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Measurement and Analysis of Acoustic Backscatter Value for Bottom Classification of Tidung Island Waters

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Abstract

Sediment in water has an important role for organisms, namely as a habitat, a place for foraging for food, and a place for spawning. These sediments can affect the composition of organisms in the water. The purpose of this study is to calculate the value of acoustic backscatter for the classification of the bottom of the water and to see the effect of sediment grain size on the backscatter value obtained from a single beam acoustic instrument. Data collection was carried out from 10 to 12 June 2021 in the water of Tidung Island, Seribu Islands, using the SIMRAD EK-15 single beam, single frequency 200 kHz instrument. Sediment sampling was carried out at 13 stations. The results showed that the Tidung Island waters were dominated by muddy substrate which was classified based on the Surface Backscattering Strength (SS) value. Meanwhile, the grain size of the sediment affects the SVb value, where the large the grain size of the bottom sediment, the SVb value will be higher. The higher SVb value, the SS value will be higher.

Keywords: Acoustic Backscatter, Bottom Classification, Tidung Island

1. Introduction

Sediment or substrate in a waters has an important role for organisms, such as habitat for benthic organisms, a place for foraging for food, and a place for spawning for some aquatic organisms (Susanto 2000). Research on the bottom substrate of the waters is usually carried out based on physical sampling in the form of corer and van veen grab (Romimohtarto and Juwana 2009). However, this is not efficient because it takes a long time, relatively narrow coverage and limited locations, and requires large costs. One of the appropriate methods to use is by using hydroacoustic technology (Manik et al 2006[a]). The method is based on measuring, analyzing and interpreting the characteristics of signals reflected or scattered on the seabed (Manik et al 2006[b]).

Hydroacoustic is a method of detecting underwater objects using a transducer where this tool will produce sound waves. The wave will propagate in the water medium and hit an object, the sound waves returned by this object will be received by the receiver in the form of an echo (Pujiyati 2008). Each acoustic pulse emitted and reflected by a target contains a variety of information. Each reflection will provide different information according to the morphology of the target. The reflected wave (echo) from the bottom of this water is called the Volume Backscattering Strength for Bottom (SVb) (Hamuna et al 2017). According to Urick (1983), Scattering Strength (SS) is used to quantify scattering originating from the bottom of the water and the surface of the bottom of the water, while Backscattering Strength (SVb) refers to the part of the acoustic wave that is reflected back towards the transmitter in a monostatic sonar system. The hard or soft bottom of the water will have an influence on the intensity of the reflected acoustic signal that is returned. Research on acoustic backscatter on Tidung Island had previously been carried out by Solikin *et al., 2018*, where it was said that MGS was not the only factor that affected the backscatter value but there were other factors such as density and porosity.

The purpose of this study is to calculate the acoustic value of the backscatter for the purpose of classifying the bottom of the water and to see the effect of sediment grain size on the backscatter value. This research is expected to be used as information material to assist decision making in the management of the area and can be used as a database that is still limited.

2. Research Method

2.1 Time and Location

The research was carried out from 10 to 12 June 2021 in the waters of Tidung Island, Seribu Islands. The speed of the ship during the acoustic survey was 4 knots or 7,408 km/hour, sampling at each station was carried out for 10 minutes and the acoustic survey line was parallel.

