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A Study in Acoustic Monitoring of Small Change at Sea Bottom
海底地形の時間的な微小変化に関する基礎的検討

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1. Introduction

The bottom boudary layer at shallow water is always changes according to the biolologycal activities, water flows above the boundary, and sediment deposition. Suspended particl materials at the bottom boundary affect the biogeocenosis around the area. Recentrly, the distribution or sediment deposition will be changing according to the climate changes. Tanaka et al. shows the distribution of seaweeds around Japan under multiple climate change scenarios[1]. As the climate change increases turburance at the sea, the movement, special and temporal distribution, the size of the particle or bulk will change and these changes affect biogeocenosis. The suspended particl include organic matter such as detritus, the environment at the bottom boundary become contaminatedf by those suspended particl. Therefore, it is important to understand how those sediments move or suspend at the sea bottom. There are some reports to moniotr the organic matter[2,3]. Hibino et al. showed the physical and chemical states in the oarganic matter sediment at Hirsohima Bay from several core sampling[2]. The depth of boundary layer changed with the seasonal variations of fiscal from the results of core sampling. But it is still unknown that how the organic matter or suspend particle occure or become deposited temporally.

Authors have measured ocean environment from the reciprocal sound propagation for several years at Hashirimizu Port in Yokosuka, Japan. The distance between the two transducers was about 120 m and the depth at the experimental area was less than 7 m. From some analysis of the experimental result, sea level change by tidal effect and large temperature gradient at the sea surface effected sound path between the two transeivers[1-3]. However, many reflected waves were monitored and there were many interfere between the direct path and reflected paths. It is required to understand more about sediment acoustic charactaristics. When the core sample at Hashirimizu Port was obtained, there was floating object which was hard to categolize sediment. This was a kind of boudary layer as mentiond above. At that time, those object was included as other sediment. In this resarch, we will focus on the floating object and discuss the potential of acoustic monitoring of the bottom boundary layer especially for the temporal thickness changes.

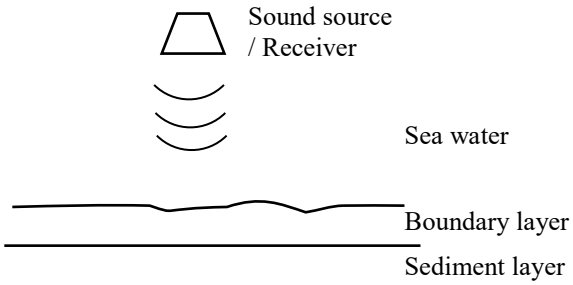

Fig. 1 The setting of the boundary bottom layer monitoring.

2. Sediment Constitution

It is necessary to clear what kind of the sediment we are going to monitor. As it may be different according to the area of the monitoring, the measurement data in Ref. 2 is referred for the first step. The bottom boundary layer consists mainly from sea water but it contains much of small particles including organic matter. The particle grain size is very fine like silt or mud. According to Ref. 2, floating mud at the boundary layer defined as that the weight percentage of sand in the boundary layer is less than 0.5%, wet density is less than 1.17 g/cm^3, and the water content is more than 400%. The depth of the bottom boundary layer varies according to the area and time. In Hiroshima Bay, it was thin at the mouth of a river and thick at the closed-off section of bay. In this study, Hashirimizu Port is assumed for the monitoring area. The thickness of the boundary layer supposes less than 10 cm. In the first sediment analysis[5], the bottom layer was classified as sand or sandy loam. The density of the sediment was about 2.82 g/cm^3 in average and the porosity was about 40%. Although the measured sound speed at the sediment

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has discrepancies because of measurement system trouble, it was about 1560 to 1670 m/s.

3. Monitoring Concept

From an idealistic viewpoint, it is the best to monitor the distribution and thickness of the boundary layer in wide area at one time like imaging sonar. But as the acoustic characteristic is unknow about the organic matter sediment, we suppose very simple situation as shown in Fig. 1. The sound source located in the same place and they faced the sea bottom in front with the incident angle 0^{o}. The back scattering is monitored with the receiver which locates at the same place of the sound source. The surface of the boundary layer and the sediment layer are supposed as flat. Sonar equation is defined as

$$SL-2TL+TS = NL-AG+DT \quad (1)$$

where, SL is sound source level, TL is transmission loss, TS is target strength, NL is noise level, AG is receiver's gain, and DT is detection threshold. Transmission loss include absorption loss at sea water, attenuation loss of sound diffusion, and attenuation loss at sediment material or organic matters. The attenuation loss in the turbid water depends on the particle size and density. If the particle size is uniform in the water, the attenuation loss α in the water defined as

$$\alpha = \varphi(712\cdot10^{-24}f^{4}(20a)^{3}+0.143\cdot10^{-3}f^{1/2}/20a) \quad (2),$$

where f and φ are sound frequency and ratio of the particle volume in the water, respectively[6].

If the other conditions except the depth of the organic matter are constant and not change at all, the back scattering or transmission loss changes only by the characteristic of the boundary layer. Therefore, the attenuation changes the depth of the boundary layer X, and transmission loss varies as αX. The particle size a at the boundary layer is unknown at this moment but they are very fine mud, $a < 0.0075$ mm.

4. Conclusion

In this research, we suggest the importance of understand the property in the boundary layer consists of organic matter. The amount of the boundary layer changes according to the season or water condition at the sea bottom, but it has not been clear how and why occurred. The acoustical method to monitor the boundary layer will be one of the solution to reveal this phenomenon. As the organic suspended matter was precursor of the sediment, it includes various size of the particles and some of them include stringy matters. Thus, the target strength may not be estimated as the bulk of the single size particle. It is required to research these conditions to reveal the acoustic character of the boundary layer. The suitable frequency for monitoring and sound power will be determined for the next step at the tank experiment.

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