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Preliminary Statistical Analysis of Transient Noise Observed at Several Coastal Waters in Japan

日本沿岸域で観測した突発性雑音の予備的統計解析

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1. Introduction

In coastal water, ambient noise is dominated by snapping shrimp, and it is necessary to know its characteristics to design and operate of sonar system. The ocean ambient noise was observed at Hashirimizu in 2007, and we counted the number of snapping sound generated by snapping shrimp. The results showed that the number of snapping sounds at night is greater than that at day, and the maximam number is appeared after sunset [1-5].

Some amplitude statistical analysis of the ocean ambient noise were conducted for the performance evaluations of signal detection and communication. Chitre at el. showed that the amplitude histogram is a non-Gaussian and it can be approximated by a Symmetric-α-stable (SαS) model for observation at the coast of Singapore [6]. Legg approximated a histogram by SαS or Gaussian-Garnele mixture model for observation at several coasts of Australia [7]. Ebihara at el. approximated it by a Gaussian-Gaussian mixture model for a ambient noise observed at Hashirimizu [8]. We approximated a histogram by SαS model for a ambient noise observed at Hashirimizu [9,10].

In this study, we analyzed the amplitude statistics of the ocean ambient noises observed at several coastal waters in Japan. For each of 4 observation sites, an amplitude histogram of a site was compared with the others. And we tried to approximated the histograms by SαS model.

2. Observation

Ambient noises was observed by using a hydrophone (B&K Type 8103). This hydrophone has a flat response over the frequency range between 0.1 Hz and 180 kHz. The signal from hydrophone was amplified by a pre-amplifier, and digitized with a data recorder (NF Corp., EZ7510) with a sampling frequency of 1 MHz and a quantization bit rate of 16 bits. Sites and dates of the observations are shown in **Table 1**.

Table 1 Observation sites, dates, and analyzed data sizes.

Site	Date	Analyzed Data Size
Hashirimizu in Yokosuka	1,2, 6~11 Aug. 2007	2 min × 48 × 8
Uchiura in Numadu	9 Nov. 2015	5 min × 4
Baten in Nanjo	23 June 2016	5 min × 8
JCGA in Kure	30 July 2016	5 min × 8

JCGA: Japan Coast Guard Academy

3. Amplitude statistics analysis

The amplitude histograms were calculated from observation data. For each of 4 observation sites, an amplitude histogram of a site was compared with the others. The sound pressure was calculated from the output voltage of the pre-amplifier with the hydrophone sensitivity and the gain of pre-amplifier. The calculated histograms are shown in **Fig. 1**. Here the width of bin is 100 Pa. Each histogram has a heavy tail shape, and is non-Gaussian. In the tails of the distributions, the large-amplitude probability, whose absolute value is greater than about 225 Pa, is largest at Hashirimizu, and that is the second-largest at Uchiura. On the other hand, that was relatively small in Baten or Kure. It shows that the snapping sounds were the loudest at Hashirimizu.

4. Approximation by SαS model

Amplitude histograms were approximated by SαS model. SαS model is defined by characteristic function

$$\varphi(x) = \exp(-|\gamma t|^{\alpha}).$$

Here α is characteristic exponent, and γ is scale parameter. Probability density function (PDF) for SαS model is

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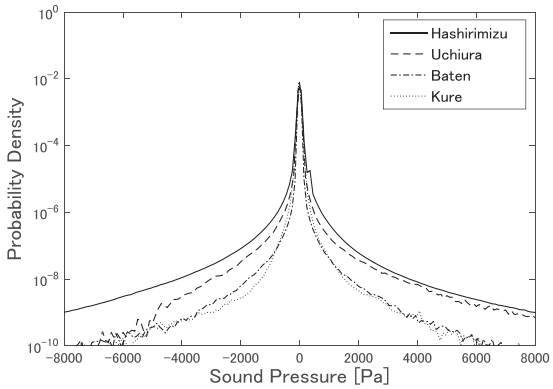

Fig. 1 Amplitude histograms of ambient noise observed at several coastal waters in Japan

$$f(x) = \frac{1}{\pi}\int_0^\infty \varphi(t)\cos(xt)\,dt.$$

The PDF was calculated by Gauss–Kronrod quadrature formula. **Figure 2** and **3** show histograms and those approximations by SaS model. Parameters α and γ were set so that the chi-square value between the histogram and the SaS model is smallest. Figure 2 shows that the approximation by SaS model is agree well with the histogram for Hashirimizu. However, the histogram is asymmetric, and the histogram in the negative amplitude is not agree with the model for Uchiura, as shown in Fig. 3.

5. Conclusion

In this study, we analyzed the amplitude statistics of ambient noise observed at 4 coastal waters in Japan. In the results of amplitude histograms, the probability of large-amplitude was different in each site. We also tried to approximate the histograms to SaS model. The histograms of the 2 sites were agreed with the model. However, those of the remaining 2 sites, which shows asymmetric shapes, were not agree. In some sites, the observations were conducted in night and around sunset, but these data are not analyzed yet. We will investigate the difference of histograms by the observation time. It was interest that some histograms have asymmetric shapes. The future work will be necessary to study its cause.

Acknowledgment

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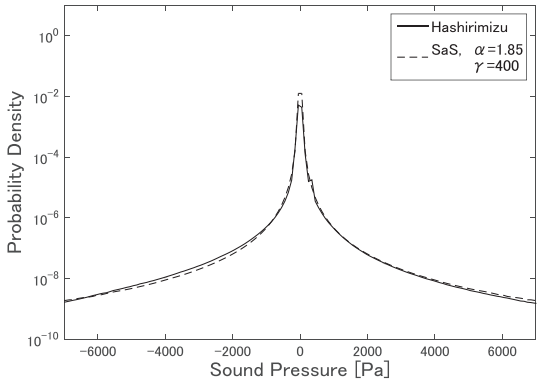

Fig. 2 The histogram and SαS model for Hashirimizu.

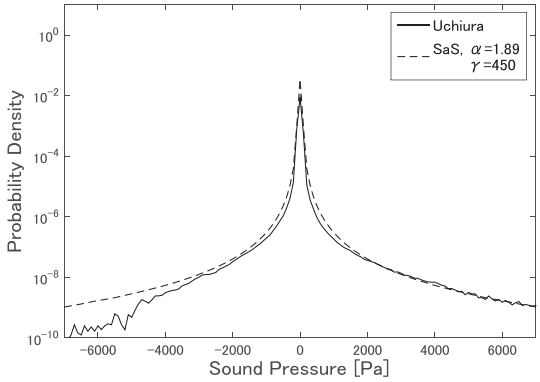

Fig. 3 The histogram and SαS model for Uchiura.

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