013, Pujiyati et al 2010). The values of acoustic backscattering for the sand substrate also greater than clay and clayed sand (Hamuna et al 2017, Ningsih et al 2013, Pujiyati et al 2010). Based on the Shepard's triangular diagram, the substrate type of clayed sand tend to have more the sand fraction than sandy clay, silty clay and clayed silt.

Echo sounders have to be calibrated in order to produce accurate estimates, and the simplest is to place a target with known acoustic size in the center of the beam and adjust the gain (Sathishkumar et al 2013). For accurate classification, the echoes should be influenced only by properties of the seabed. The bottom acoustic roughness and hardness would affected the echo shapes and energies (Penrose et al 2005). Acoustically, greater penetration into softer sediments weakens signal strength more than harder sediments and a smooth flat seafloor returns the incident ping with a form that is largely unchanged. Smoother sediment surfaces provide less backscattered energy from the beam outer parts than rougher sediment surfaces, at the same composition, a rougher surface is expected to have a lower peak and a longer tail (Penrose et al 2005, Hamilton 2001).

In reality the situation is more complicated if suitable averaging techniques are not used because of the harder seafloor surfaces such as rock that tend to own greater roughness than others sediments, produce vary the return shape and energies that could own an average signal strength that identical with mud (Hamilton et al 1999). A very rough rocky bottom maybe appear had less reflection than a muddy sediments, as well as losses in consequence of the roughness effect could produce sand with ripples, waves, holes and scour to appear on several acoustic measures that have the identical properties as mud (Penrose et al 2005, Hamilton 2001).

Some bottoms may have similar acoustic signatures but are not similar for their substrate type. This is due to differences in the specifications of acoustic instruments used, and differences in water conditions, such as: salinity, depth and temperature.

Although the acoustic system (Hamilton et al 1999) provides useful information, its use requires the ground truth data of the seafloor which is classified by conventional techniques.

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References

- Amiri-Simkooei A R, Snellen M, and Simons D G 2011 Principal component analysis of single-beam echo-sounder signal features for seafloor classification *IEEE J. Oce. Eng.* **36**(2) 259-271.
- Anderson J T, Holliday D V, Kloser R, Reid D G, and Simard Y 2008 Acoustic seabed classification: current practice and future directions *ICES J. Mar. Sci.* **65** 1004-1011.
- Bartholomä A 2006 Acoustic bottom detection and seabed classification in the German Bight, southern North Sea *Geo-Mar. Lett.* **26** 177-184.
- Collins W, and Lacroix P 1997 Operational philosophy of acoustic waveform data processing for seabed classification *Proc. Oceanol. Int.* '97, 1 225-234.
- Costa P L, Madureira L A S P, and de Pinho M P 2013 Seabed acoustic classification in the Pelotas Basin, Brazil", *Brazilian J. Ocean.* **61**(1) 13-22.
- de Pinho M P, Madureira L S P, Calliari L J, Weigert S C, and Costa P L 2016 3D bathymetry and acoustic seabed classification of Pelotas Basin, Brazil *Rev. Bras. de Geo.* **34**(1) 117-128.
- Eleftherakis D, Amiri-Simkooei A R, Snellen M, and. Simons D G 2012 Improving riverbed sediment classification using backscatter and depth residual features of multi-beam echosounder systems *J. Acoust. Soc. America* **131**(5) 3710- 3725.
- Ellingsen K E, Gray J S, and Bjørnbom E 2002 Acoustic classification of seabed habitats using the QTC VIEW system *ICES J. Mar. Sci.* **59**, 825-835.
- Fauziyah, Agustriani F, Purwiyanto A I S, Putri W A E, and Suteja Y 2019 Influence of environmental parameters on the shrimp catch in Banyuasin Coastal Water, South Sumatra, Indonesia *J. Phys.: Conf. Ser.* **1282** 012103
- Fauziyah, Nurhayati, Bernas S M, Putera A, Suteja Y, and Agustriani F 2019 Biodiversity of fish resources in Sungsang Estuaries of South Sumatra *IOP Conf. Ser.: Earth Environ. Sci.* **278** 012025
- Fauziyah, Priatna A, Prakoso W F, Hidayat T, Surbakti H, and Nurjuliasti E 2018 Measurement and analysis of acoustic backscattering strength for characteristics of seafloor sediment in Indian Ocean WPP 572-573, *IOP Conf. Series: Earth Environ. Sci.* **162**, 012024.
- Hamilton L J 2001 *Acoustic Seabed Classification System* Australia: DSTO Aeronautical and Maritime Research Laboratory. pp. 66.
- Hamilton L J, Mulhearn P J, and Poeckert R 1999 Comparison of RoxAnn and QTC-View acoustic bottom classification system performance for the Cairns area, Great Barrier Reef, Australia *Cont. Shelf Res.* **19**(12): 1577-1597.
- Hamuna B, Dimara L, Pujiyati S, Natih N M N 2017 Hambur balik *J. Sum. Akua. Indo.* **1**(2) 23-30.
- Harahap Z A, Manik H M, and Pujiyati S 2010 Acoustic backscatter quantification of seabed using multibeam echosounder instrument *Proc. of the Third Int. Conf. Math. Natur. Sci.*, 911-922.
- Haris K, Chakraborty B, Menezes A, Fedinandes W, and Naik M 2015 Seafloor micro-roughness, benthic macro-fauna, and sediment substrate: A study if their interrelationship using high-freqyuncy echo-sounding *Indian J. Geo-Mar. Sci.* **44**(2) 156-163.

