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Bottom sand waves influence on low-frequency propagation in shallow water environment

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1. Introduction

For understanding characteristics of acoustic propagation in shallow water environment, reliable geoacoustic data such as bottom composition, topography, and sediment layer are necessary in theoretical and practical approach. As the full data acquisition, however, is limited in the field, it has applied to simplify the geological structures in most cases [1]. The simplification of the environment variable is limited on the analysis of the acoustic propagation and theoretical verification of the measured data in shallow water.

The study area was Yellow Sea that it has a well-developed shallow continental shelf and especially strong tide. The seabed due to the strong tide has been formed various bed-form (ripple, sand wave and sand dune) along direction and strength of the tide [2]. Unlike water-sediment interface with flat bottom, the sand wave and sand dune have a strong influence on acoustic propagation, reflection and scattering.

In this paper, we present the effects of low-frequency sound waves caused by sand wave zone with the acoustic transmission loss data measured in shallow waters.

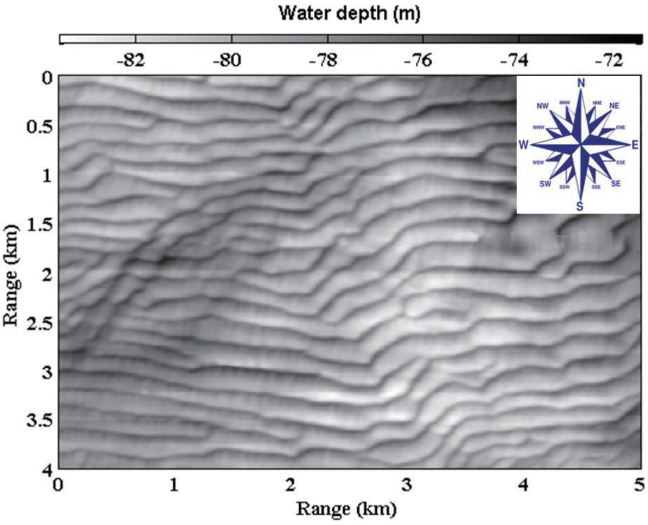

Fig. 1 An example of bathymetry measurements around the study area using the multi-beam echo sounder. The principal tidal direction is from north to south.

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2. Field Measurements

2.1 Geological surveys

Yellow Sea is generally known that diverse seafloor formed due to an impact of strong bottom current. In order to investigate the effect of bottom sand wave affecting on low-frequency propagation, intensive geological surveys were performed to measure the geoacoustic properties of the study area using multi-beam echo sounder (EM710), sub-bottom profiler (Chirp III), sparker system (SIG 2 mile), and sediment grab sampler. **Figure 1** shows an example of the high-resolution bathymetry around the study area 5 x 4 km (20 km^2).

As both strong tidal current speed and direction have consistently affected the seafloor of this region, bottom sand waves with wavelengths of about 200 m and wave heights of 4-10 m were formed perpendicularly to the tidal direction. And average depth is about 78 m. The analysis results of the grain-size distribution estimated from grab sampling showed that the surficial sediment consisted of gravelly muddy sand, with a grain-size ranged between 0.5 and 2.0 ϕ.

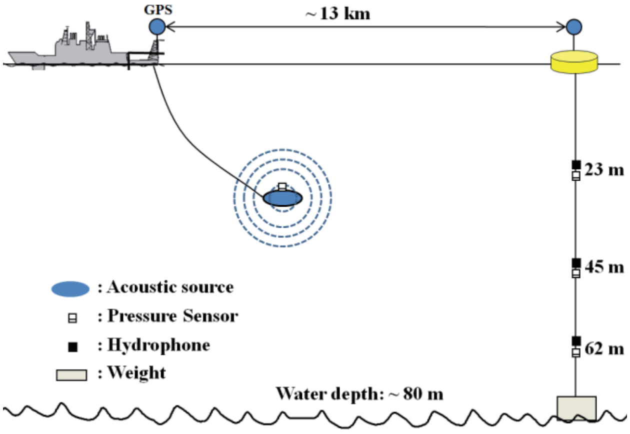

Fig. 2 Experimental geometry for measuring the low-frequency transmission loss. Pressure sensors are attached to both an acoustic source and receivers to measure the precise mooring depth of those.

2.2 Acoustic Measurements

The acoustic observations were made on March 2011 within the region where the geological surveys were conducted. For the measurements, the acoustic source was low-frequency tonal signals (<

1 kHz) and was deployed from the stern of R/V EARDO at depth 30 m in **Fig. 2**.

