3P6-1

The 3rd Sea Trial for 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の第 3 回実海域試験

Kazuyoshi Mori[1†], Hiroyuki Kawahara[1], Hanako Ogasawara[1], and Takenobu Tsuchiya[2]
([1]National Defense Academy; [2]Kanagawa Univ.)
森　和義 [1†]，河原宏幸 [1]，小笠原英子 [1]，土屋健伸 [2] ([1]防衛大学校, [2]神奈川大)

1. Introduction

Buckingham *et al.* developed a revolutionary 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 an acoustic lens system would be a suitable choice for realizing ANI. 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 (FOV) from -7 to +7°. [2] In the 1st and 2nd sea trials, the silent targets were successfully imaged under only ocean natural ambient noise, which is mainly generated by snapping shrimps. [3-5] In this report, the outline of the 3rd sea trial is described to image frequency dependent targets.

2. The 3rd Sea Trial and Some Results

The 3rd sea trial was conducted in an actual ocean environment on November 28-30, 2016. As in the 1st and 2nd sea trials, the equipment was deployed on the barge “OKI SEATEC II”, which is moored at Uchiura Bay. The water depth at this location is a nominal 30 m. The experimental arrangement is shown in Fig. 1. The 2nd prototype imaging system constructed with the acoustic lens and receiver array was suspended from the end of the barge. Two sphere targets, called SonarBells® (SALT Ltd.), were suspended from the barge. The SonarBell is a kind of passive sonar reflector, and can be designed beforehand to have a frequency response for single or multiple peaks, or for a broadband response. In this trial, we designated the frequency response of each target to have a single peak of 80 kHz or 160 kHz, and each diameter was 275 mm. Two pingers were also attached near the targets for verification of ANI detection and target alignment; these radiated burst pulses of 130 kHz. At the beginning of the trial, we confirmed that the targets were present in the FOV using the pingers’ sound. The frequency-dependent echoes from the targets were collected under natural ambient noise generated by snapping shrimps, after pingers’ radiations were silenced.

Figure 2 shows the preliminary data analysis results in the 3rd sea trial. In Fig. 2(a), echoes from the 80-kHz target were detected by the received beam for the horizontal angle of +1° and the vertical angle of 0°. The SonarBell generates echoes composed of two components. We can see that the time series includes a 1st echo at about 600 μs and a 2nd echo at about 1600 μs. The former is scattered from the front face of the target, and the latter is focused and back in the direction of the sound source by the inner structure of the SonarBell. The power spectra at on- and off-targets show the different shapes around 80 kHz, and the difference in the spectra shows that the echoes have a frequency response peak of 80 kHz. In Fig. 2(b), for the 160-kHz target, similar echoes were detected by the received beam for the horizontal angle of +6° and the vertical angle of 0°. It can be seen that the time series includes a 1st echo at about 500 μs and a 2nd echo at about 1500 μs. The power spectra at on- and off-targets show the different shapes around 160 kHz, and the difference in the spectra shows that the echoes have a frequency response peak of 160 kHz. Thus, it was confirmed that our ANI system can receive different frequency-dependent echoes from two targets.

In the near future, we plan to create the target image by these received echoes to express target frequency dependence with RGB additive color mixing, as shown in Fig. 3. Here, the received frequency band from 50 to 200 kHz will be divided into three parts, and the received intensities of the low-, mid-, and high-frequency bands will be assigned to Red, Green, and Blue color, respectively. Then, the each pixel of the image will provide information not only regarding the intensity, but also the principal frequency of the target echo.