- Kloser R J, Penrose J D, and Butler J 2010 Multi-beam backscatter measurements used to infer seabed habitats *Cont. Shelf Re.* **30**:1772-1782
- Lied T T, Walday M, Olsgard F, Ellingsen K E, and Holm S 2004 SEABEC-A single beam echo sounder seabed classification system *Proc. Conf. Oce. '04, MTS/IEEE Techno-Ocean '04: Bridges Across the Ocean* **4** 2024-2028
- Manik H M 2011 Underwater acoustic detection and signal processing near the seabed, *Sonar Systems*, Nikolai Kolev (Ed), (InTech, Croatia, 2011), pp. 255-273.
- Manik H M 20015 Acoustic characterization of fish and seabed using underwater acoustic technology in Seribu Island Indonesia *J. Mar. Sci.: Res. & Dev.* **5**(1) 157
- Manik H M, Mamun A, and Hestirianoto T 2014 Computation of single beam echo sounder signal for underwater objects detection and quantification *Int. J. Ad. Comp. Sci. App.* **5**(5) 94-97.
- Manik H, Furusama M, and Amakasu K 2006 Measurement of sea bottom surface backscattering strength by quatitative echo sounder *Fish. Sci.* **72**(3) 503-512.
- Monteale-Gavazzi G, Roche M, Lurton X, Degrendele K, Tersleer N, and Lancker V V 2018 Seafloor change detection using multibeam echosounder backscatter: case study on the Belgian part of the North Sea *Mar. Geo. Res.* **39** 229-247.
- Ningsih E N, Supriyadi F, and Nurdawati S 2013 Acoustic backscattering strength analysis to classify riverbed type of Delta Mahakam Water *JPPI* **19**(3) 139-146.
- Penrose J D, Siwabessy P J W, Gavrilov A, Parnum I, Hamilton L J, Bickers A., Brooke B, Ryan D A, and Kennedy P 2005 *Acoustic Techniques for Seabed Classification*, Cooperative Research Centre for Coastal Zone Estuary and Waterway Management, Technical Report 32, 2005), pp. 130.
- Preston J M, Collins W T, Mosher D C, Poeckert R H, and. Kuwahara R H 1999 The strength of correlations between geotechnical variables and acoustic classifications", *IEEE Oce.* **3** 1123-1128.
- Pujiyati S, Hartati S, and Priyono W 2010 Effects of grain size, roughness, and hardness of sea floor on back scattering value based on hydroacoustic detection", *J. ITK Trop.* **2**(1) 59-67.
- Sathishkumar R, Gupta T V S P, and Babu M A 2013 Echo sounder for seafloor object detection and classification *J. Eng. Comp. App. Sci.* **2**(1):32-37 .
- Snellen M, Siemes K, and Simons D G 2011 Model-based sediment classification using single-beam echosounder signals *J. Acoust. Soc. of America*, **129**(5) 2878-2888.
- Zakariya R, Abdullah M A, Hasan R C, and Khalil I 2018 Automatic classification techniques for type of sediment map from multibeam sonar data *IOP Conf. Series: Earth Environ. Sci.* **117** 012047.

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