ASIAEX Reverberation Studies

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LONG-TERM GOALS

This research is intended to establish an understanding of the scattering mechanisms operating in low frequency reverberation in shallow water typical of continental shelf regions. The intent is to distinguish among the effects of different scattering components, such as sediment interface and layering roughness, fluctuations in sediment properties, and discrete scattering components, and to quantify their relative contributions. This research is being performed with David Knobles, ARL:UT, with our two efforts together forming an integrated research effort.

OBJECTIVES

Using a normal mode propagation model and a physics-based bottom scattering coefficient [1 and cited references] in a two stage simulated annealing optimization [2], the specific objectives of the work will be to invert low frequency reverberation and transmission data obtained during the summer 2001 ASIAEX in the East China Sea to recover the bottom scattering strengths associated with volume, surface and sediment layering.

APPROACH

Experimentally, the determination of bottom scattering strength in shallow water is complicated by the multipaths associated with the proximate boundaries: scattering strengths must be extracted from reverberation measurements, which necessitates some integration over the incident and scattering angles involved. As a consequence, comparisons of scattering strength models and measurements must account for experimental constraints and limitations that intrinsically convolve propagation to and from the scattering site with the scattering kernel. The motivation for turning to a high-resolution global inversion method, such as simulated annealing, is that it can be used to efficiently search the large parameter space physically describing transmission to the bottom scatterers and the scattering process to obtain optimal parameter values to extract scattering strength.

Detailed modeling of propagation for the shallow water channels with sand-silt bottoms has indicated that beyond about 5-10 km ranges, propagating energy is confined to bottom grazing angles less than the critical angle. In consequence, beyond the indicated ranges, acoustic bottom penetration is limited to the evanescent field extending about one wavelength into the bottom. Thus, the proposed mechanism for bottom scattering in these environments is scattering of the evanescent field into the water by roughness at the sediment-water interface and by volume scatterers just below the interface.

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14. ABSTRACT
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15. SUBJECT TERMS

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Volume scatter candidates include fluctuations in sediment density or compressional wave speed and discrete inhomogeneities within the sediment such as shells or rock fragments. In addition, scattering from roughness at near-surficial sediment layer boundaries, observed in some areas such as the New Jersey Shelf, should be included as a candidate component. The theory describing the sediment fluctuation contributors has been developed in the Born approximation [1]. The theory will be straightforwardly extended to include layering roughness [4] and discrete scattering components and will be used to define the parameters needed to obtain a complete determination of bottom scattering strength.

The activities being performed under this research effort are: (1) preparations for ASIAEX data collection and coordination with seagoing participants in the tests; (2) preparation of initial models for use in the data inversion process and testing by simulations; (3) performance of two stage data inversion (forward propagation and scattering) on ASIAEX data; (4) refinement of physical models of scattering process based on inversions; (5) performance of refined inversions employing improved physical models to identify and quantify scattering mechanisms. Peter Cable (BBN) will be responsible for direction of the research and development of the scattering model and Rob Gibson (BBN) will be responsible for data analysis. They will work closely with David Knobles (ARL:UT) and his associates.

WORK COMPLETED

A list of data requirements and specifications to meet the research objectives was prepared and discussed with Bill Hodgkiss and with Peter Dahl. The workshop report from the January 2001 ASIAEX East China Sea Planning Meeting was reviewed and discussed with Peter Dahl. Inputs on expected level of noise interference contributed by *R/V Melville* during the ASIAEX ECS long range reverberation measurements were provided to Peter Dahl at his request.

RESULTS

This research is a new start. Data from the East China Sea ASIAEX have not been distributed and there are not yet technical results.

IMPACT/APPLICATIONS

Current low frequency shallow water reverberation models for sonar performance prediction use phenomenological bottom scattering strengths arbitrarily extrapolated from high frequency experience. There currently does not exist a model of shallow water reverberation that comprehends the reverberation results obtained in the DARPA Adverse Environments Program and in HEP littoral area surveys or that explains system performance achieved by Distant Thunder (DT) and EER in shallow water operations. Reverberation is the dominant factor in the operation of active sonars in shallow water, and to support mission planning and operational performance prediction for systems such as DT, LFA and EER, especially when HEP-type survey data are unavailable, there is a need for a bottom reverberation predictive capability requiring geoacoustic inputs such as those needed for propagation predictions.

TRANSITIONS

The data and bottom reverberation models, which will be the products of this work, could transition, respectively, to standard Navy acoustic databases and to tactical decision aids (TDA) for low frequency shallow water active systems such as IEER and Distant Thunder (DT). The transition path for these products must be defined as the work progresses.

RELATED PROJECTS

This research is being conducted jointly with David Knobles, ARL:UT. In addition the long range reverberation ASIAEX studies of Renhe Zhang and Jixun Zhou have responsibility for the data that will be used in the present research.

REFERENCES

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