The transmitted signals from the source were received with vertical hydrophone array, and receiving depths were 23, 45, and 62 m, respectively. From CTD data measured simultaneously with acoustic experiment, the sound speed was vertically same value with approximately 1466 m/s, and then wind speed was 5 m/s.

Figure 3 shows acoustic receiving signals expressed a power spectral density (PSD) with 1 Hz band. The distance between source and receiver was approximately 3.8 km, and frequency of the transmitted signal was 75, 100, 175, 200, 350, 400, and 700 Hz, respectively. The PSD value with frequency and receiving depth varied between 2 and 8 dB and totally the value was higher at receiver with mid-depth.

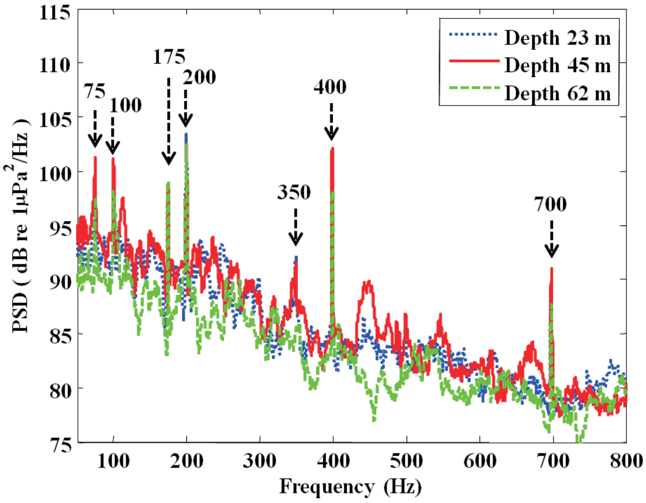

Fig. 3 Power spectral densities for received signals measured using 3 hydrophones. Each spectral peak corresponds to the transmitted frequencies.

3. Results and discussion

Figure 4 shows a result that transmission loss with range measured with 175 and 400 Hz (hydrophone depth 23 m) compared with coherent transmission loss calculated from an acoustic model, OASES (Ocean Acoustics and Seismic Exploration Synthesis) based on the wave-number integration [3].

As an input parameter for acoustic model, we used sound speed profiles measured from the field experiment. At the same time, we considered with two assumptions; (1) bathymetry information is flat bottom condition without sand wave condition, and (2) bottom layers have 3 layers above half space from measured data.

Comparing between model and measurement in Fig. 4, transmission loss ranged between 4.0 and 4.7 km was relatively low, because source signal didn't transmit at the ranges. At the 175 Hz that is relatively low-frequency, transmission loss of the acoustic measurement was almost similar with that of the theoretical model, and modal interference for both transmission losses showed similar patterns. On the contrary, at the 400 Hz that is relatively high-frequency, transmission loss obtained from the acoustic measurements was slightly low than that from theoretical model. These differences might be caused by reduction of the forward energy from acoustic scattering effects due to sand wave of the upper bottom. In the acoustic experimental area, rms (root mean square) height and wave length of the sand wave were 1.0 m and approximately 200 m, respectively.

These bottom environments such as sand wave and sand dune have a strong influence on acoustic transmission loss and scattering at higher frequency.

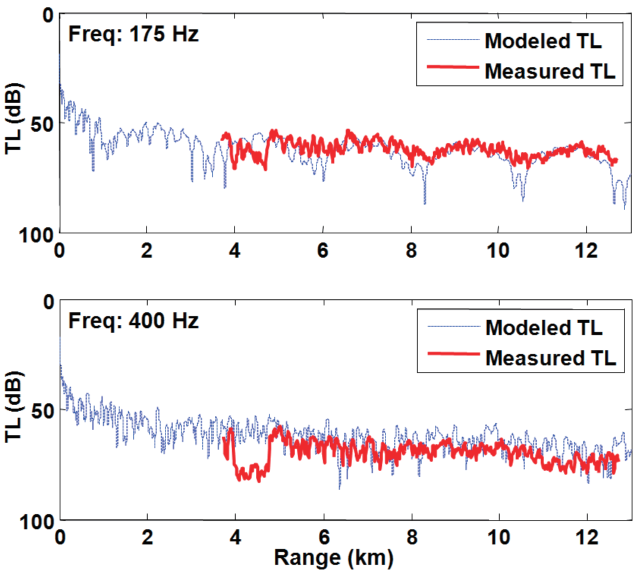

Fig. 4 Comparison of experimental and theoretical range-independent transmission loss at 175 (top) and 400 Hz (bottom).

Acknowledgment

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References

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