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CHARACTERIZING THE SURF ZONE WITH AMBIENT NOISE MEASUREMENTS

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LONG-TERM GOAL

The long term goal is to utilize the underwater sound generated by breaking surf to characterize properties of the littoral zone environment such as beach slope and sea floor composition.

SCIENTIFIC OBJECTIVES

The immediate objectives are to characterize the source mechanisms and propagation of breaking surf noise with experiments, and develop theoretical models of sound generation and propagation through the surf zone. Complimentary experimental and theoretical work is necessary to understand the physics and application of wave noise sound in the relatively new field of surf zone acoustics.

The experimental objective is to establish a comprehensive data set of the wave noise source spectrum levels and coherence at different off-shore ranges and for different incident wave field conditions. The theoretical objective is to develop a theory of wave noise generation, and model the effects of entrained bubbles and proximity of the sloping sea floor on wave noise propagation from the littoral zone to deeper water.

Of particular interest in both experimental and theoretical studies are those statistical properties of the breaking wave noise that contain information about the littoral zone environment. One such property is the surf noise coherence, measured over a broad band of frequencies at two fixed points in space. The surf noise coherence is related to the noise field directionality, which is itself a function of the bottom bathymetry and composition.

APPROACH

Two acoustics-based experiments have been conducted during 1997 to study surf noise and the plumes of bubbles generated by breaking surf. The air bubbles left in the wake of a breaking wave play an important role in wave noise production, and the propagation of sound away from the breaking wave region.

The first experiment took part during the Adaptive Beach Monitoring program conducted by MPL at Red Beach, Camp Pendleton. Two hydrophones and an acoustic source were

deployed on a frame in the breaker zone. Active acoustic measurements of the acoustic properties of bubble plumes formed beneath breaking waves, and passive measurements of wave noise were made over a two week period.

The second experiment is designed to make long time-base surf noise level and coherence measurements during different weather and wave conditions, and consists of 4 hydrophones and a pressure sensor mounted on the sea floor in 8m of water, 200m southwest of Scripps Pier .

The theoretical modeling is a synthesis of data interpretation and mathematical analysis, and is progressing concurrently with the experimental work. The results of the modeling effort are summarized below.

RESULTS

The passive wave noise measurement made during the adaptive beach monitoring experiment have shown the existence of an acoustic 'hot-spot' which follows the movement of the wave break-point along the shore line. In addition, a pronounced reversal of the ambient noise field directionality occurs within 50m of a wave when it breaks. The active measurements of bubble plumes have confirmed that the air entrained by breaking surf has a strong impact on the radiation of wave noise. Significant reductions in sound speed and very high absorption levels are observed. The long time base noise measurements have been running continuously for three months. The data show a strong variation of surf noise levels with incident wave height in the frequency band 100Hz to 2kHz at a range of 500m from the shore line.

A theoretical model of the acoustic hot-spots has been developed based on the idea that they are caused by the strong acoustic absorption of the air bubbles left in the wake of the breaking wave. The air in the water column renders the breaking region inaudible behind the breaking wave, except the very edge of the breaking region which is in a relatively bubble-free zone.

IMPACT/APPLICATION

The discovery of acoustic hot-spots associated with breaking surf is new, and is significant in terms of the relationship between surf noise directionality and beach topography. The hot-spots identified in the experimental program provide an exploitable link between ambient surf noise and beach topography. If the theoretical explanation for the hot spots proves correct, it will provide a means of determining beach topography from wave noise and incident wave field measurements made close to the shore line.