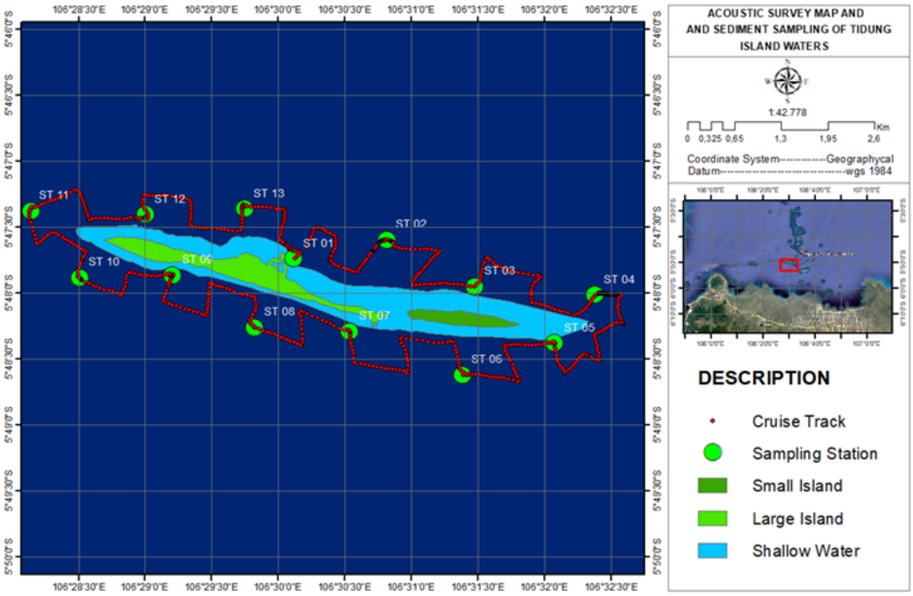


Figure 1. Research Location

2.2 Research Tools

The equipment used at the time of the study was a single beam echosounder SIMRAD EK-15 200 kHz. laptop, Garmin 585 GPS map, fishing boat, grab, and plastic streep. The software used includes EK-15 Software, Google Earth, Echoview 4.0 (Demo), Mircosoft Excel, Microsoft word.

2.3 Acoustic and Sedimentary Data Collection

Figure 2. SIMRAD EK-15

Acoustic data retrieval using a single beam instrument SIMRAD EK-15 200 kHz (Figure 2). Sediment sampling using a grab was carried out at 13 stations (Table 1), the sediment taken was put into a plastic streep and then put into a cool box so that the sample condition was not damaged. After each sampling is carried out, the acoustic data is echoed stationary for 10 minutes. The results of sediment sampling are then analyzed in the laboratory to see their physical properties such as percentage, weight and grain size of the sediment which will be used as in situ data and comparison data from acoustic data.

Table 1. Coordinates for data collection 13 stasions

Station	Longitude	Latitude
01	106.5019524	-5.79561597
02	106.5141273	-5.794783158
03	106.5246374	-5.799122328
04	106.5396314	-5.800195956
05	106.5345907	-5.806323544
06	106.5230503	-5.81032897
07	106.5089718	-5.80485621
08	106.4970745	-5.804301002
09	106.4868032	-5.797717827
10	106.4751438	-5.797995431
11	106.469009	-5.78958356
12	106.4821632	-5.790460471
13	106.4958122	-5.789304957

2.4 Data Processing

The Volume Backscattering Strength (SVb) value of the bottom of the waters was processed using the software echoview 4.0 (Demo). The backscattering data from the SIMRAD EK-15 instrument was analyzed to obtain the Surface Backscattering Strength (SS) value. Threshold used in data processing ranging from -50 dB to 0 dB with ESDU (Elementary Sampling Distance Unit) 50 ping and a thickness of 20 cm. According to Johanesson and Mitson (1983), the formula for calculating SVb is as follows:

$$SV_b = 10 \log \frac{I_r \text{ in units fo volume at a distance of } 1\, m}{I_i} \ldots (1)$$

The Surface Backscattering Strength value is obtained from the relationship between the coefficient Svb and the coefficient Ss (Manik 2011). The beam angle integration value for backscattering volume (ψ) is equivalent to the beam angle for the base surface (ф). This SS value is obtained by the formula:

$$Ss = \frac{c\tau}{2} Sv_b \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2)$$

$$SS(dB) = 10 \log \left(\frac{c\tau}{2}\right) + Sv_b \ldots \ldots \ldots (3)$$

Where :

Φ : Instantaneous equivalent beam angle for surface scattering

ψ : Equivalent beam angle for scattering volume

c : Sound speed

τ : Pulse length

SVb : Volume backscattering strength of Bottom

The type of substrate is determined from the results of laboratory analysis, and can be classified based on the percentage value of the dominant sediment. Meanwhile, the average sediment grain size in (mm) can be calculated by the following formula:

$$\frac{\sum \text{Grain size(mm)} * \text{Weight of each grain(g)}}{\text{Total weight(g)}} \ldots (4)$$

The stages of data collection, data processing, and data analysis are persented in Figure 3.

