Some Near Shore Breaking Wave Statistics Outside the Surf Zone

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Abstract

Initial analysis of bubble density and distributions using 4 floating acoustic resonator arrays we deployed during the Sandy Duck '97 experiment are presented. Bubbles generated by a 15m/s wind at the beginning of a storm event penetrate to at least 3.6 m below the surface. The bubble spectra demonstrate the existence of a peak in the oceanic bubble density spectrum near \( r = 25 \) – 30\( \mu \).

KEYWORDS: Oceanic bubbles, breaking waves, bubble density distribution

1 Introduction

Outside the surf zone that is normally located within 300 to 400 meters from the beach, and with mean water depths less than 5 meters or so, the shoaling effect on locally wind-generated waves and swells from far off regions becomes less significant. We shall call the region between 1.0 and 3.0 km offshore as the near-shore area, where characteristics of wave breaking and associated bubble distributions are more similar to those observed in the open deep ocean (so called blue water region) (Su et al., 1988).

During the Sandy Duck '97 Experiment, at Duck, NC, from September through October, 1997, NRL-SSC scientists deployed four surface-following arrays in the nearshore region. See our lead paper in this Proceedings (Su et. al. A Field Experiment on Breaking Waves and Bubble Distribution in Shallow Water) for more details on the overall Sandy Duck and NRL-SSC participation. In this paper we shall provide more detailed information about these four arrays and some examples of the data collected by the sensors on these arrays. Two main kinds of sensors were mounted on the arrays: void fraction meters, and acoustic resonators. In the other paper in this Proceedings, we have reported on the void fraction meters and data collected by those sensors.

In this paper we shall stress the data from the acoustic resonators and statistics of near shore breaking waves and bubbles of locally generated wind waves as measured by these sensors.

2 Acoustic Resonator Arrays

The acoustic resonator (AR) is a sensor for measuring the bubble size spectrum and density, based on acoustical principles (See Su and Cartmill, 1993 and Su et.al. 1994 for details). We shall describe it here in brief terms for the readers' convenience. The acoustic resonator consists of two circular plate transducers, oriented parallel to each other and about 25cm apart. One plate acts as a sound source and the other as both reflector and receiver. The operating acoustic frequency is from 0.1 to 200kHz. The signal from the receiver plate is processed to produce a power spectrum from which the bubble size spectrum is derived by an inverse technique. Two types of acoustic resonance are involved in this technique. The first is the simple geometric resonance between two plates (Fabry-Perot). The second is the intrinsic resonance of single bubbles with respect to a specific frequency of acoustic excitation. In the second type, acoustic energy is both scattered and absorbed. The latter effect is directly related to the density of the bubbles and their radii. In simple terms, the resonant frequency for a given bubble is inversely proportional to its radius.

In our sensors, the separation between the two transducer plates is about 25cm, giving a fundamental frequency of the geometrical resonance in water about 3kHz. In the operating bandwidth of 200kHz, there are close to 70 higher harmonics present. Each of these harmonics acts as a resonant excitation frequency for a separate size population of bubbles. Therefore we can obtain bubble densities for the same number of bubble radii as harmonic peaks in the spectrum. Figure 1 shows a resonator power spectrum generated in water without bubbles. Each peak with an asterisk is a resonant peak. Figure 2 shows the power spectrum when