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Abstract: Concurrent underwater sound, wind, radar, and rainfall measurements were made on November 5, 1992, off Duck, North Carolina. A wind speed increment from 5 meters per second to 13 meters per second in 90 seconds resulted in a reduction in the rainfall sound spectrum level beginning at about 50 kHz and extending downward in frequency with time to about 10 kHz. The reduction in rainfall-generated sound spectrum level with time is thought to be due to sound absorption by the evolving wind-generated bubble field.

On November 5, 1992, concurrent measurements of underwater sound spectral levels, wind speed and direction, and rainfall rates were made in proximity to the seaward terminus of the U.S. Army Corps of Engineers research pier at Duck, North Carolina (hydrophone depth is approximately 6 meters). Shown in Figure 1(a) are underwater sound spectral levels (with a reference/background spectrum removed) in the 0.5-50 kHz band for the time interval 0430-0452. Shown in Figure 1(b) are the rainfall rate, wind speed, acoustical discriminant, and radar rainfall classification.

The acoustical discriminant is defined as the difference between the 10-30 kHz band averaged sound level and the 4-10 kHz band averaged sound level. The discriminant is used to classify rainfall as convective (when the discriminant is zero or less), or as stratiform (when the discriminant is greater than zero), and is discussed in Black et al. (1). Immediately below the discriminant are the weather radar determined rainfall types with c, denoting convective, and s, denoting stratiform. During convective rainfall (which generally, but not always, corresponds to rainfall rates in excess of 25 mm/hour) the acoustical sound spectrum may change in terms of total energy, but its
shape remains generally the same (1). Thus, if the acoustical spectrum shape changes significantly during a period of convective rainfall, it is likely that a cause other than changing rainfall rate is responsible.

At 0438 and 30 seconds, a rapid increase in wind speed occurs with the wind increasing from an initial value of about 5 m/sec to a value of about 13 m/sec in 90 seconds. The rainfall rate is also seen to be increasing during this rapid increase in wind speed, so that the shape of the acoustical spectrum is not expected to change. However, a reduction in spectral levels is seen to begin in frequencies above 10 kHz at a time corresponding to the increase in wind speed. A reduction is first noted in the highest frequency levels displayed, i.e., between 45-50 kHz between 0440 and 0441. Between 0440 and 0444, a reduction in spectral levels is seen to extend to lower and lower frequencies with time. Between 0443 and 0444 the rainfall rate decreases from a peak of roughly 100 mm/hr to about 15 mm/hr and correspondingly the acoustic spectral levels reduce by about 20 decibels. A second wind burst is seen to onset at 0444. However, due to the significantly reduced rainfall rate and significantly reduced accompanying acoustical spectrum, no major second sound reduction effect is seen.

The foregoing behavior is suggested to be due to absorption by wind-generated bubbles at frequencies initiating at 50 kHz and extending rapidly downwind in frequency to between 10 kHz and 20 kHz. This suggestion is consistent with the results of Nystuen and Farmer (2) and Willie and Geyer (3) and may yield information on the bubble size distribution generated by rapidly changing winds.

REFERENCES