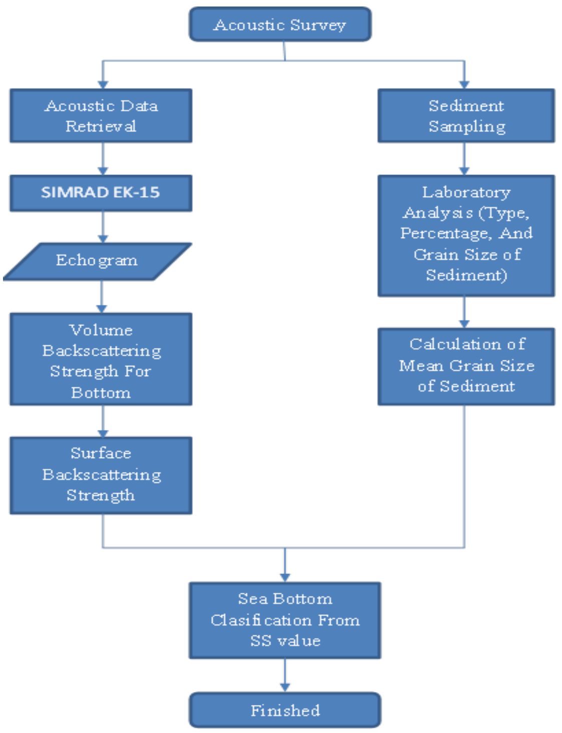


Figure 3. Data Collection, Processing and Analysis Diagram

3. Result and Discussion

3.1 Percentage and Mean Grain Size of Sediment

The results of laboratory analysis of substrate samples from 13 stations (Figure 4) consisted of rubble, shell fragments, gravel fraction, sand fraction, clay fraction, and silt fraction. Based on the percentage of samples taken, the waters of Tidung Island are dominated by the sand fraction. According to Wibisono (2005), the waters of the Seribu Islands are waters where the sediment characteristics are neatly arranged which includes coastal areas, coral, sand and mud. The results of the laboratory analysis are presented in Figure 4.

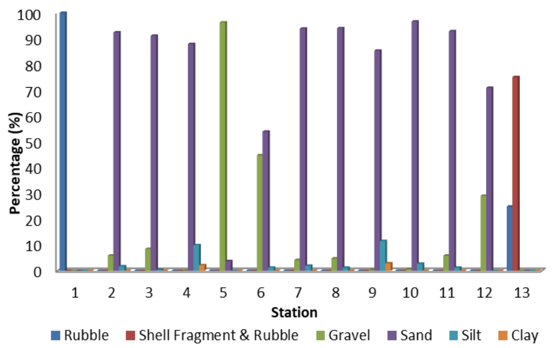


Figure 4. Result of laboratory analysis of sediment samples from Tidung Island waters

Figure 4 shows that the composition of gravel, sand and silt is almost found at every station except stations 1 and 13, and station 5 which only consists of gravel and sand. Station 1 only consists of 1 fraction, namely rubble with a percentage of 100%, then at station 13 there are two types of fractions, namely rubble with a percentage of 24.9% and shell fragment with a percentage of 75.1%. The largest gravel fraction is at station 5 with a percentage of 96.27% and the smallest percentage is at station 4, which is 0.02%. The highest sand fraction was obtained at station 10 with a percentage of 96.66%, and the smallest at station 5 with a percentage of 3.74%. The highest silt fraction is at station 9 with a percentage of 11.49% and the smallest is at station 3 with a percentage of 0.38%. Fractions are only found at two stations. The highest fraction was obtained at station 9 with a percentage 2.88% and the lowest at station 4 with a percentage of 2.13%.

The mean grain size for rubble is 136.57mm, followed by the composition of shells and rubble with a size of 81.13mm. On coarse gravel obtained MGS of 14.33mm, then gravel sand obtained MGS of 2.62mm to 3.90mm. Meanwhile, fine sand has an MGS of 0.58mm to 0.69mm. In the muddy sand fraction obtained MGS of 0.31mm to 0.38mm. At station 10 found a fraction of fine sand with a relatively small MGS of 0.33mm. This is because the dominant composition at station 10 is fine sand and very fine sand. However, the composition of the fraction at station 10 cannot be said to be the muddy sand fraction because at this station only a small silt fraction composition was found, namely 2.96%, while the dominating fraction was the sand fraction, which was 96.66%. The result of the calculation of the mean grain size (MGS) are presented in Table 2.

