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Preliminary Analysis for Transient Event of Target Scattering on Ambient Noise Imaging with Acoustic Lens

音響レンズを用いた周囲雑音イメージングにおけるターゲット散乱波の過渡的事象の解析

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1. Introduction

Buckingham *et al.* developed a radical idea, which views ambient noise as a sound source rather than a hindrance, and which is neither a passive nor an active sonar. [1] This method is often called ambient noise imaging (ANI), and some experimental systems incorporating ANI have been built. The Acoustic Daylight Ocean Noise Imaging System, consisting of a 3 m diameter spherical reflector with an array of 126 hydrophones attached to the focal surface, was built by Epifanio *et al.* [2] Recently, the Remotely Operated Mobile Ambient Noise Imaging System (ROMANIS), consisting of a 2-D sparse array of 504 hydrophones fully populating a 1.44 m circular aperture, was built by Venugopalan *et al.* [3] Both systems successfully detected silent target objects under snapping shrimp dominant noises.

On the other hand, an acoustic lens system would be a powerful choice for realizing ANI, because such a system would not require a large receiver array and a complex signal processing unit for two-dimensional beam forming, which could reduce the size and cost of the system. In our past studies, we analyzed a sound pressure field focused by an acoustic lens constructed for an ANI system with a single spherical biconcave lens or a single aplanatic lens using the 2-D and 3-D Finite Difference Time Domain method and the small scale trial in water tank. Our aim was the development of a lens with a resolution similar to the beam width of ROMANIS, which is 1° at the frequency of 60 kHz. These results showed that the lens with the aperture diameter of 2.0 m has the sufficient resolution. [4-6]

We already designed and made an aspherical lens with an aperture diameter of 1.0 m for ANI. It was verified that this acoustic lens realizes directional resolution, which is a beam width of 1° at the center frequency of 120 kHz over the field of view from -7 to +7°. [7] Here, the silent target detection trial was conducted under only ocean natural ambient noise. The received signals were classified roughly into silent periods and transients. In this study, we proposed a classification method to extract transients of only target scatterings, and preliminary analysis results were reported.

2. Experimental Setup

The equipment was deployed through the barge "OKI SEATEC II", which was moored at Uchiura Bay. The water depth at this location is a nominal 30 m. The experimental setup conducted on November of 2010 is shown in **Fig. 1**. The prototype imaging system constructed with the acoustic lens and hydrophone array were suspended from the end of the barge. Here, fifteen hydrophones corresponding to the angles of look directions of -7, -6, …, +7° were arranged on the focal plane. Focusing any object range is achieved by shifting the hydrophone array from 1.0 to 1.5 m at the origin, which is the center of the lens. The aluminum panels of Target A and B attaching pingers were suspended. The distance between the lens and each target was about 30 and 15 m, respectively. The center axis was aligned by adjusting the rotation angle and by shifting the hydrophone array so that the amplitude voltage of the hydrophone output corresponding to 0° of the angle of look direction is maximized. The pinger was stopped when the target detection trial was conducted.

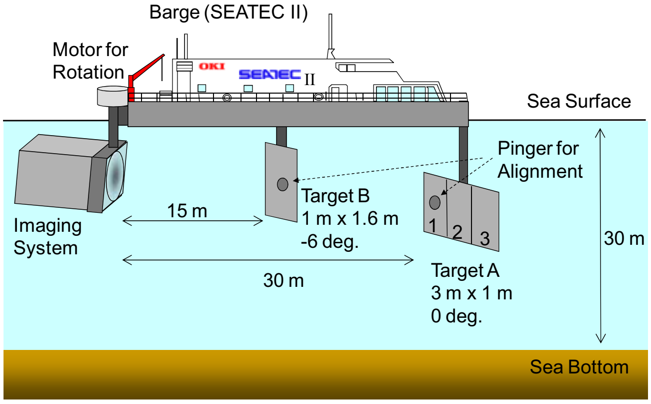

Fig. 1　Experimental Setup

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3. Classification Method and Preliminary Analysis Results

An example of transient of target scattering is shown in **Fig. 1**. We can see the transient pulses at the look directions around 0°. Like this example, many transients of target scatterings were received by the hydrophones corresponding to the target direction through the lens. However, much more transient noises were directly received by all hydrophones without the lens because the soundproof boards were not attached around the hydrophone array. Their amplitudes were similar values in all look directions. Also their received time were similar values. We proposed a classification method to extract transients of only target scatterings satisfying three conditions as described below.