† kmori@nda.ac.jp

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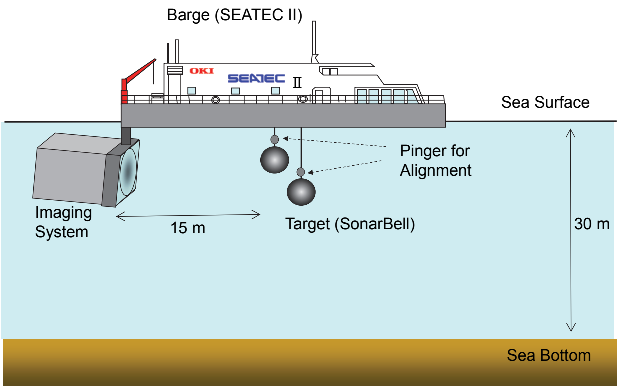
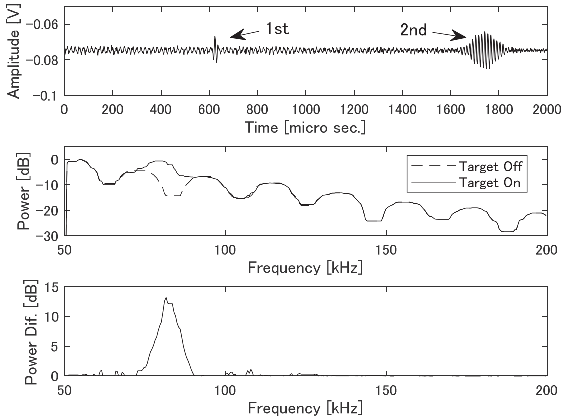
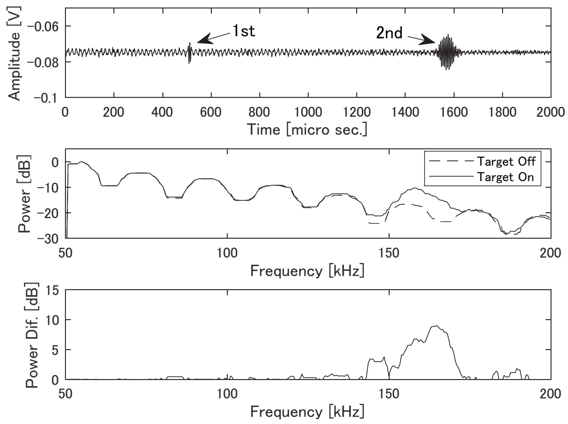


Fig. 1　Experimental arrangement.



(a) 80 kHz



(b) 160 kHz

Fig. 2　Example of time series of target echo (top panel), its power spectrum (mid panel, solid line: on-target; broken line: off-target), and spectrum's difference between on-target and off-target (lower panel) obtained in the 3rd sea trial. (a) Results of 80-kHz target; (b) results of 160-kHz target.

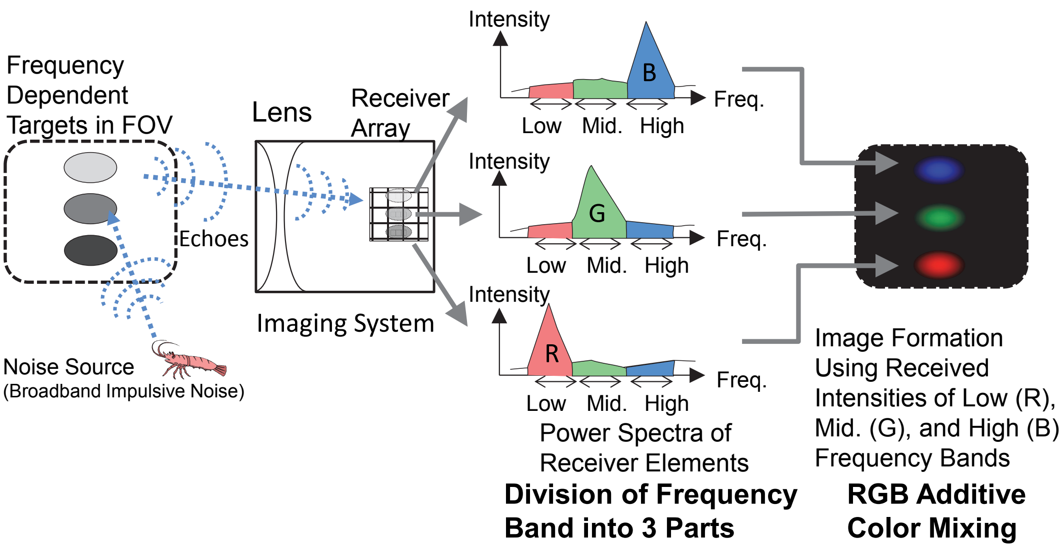


Fig. 3　Concept of image formation of frequency dependent target.