Table 2. Result of calculating mean grain size

ST	Depth(m)	MGS(mm)	Description
1	37.02	136.57	R
2	41.72	0.69	FS
3	43.14	0.89	RS
4	54.67	0.31	MS
5	30.08	14.33	CG
6	71.29	3.90	GS
7	33.94	0.58	FS
8	58.44	0.80	RS
9	28.80	0.38	MS
10	63.96	0.33	FS
11	34.90	0.61	FS
12	36.56	2.62	GS
13	48.48	81.13	SFR

Information:
R : Rubble
SFR : Shell Fragment & Rubble
CG : Coarse Gravel
GS : Gravel Sand
RS : Rough Sand
FS : Fine Sand
MS : Muddy Sand

3.2 Surface Backscattering Strength

The echogram of surface backscattering strength data procesing presented in Figure 5. The data is processed using the echo integration method with a threshold value of -50 dB to 0 dB. Bottom line is obtained by digitizing each pixel and integrated every 50 pings with a thickness 20 cm.

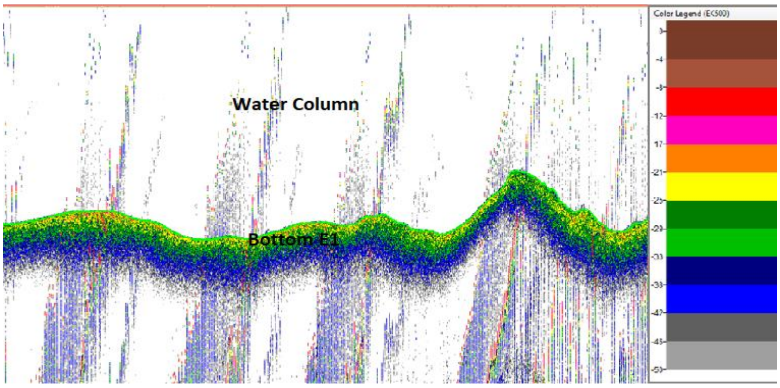


Figure 5. Echogram Surface Backscattering Strength

The result of the SS value are persented in Table 3. The calculation results show that the highest SS value is obtained from the rubble substrate, which is -13.22 dB. then followed by the composition between shell fragments and rubble with an SS value of -15.96 dB. On coarse gravel substrate, the SS value is 17.72 dB. Gravel sand obtained SS values from -18.21dB to -18.19 dB. Meanwhile, the fine sand fraction obtained SS values from -22.87dB to -18.21 dB, and the muddy sand fraction obtained SS values from -25.09 dB to -24.84 dB.

Table 3. Calculation result of Surface Backscattering Strength (SS)

Station	Sound speed (m/s)	cτ/2	SV_B (dB)	SS (dB)	Keterangan
1	1540.01	0.246402	-7.14	-13.22	Rubble
2	1540.65	0.246504	-13.48	-19.56	Fine Sand
3	1540.66	0.246506	-12.31	-18.39	Rough Sand
4	1542.76	0.246842	-19.01	-25.09	Muddy Sand
5	1542.88	0.246861	-11.65	-17.72	Coarse Gravel
6	1542.88	0.246861	-12.11	-18.19	Gravel Sand
7	1543.17	0.246907	-13.81	-19.89	Fine Sand
8	1543.04	0.246886	-12.38	-18.46	Rough Sand
9	1543.08	0.246893	-18.76	-24.84	Muddy Sand
10	1541.93	0.246709	-16.79	-22.87	Fine Sand
11	1542.74	0.246838	-13.53	-19.60	Fine Sand
12	1542.72	0.246835	-12.14	-18.21	Gravel Sand
13	1539.95	0.246392	-9.88	-15.96	Shell Fragment &Rubble

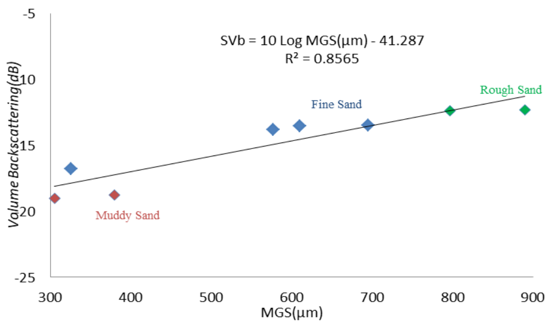
This research has been carried out by previous researchers, some of which are presented in Table 4. The results of previous researchers showed that the larger the grain size, the higher the SS value obtained. This statement was also expressed by Manik et al, (2006a). In addition, the coarser and harder a substrate detected by an acoustic instrument, the higher the reflection value or backscatter given by the bottom of the water (Hamilton 2001). The factor that affects the size of the backscatter value from both E1 and E2 in addition to grain size is depth (Siwabessy 2001).

