MODAL CHARACTERISTICS OF ACOUSTIC INTERACTIONS WITH INTERNAL WAVES IN SHALLOW WATER

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LONG-TERM GOALS

To understand acoustic interactions with internal waves (IWs) in a shallow-water waveguide, including IW induced acoustic mode-coupling, signal fluctuations and coherence loss.

SCIENTIFIC AND TECHNOLOGICAL OBJECTIVES

To analyze the interactions of individual acoustic normal modes with internal waves, and the characteristics of a multimode sound field interacting with shallow-water internal waves.

BACKGROUND

(1) The in-field measurements show that shallow water IWs differ significantly from deep sea IWs. The spectral density of IWs, measured within the seasonal thermocline, exceeds the GM spectrum level over the whole frequency range. Almost every measurement yields high narrow power peaks associated with the tidal IWs of main periods of 12 hours. Shallow water IWs often show an intermittence, high amplitudes, quasi-sinusoidal behavior in both time and space domains, and a narrow bandwidth, characterized by large-amplitude soliton packets. The effects of Shallow-water IWs with these specific characteristics on a sound field should be examined.
(2) Numerical simulations have shown that the resonant mode coupling induced by internal waves can become an important loss mechanism of shallow water sound propagation [1,2]. Our preliminary measurements show that signal fluctuations of the first acoustic mode are very different from those of multimode signals. The result motivates us to analyze interactions of individual normal modes with shallow water IWs.

APPROACH

(1) To simulate IW induced mode-coupling and signal fluctuations numerically, taking shallow water IW characteristics into account. (2) To conduct an at-sea experiment for simultaneous observations of internal wave activity and acoustic wave propagation, in order to validate the predicted modal coupling and fluctuations.

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RESULTS

(I) Measured internal waves from the Yellow Sea and the Massachusetts Bay are used as inputs for numerical simulations of acoustic fluctuations. It is shown that the fluctuations induced by large amplitude shallow-water internal waves strongly depend on receiver depth and distance, and exhibit anisotropy. Different acoustic modes have different sensitivities to IWs. Both acoustic intensity and phase fluctuation spectra are different from the shallow-water IW spectrum, and become much wider. Individual acoustic mode fluctuations directly and clearly correspond to the characteristics of IWs. For shallow water with a strong thermocline, there is a particular group which is more sensitive to IWs than others; arrival time of the first mode is the most stable. [3]
(2) A large-scale joint U.S.-China Yellow Sea Experiment was conducted between China and Korea in the late Summer, 1996. (76 m water depth) Propagation was measured over distances up to 55 km using narrow and broad band electroacoustic as well as with explosives sources. Internal wave activity was monitored using several moored and suspended thermistor chains as well as by using CTD. Preliminary analyses show that there is strong internal wave activity in the area. IW data obtained from this area exhibit shallow water IW characteristics: large amplitude, strong tidal waves and narrow band soliton packets. Acoustic signal fluctuations of more than 20 dB were observed, and can be explained by the multimode interference caused by internal waves. Some results on sound propagation, reverberation, IW field and inversed bottom acoustic parameters were reported at the international conference on shallow-water acoustics. [4]

IMPACT/APPLICATION

The role of water column variability in shallow water was ignored for many years. Our work on acoustic interaction with shallow-water internal waves in the Yellow Sea was called "the seminal one on this topic" (Apel et al, IEEE JOE, 22, pp. 465-500,1997), and "started changing opinions about the water column's relative importance and gave impetus to the current work on soliton scattering." [5] Since 1992, a number of multi-national and multi-institutional at-sea experiments (addressing water column issues) have been performed. In these experiments, acoustic and oceanographic data were simultaneously collected in shallow water. Their good results allow us to make up significant ground. [5]

REFERENCES

[1] J.X. Zhou, X.Z. Zhang and P.H. Rogers, "Resonant interaction of sound waves with internal solitons in the coastal zone," J. Acoust. Soc. Amer. 90, 2042-2054 (1991).
[2] J.X. Zhou, X.Z. Zhang and P.H. Rogers, D. Wang and E. Luo, "Anomalous sound propagation in shallow water due to internal wave solitons," IEEE Proc. OCEANS

[3] J.X. Zhou, X.Z. Zhang and P.H. Rogers, "Modal characteristics of acoustic signal fluctuations induced by shallow-water internal waves," IEEE Proc. OCEANS 96, 1, 1-8 (1996).]
[4] <Shallow-Water Acoustics > R.H. Zhang and J.X. Zhou, Eds., China Ocean Press, 1997.

[5] J.F. Lynch, "Report on the Office of Naval Research Shallow-Water Acoustics Workshop, 1-3 October 1996" WHOI Rept-97-12.