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14. ABSTRACT
The objectives of this work were both observational and theoretical. Several low-frequency and broadband long-range transmission data sets in which data was obtained on long vertical receiving arrays were analyzed to quantify acoustic phase and intensity variability, as well as temporal and vertical coherence. One short range experiment (87 km) was also examined to quantify acoustic scattering over the first 2 upper turning points. In addition, analysis of oceanographic measurements of upper ocean processes quantified acoustic scattering structures. Coupled mode, Geometric (ray-based) and parabolic equation models were used to examine the underlying acoustic scattering physics.

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An analysis of long-range acoustic propagation fluctuations and upper ocean sound speed variability

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LONG-TERM GOALS

The long-term goals of this research are to understand the predictability limits of long-range acoustic transmissions, and to delineate the important environmental factors contributing to predictability.

OBJECTIVES

The objectives of this work were both observational and theoretical. Several low-frequency and broadband long-range transmission data sets in which data was obtained on long vertical receiving arrays were analyzed to quantify acoustic phase and intensity variability, as well as temporal and vertical coherence. One short range experiment (87 km) was also examined to quantify acoustic scattering over the first 2 upper turning points. In addition, analysis of oceanographic measurements of upper ocean processes quantified acoustic scattering structures. Coupled mode, Geometric (ray-based) and parabolic equation models were used to examine the underlying acoustic scattering physics.

RESULTS

Scientific results from this project can be found in 12 published journal articles (See below). Several highlights are noteworthy.

My colleagues and I were able to show that acoustic ray propagation through ocean internal waves can describe many of the observed wavefront features even though ray theory is a high frequency approximation which is susceptible to chaotic behavior. While ray theory did a good job on the geometry of the wavefront, results with regards to intensity variability were not as convincing. Therefore this project also set out to explore the effects of internal waves on acoustic mode propagation. Here we developed a stochastic coupled mode theory that does a great job at predicting the mean acoustic intensity. We are working on higher moments of intensity, and including broadband effects.

Using observations of upper ocean current shear and sound speed fluctuations I was able to demonstrate that acoustic scattering in the upper ocean may be strongly influenced by internal wave induced current shear. The observations were used in conjunction with ray theory for a moving ocean.

Using observations from 5 different experiments at frequencies of 28, 75, and 84 Hz, I quantified acoustic fluctuations in the finale of long range transmissions from the 3000-5000 km range. The finale was used because the signal to noise level was most favorable. The finale is a region of complex multipath interference and is thus the most unstable part of the wavefront. Using acoustic quantities like variance of phase, intensity, and coherence, I was surprised to find that the finale was relatively stable over short 20-40 minute observations times. These results give great hope to using other more stable regions of the wavefront for signal processing analysis.

Finally, using 75 Hz short range data (87 km) my graduate student and I were able to demonstrate the important mechanism of acoustic ray-internal wave resonance. This resonance occurs when the acoustic ray path is parallel to the internal wave crests.

PUBLICATIONS RESUTING FROM THIS PROJECT

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12) J. A. Colosi, ``Geometric sound propagation through an inhomogeneous and moving ocean: Scattering by small scale internal wave currents'', J. Acoust. Soc. Am., in press, 2005.

In Preparation:

1) J.A. Colosi, J. Xu, and The NPAL Group, "Observations of upper ocean sound speed variability in the North Pacific Ocean", J. Acoust. Soc. Am.
2) J. Xu, and J. Colosi, ``Observations and modeling of single and double turning point acoustic scattering for 75 Hz sound transmission in the North Pacific Ocean'', J. Acoust. Soc. Am.

Conference Proceedings:

1) A. Morozov and J. Colosi, "Entropy of acoustical beams in a random ocean", IEEE Oceans Symposium, September 2003.