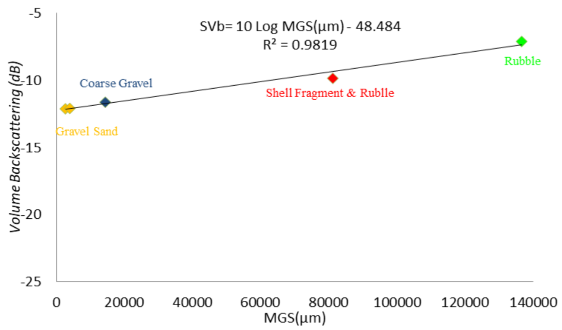
Table 4. Research on Previous Surface Backscattering Strength

Name	Year	Tool	Location	SS(dB)
Manik	2006	Quantitative Echosounder, Multibeam	Indian Ocean	Sand :-18.30 Sandy Mud :-23.40 Mud : -29
Purnawan	2009	SIMRAD EY 60 Splitbeam	Pari Island	Sand:-16.35
Zulham	2010	SIMRAD EM3000 Multibeam	Aceh waters	Sand :-19.19 Muddy Sand :-19.54 Sandy Mud :-21.89 Mud :-26.96
Taruk Allo	2011	SIMRAD EY 60 Splitbeam	Pramuka Island Panggang Island Semak Daun Island	Sand :-13.23 Muddy Sand :-21.15
Ningsih	2013	SIMRAD EY 60 Splitbeam	Mahakam Delta, East Kalimantan	Sand -12.97 Muddy Sand :-13.96 Sandy Mud :-17.14 Mud -30.87
Hamuna	2018	Single beam Echosounder	Tami Estuary, Enggros, Kosong Island	Mud :- 46.98 to -45.16 Fine Sand : -37.48 to -37.19 Sand :-37.10 to -36.03
This Research	2021	Single beam Echosounder	Pari Island	Rubble :-13.22 Shell Fragment and Rubble :-15.96 Muddy Sand : -25.09 to -24.84 Fine Sand :-22.87 to -19.56 Rough Sand :-18.46 to -18.39 Gravel Sand :-18.21 to -18.19 Coarse Gravel :-17.72

3.3 Relationship between SVb and MGS

According to Manik (2011), the value of Surface Backscattering Strength (SS) is obtained from the relationship between SVb and the coefficient Ss. So the value of SVb can affect the value of SS. Meanwhile, the SVb is influenced by the grain size of the sediment, where the larger the grain size of the bottom sediment, the higher the SVb value (Pujiyati 2010). The relationship between grain size and SVb value is presented in Figure 6.





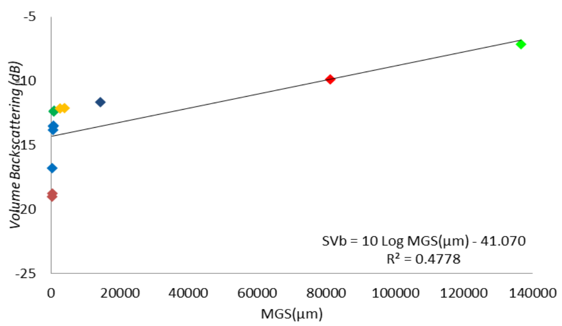


Figure 6. SVb Relationship with MGS(μm)

Figure 6a shows the relationship between the grain size of the sediment below 1000μm and the value of SVb. The results of this relationship obtained a coefficient of determination of R^2 = 0.8565, which means that this MGS has a contribution of 85.65% to the SVb value which can be proven by the presence of a formula $SV_b = 10\log MGS(\mu m) - 41.287$. Meanwhile, Figure 6b shows the relationship between grain size above 1000µm and the value of SVb. From this relationship, the coefficient of determination is R^2 = 0.9819, which means that this MGS has a contribution of 98.19% to the SVb value. this can be proven by the formula $SV_b = 10\log MGS(\mu m) - 48.484$. Figure 6c presents the relationship between grain size of all sediment types and the value of SVb, where the relationship is obtained by the coefficient of determination of R^2 = 0.4778, which means that the MGS of each sediment type has a contribution of 47.78% to the SVb value.

