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A Study of Acoustic Propaties of Surface Seabed Sediment at the Ariake Sea

有明海における表層堆積物の音響特性

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1. Introduction

Assessment of the impact on coastal environments caused by global warming has mainly been done so far based on disappearance of sandy beach areas by sea surface elevation, and changes of biota by elevated water temperature. However, it is required to carry out composite environmental assessment to understand unequivocal ongoing global warming. At the boundary of water and seabed, there are mixed layer with water and particle of sediments. The particle includes not only sand, mad, silt but also organic matter such as plankton and algae. The thickness and density of the boundary area effect benthic ecosystem. Therefore, it is important to monitor temporal and spatial change of the boundary configuration. Acoustic is one of the best methods for underwater monitoring.

Multipath transmission is one of the major reasons to deteriorate of underwater sound communication[1, 2]. Usually, reflected waves arrives a receiver after the direct signal from a source. But in case of short travel distance or very shallow area, there is not so much time lag between the direct signal and the reflected signals. Therefore, as reflected signals overlap with the direct signal, signal-to-noise ratio decrease because of reflected signals. Sometimes, as coherent with reflected signals and a direct signal makes destructive interference, sound signal from the source cannot be received at the receiver[3]. It is very important to understand how much the reflected signals affect to the main direct signal. Calm sea surface could be assumed as a mirror acoustically. According to the sea state or wind speed, many approximate formula or sea surface model were studied to explain the effect of sea surface reflection and scattering[4, 5]. The same methods are also applied to understand the sea bottom reflection[6]. But as the sound propagation of the sediment at the bottom sometimes very similar behavior to sea water especially the sediment consists with mad and contained much water. Moreover, some sound wave incident into the sediment and refracts upper side then they re-enter to the sea water. To understand such behavior of the sound at the sea bottom, it is necessary to know acoustic characteristics such as sound speed, sound attenuation of the sediment and their dependency of the depth from the sea bottom.

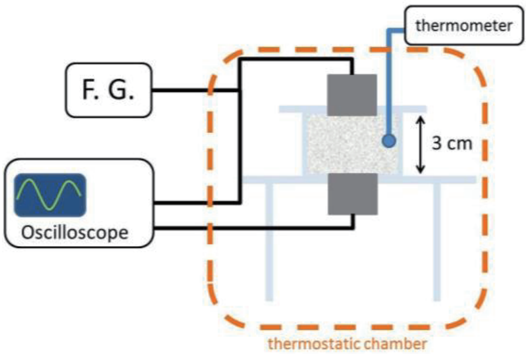

Fig. 1 A diagram of sediment sound speed measuring system.

2. Figures and Tables

In this study, acoustical characteristics, especially the sound speed changes according to the density of sediment matters in water are the most interesting topic. As the obtained sample includes different grain size sediment, authors decided to compare the difference between the upper side and the lower side of the sample. Therefore, a new measurement system to sound speed of a sample in a 4 cm diameter cylinder with 3 cm height is required. Figure 1 shows a diagram of the sound speed measurement system. A transmitter and a receiver (KGK: 2 MHz) were faced each other across the sample with 3 cm distance fixed with acrylic pipe which has the same diameter and thickness to that of used at the core sampling. As sound speed varies according to temperature, it is important to control temperature of the sample. Therefore, a part of the measurement system including the sample which is indicated by dashed line in Fig. 1 was put into an incubator to control the temperature but it was broken in this experiment. To monitor temperature changes of the sample, a

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K-type thermocouple was inserted into the sample from the upper side of the pipe. The burst signal was sending from the transmitter and received at the receiver located opposite side of the pipe. The career frequency was 2 MHz which is resonance frequency of the transmitter and the receiver. Both sending and receiving signals were monitored by an oscilloscope (Agilent: 33220A) to measure travel time. After recording the receiving signal through the oscilloscope, peak time was measured as the difference of phase from oscilloscope monitor.

3. Results

At the boundary layer, small size particles mast float with some density distribution. To recreate the boundary layer, add the sediment of the smallest particle size into water of 70 ml and stir it for 1 min. Then the liquid put into the acrylic pipe and measured travel time. The travel time measured 5 times and took their average to calculate sound speed. Unfortunately, the thermostatic chamber could not keep temperature with some trouble, the liquid temperature was not same throughout the all experiment. As the temperature also affect the sound speed, Figure 2 shows ratio to pure water at the measured temperature. The sound speed of the pure water was calculated from UNESCO equation[7]. From Fig. 2, sound speed clearly decreases when the sediment weight percentage increases.

In the same way, sound attenuation of received signal to the sending signal was monitored as shown in Figure 3. When the added sediments amount over 15‰, the received signal could not confirm from the oscilloscope. As the density of the particles increase, sound scattered and could not reach to the receiver side.

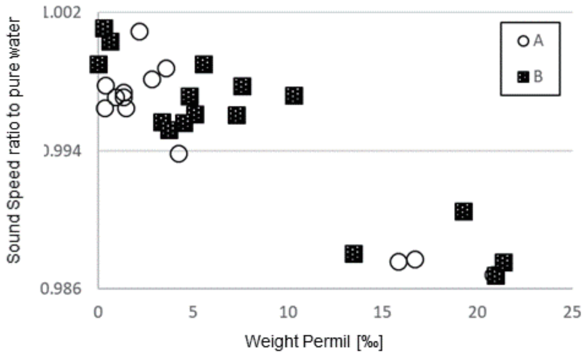

Fig. 2 Estimated sound speed according to the weight permil.

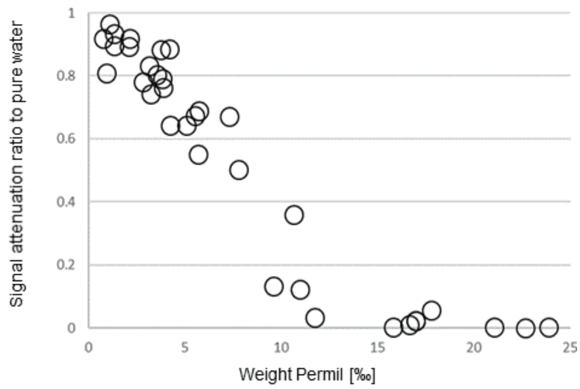

Fig. 3 Ratio of liquid sound speed to pure water according to the weight permil.

4. Conclusion

In this paper, the grain size distribution of the Ariake Bay was investigated and measure the acoustic properties with frequency of 2 MHz. In this method, it is possible to measure sound speed and attenuation according to the contained sediment amount. As it was measured only single frequency, we will carry out the same experiment with different frequency. Also, as the contained sediment material was limited the particle size, more close-to-reality contamination is better for future experiments.

Acknowledgment

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