Observations of underwater sound: Wave breaking noise in the beach and cliff zone

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ABSTRACT

Underwater sounds, in the frequency ranging from 30 Hz to 10 kHz, generated by waves breaking on the beach and a cliff were measured by hydrophones located very close to the wave-breaking sites. Measurements of the plunging sounds and video recordings of the breaking events to isolate sounds from the spilling or plunging waves were performed concurrently. Analysis of spectrogram and power spectral density of the breaking sounds on the beach and on the cliff showed that for frequencies above 100 Hz, the maximum sound level appears near 500 Hz with 100–110 dB for the beach and 120–135 dB for the cliff. The 500-Hz sound level for the spilling waves were 5–10 dB lower than the plunging sounds on the beach.

1. INTRODUCTION

Since World War Ⅱ, the study of ambient noise in the open ocean and coastal waters has been a well-established field [1]. Recently, acousticians began regarding the breaking of waves in the surf zone as an important field of study. As will be shown, it is intimately related to the bubble pulsating (single bubble and bubble plumes) in the water column by the passage of wave-generating sound [2]–[4]. Although a number of acoustic studies are directly relevant to the surf zone, there have been few field measurements of waves breaking both on the beach and cliff. In this paper, we are concerned with the sound production of individual waves breaking on the beach and cliff. A source level of wave breaking noise was observed and a spectrogram is shown as frequency versus time of the wave breaking noise before, during, and after the breaking event.

2. AMBIENT NOISE EXPERIMENTS

The experiment was carried out in January and April 2007, on a sandy beach, surf zone, and cliff on the coast of the East Sea and Southern Sea in Korea. Concurrent with the acoustic measurements, video recordings of individual breaking waves were conducted to estimate the location, size, and time of wave breaking. For the measurement of ambient noise, a broadband hydrophone was located 50 cm over the bottom of the sandy beach or the surf zone, where water depth was about 2 m. In the cliff zone experiment, the wave breaking noise was recorded using two broadband hydrophones, located approximately 3–8 m below the mean sea surface space apart by about 30 m horizontally from the cliff zone. The signals received from the hydrophone were recorded using a Sony digital recorder (PC204A), and the recorded signals were filtered between 30

Hz and 10 kHz during playback; then the spectrogram and power spectral density were acquired.

3. Results and Discussion

In this report, we analyze the time–frequency signature and spectrum level of wave breaking noise on the beach and cliff zone (Fig. 1).

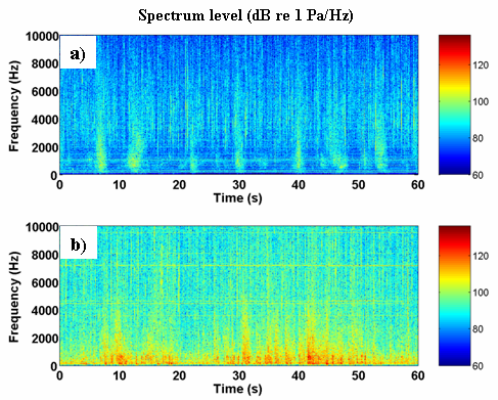

Fig. 1. Time–frequency signatures for the received level measured on the beach (a) and cliff (b) during a 1-min period.

The acoustic time series of these two signatures were processed to obtain higher time resolution (0.1s). The differences between the two breaker-type signatures may be seen in comparing the enlargements of two signatures at 6 s in Fig. 1(a) and at 41 s in Fig. 1(b). The signatures in Fig. 1(a) were generated by waves periodically breaking on the beach. The sharp onset of the signature is characteristic of the impulsive nature of wave breakers. The low-frequency tail is rarely observed in most breaking events. The signatures of wave breaking on the cliff, Fig. 1(b), have a low-frequency tail for 4–5 s after the sharp onset.

We compared average source level spectra for wave breaking on the beach and cliff. The source level spectra for all seven signatures were obtained by synthesizing the video and acoustic measurements. The estimated noise source level densities for waves breaking on the beach varied from 100 to 110dB re 1 μPa/Hz/m at 500 Hz. On the other hand, the source level of the cliff zone varied from 120 to 135 dB re 1 μPa/Hz/m at 500 Hz. The source level of wave breaking on the beach is roughly 20–25 dB higher than that on the cliff. These time–frequency signature differences between two breaker types were observed from different depths and sound generation mechanisms.

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