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Underwater Acoustic Communication Channels at Two Different Bottom Types

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1. Introduction

Acoustic multi-paths generated in shallow water waveguide produce a significant delay spreading of transmitted signal, which is referred to as ISI (Inter Symbol Interference). Because the ISI results in distortion of communication signals, many studies have used several equalizer techniques to reduce the effect of ISI. Nevertheless, it remains difficulty to estimate communication performance in spatial and temporal variations of communication channel in shallow water. In this study, the communication channel is estimated using the RMS (Root Mean Squared) delay spread [1] and E_1 [2]. The purpose of this study is to investigate the effects of bottom components of seafloor on communication performance

In this study, the degree of time dispersive channel was estimated using two factors; the RMS delay spread and E_1. The RMS delay spread is defined as a measure of the frequency selectivity of a channel, and calculated as functions of the arrival time and energy of multi-path [1]. E_1 is defined as a cumulative energy of channel impulse response included in one symbol [2]

2. Field Measurements

Experiments for underwater acoustic communication were conducted in two different seafloor environments; sandy clay sediment (southern coast of Korea in May 2012, water depth of 45 m) and sand sediment (eastern coast of Korea in April 2015, water depth of 60 m).
An omnidirectional transducer was used as a source, which was deployed at depths of 30 and 32 m for the southern and eastern coasts, respectively. Communication signals were received by four channel receiving array, which covered waters 5–35 m in depth for both cases (Fig 1).

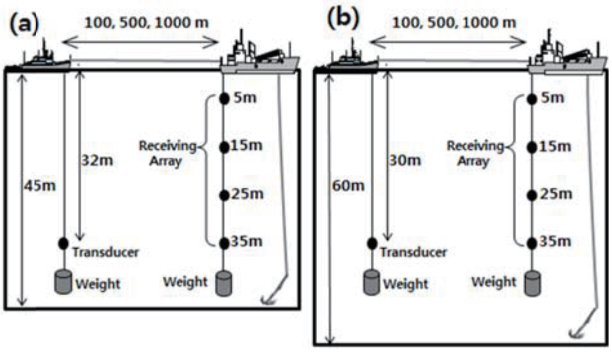

Fig. 1. Experimental layouts of underwater acoustic communication measurements for (a) southern coast and (b) eastern coast of Korea.

Sound speed profiles were measured by CTD (Conductivity-Temperature-Depth) casts during the experiment periods. The sediment components for both sites were analyzed from grab samples (Fig 2). The mean grain sizes of eastern and southern coasts of Korea were 2.7 and 7 ϕ, respectively, which is referred to as hard and soft bottoms hereafter.

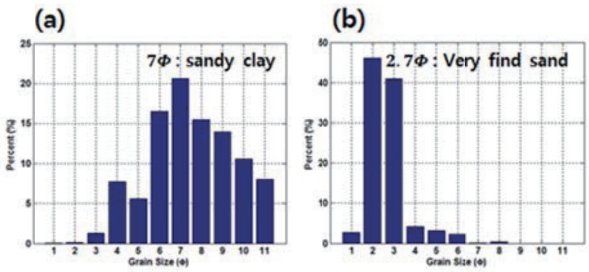

Fig. 2. Grain size distributions of sediments in (a) southern coast (soft bottom) and (b) eastern coast (hard bottom).

Communication signal configuration consisted of 13–17 kHz LFM probe signal, followed by a pause lasting 0.5 s, and followed by BPSK signals with a center frequency of 15 kHz and a symbol rate of 500, 1000, and 2000 symbols per second. The communication experiments were performed at

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Correspondence to J. W. Choi :choijw@hanyang.ac.kr source-receiver ranges of 100, 500, and 1000 m for both cases.

4. Results

Fig. 3 shows channel intensity impulse responses (CIIR) for hard and soft bottoms. The CIIRs were estimated by matched-filtering with the LFM probe signals.

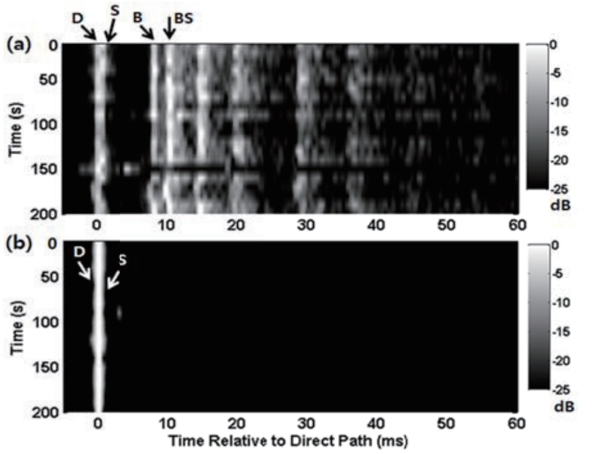

Fig. 3. CIIRs at source-receiver range of 500 m and at receiver depths of 15 m in (a) eastern coast (hard bottom), (b) southern coast (soft bottom). D, S, B, and BS indicate direct, surface, bottom, and bottom-surface paths.

The bottom of the eastern coast is more reflective bottom, producing significant multi-path time dispersion and therefore causing severe ISI in communication. In contrast, southern coast is characterized by a non-dispersive channel, where only direct and surface paths propagated for the source-receiver range of 500 m.

Figure 4 (a) and (b) show the communication performance in terms of BER as function of E_1 for hard and soft bottoms, respectively. In both cases, the BER performance improved as E_1 increased. However, the performance in soft bottom is improved more rapidly than that in hard bottom. Figure 4 (c) and (d) show the BER performances as function of the RMS delay spread for hard and soft bottoms, respectively. The BER performance improved as RMS delay spread decreased in both cases. In conclusion, out results imply that E_1 and the RMS delay spread have correlations with the communication performance.

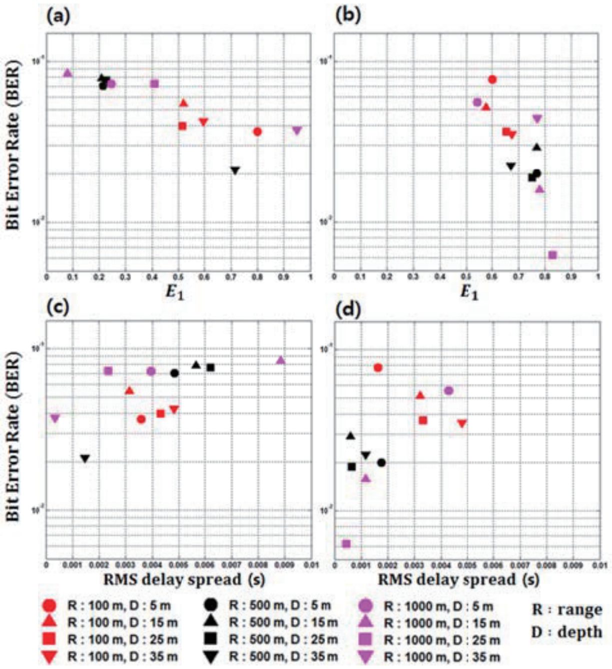

Fig. 4. Communication performances in term of BER as a function of E_1 for (a) hard and (b) soft bottoms, respectively. (c) and (d) are the performance results as a function of the RMS delay spread for (c) hard and (d) soft bottoms, respectively.

Acknowledgment

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References

1. J. G. Proakis: *Digital Communications*, 3rd ed. (McGraw-Hill, New York, 1995) p. 640.
2. S.-U. Son, H. Kim, J. Joo, and J. W. Choi: Jpn. J. Appl. Phys. 52 (2013) 07HG03