The value of the coefficient of determination is relatively smaller than the previous 2 graphs, because in graph 3c it presents the relationship of SVb with the grain size of the sediment which has a large size variation between one sediment type and another. However, the results of this research prove that the larger the grain size of the bottom substrate, the higher the Backscattering for Bottom Volume value (Pujiyati 2010). However, this grain size does not always contribute in all cases. But it depends on other sediment physical parameters, such as density and porosity (Solikin et al, 2018).

3.3 Horizontal Distribution of Sediment

Horizontal distribution map of substrate types is presented in (Figure 7). The figure shows that the type of bottom substrate of Tidung Island waters varies greatly, starting from a very large size (rubble) to a very small size (mud). The classification results based on this SS value show that the waters of Tidung Island are dominated by mud substrate. The SS value for this mud seen from previous researchers ranges from -26 dB to -50 dB. On line transect one between stations one and two is dominated by rubble. Then in the East also found the type of rubble. Meanwhile, in the southern part, the types of substrates were found starting from fine sand, muddy sand and mud. Then the north west is dominated by coarse sand.

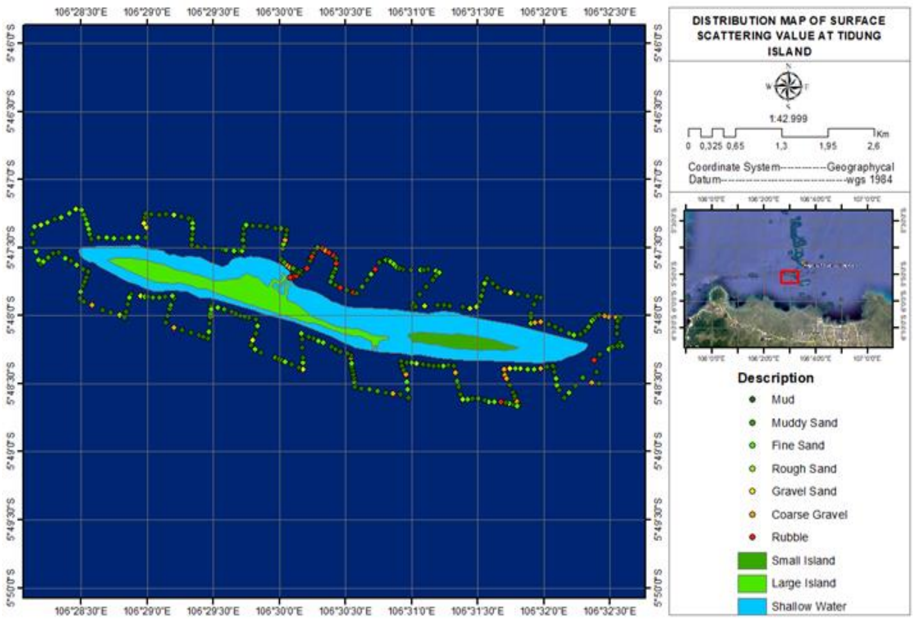


Figure 7. Classification Map of The Distribution of Substrate Types Based on the Value of Surface Backscattering Strength

The type of substrate classified by the SS value is close to the results of Suman et al, (2011), that the type of substrate in the waters of Tidung Island consists of coral reefs from a depth of 1 to 5 meters, then at a depth of 7 meters the bottom slope of the waters is 30^0, and at a depth of 20 meters more visible again the average muddy sand substrate and a little bit of live coral. According to Wibisono (2005), the sediment characteristics of the Seribu Islands include coral, sand and mud.

4. Conclusion

The results of this research can be concluded that the Volume Backscattering Strength (SVb) value is strongly influenced by the grain size or Mean Grain Size (MGS) where the larger the grain size of the bottom sediment of the water, the value (SVb) will be higher, and the smaller the size of the bottom sediment. waters, the value (SVb) will be lower. However, the SS value from previous researchers is different because there are several other factors that affect this SS value. From the calculation of the SS value, the waters of Tidung Island are dominated by mud substrate and followed by muddy sand substrate.

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