- The received amplitude is over 136 dB re 1 μPa.
- The difference of maximum amplitudes between hydrophones is greater than 10 dB.
- The difference of times at maximum amplitudes between the neighboring two hydrophones is greater than 14 μs.

Figure 2 shows band levels vs. look direction for extracted transients of target scatterings. Here, the top 15 levels (dotted lines and circle marks) and the maximum (solid line and asterisk marks) are drawn. The band level was calculated by the mean value of spectrum level from 60 kHz to 200 kHz. We can see that the band levels of the on-target directions are greater than those of the off-target directions. The preliminary data analysis results as of this writing shows that the target scatterings are successfully detected.

Acknowledgment

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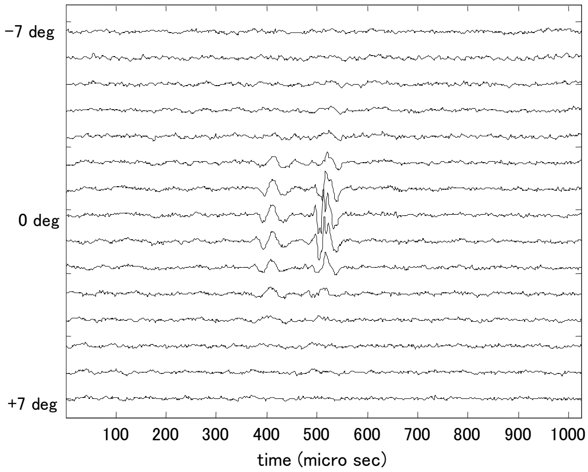
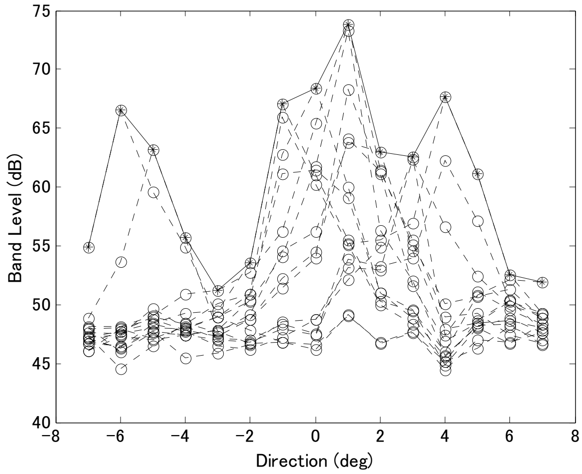
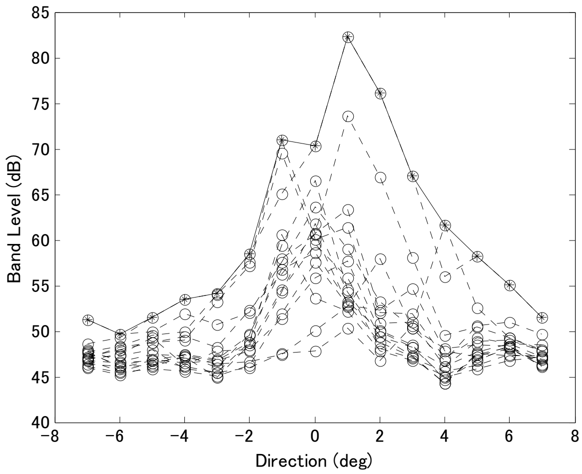


Fig. 1 Example of transient of target scattering



(a) Band level for arranging Target A and B



(b) Band level for arranging Target A only

Fig. 2 Band level vs. look direction for classified transients as target scatterings.