

Mid-Frequency Shallow Water Studies and SW06 (LEAR)

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LONG-TERM GOALS

To develop a basis for the Navy to make decisions on what environmental parameters to measure, to what spatial and temporal scale they should be measured, and how to best select frequencies for sonar design. Emphasis is on the mid- to high-frequency range defined as nominally 1-20 kHz.

OBJECTIVES

The primary objective this year was to prepare for and carry out the LEAR (Littoral Environmental Acoustics Research) experiment in August 2006 in collaboration with Dajun Tang of APL-UW and other Shallow Water 06 (SW06) participants.

APPROACH

The main item of experimental instrumentation, the Moored Receiving Array (MORAY 1+) was modified to include a horizontal line array, in addition to its two vertical line arrays, with extensive testing done in Puget Sound last spring. Experimental preparation included simulation of bottom loss associated with the proposed SW06/LEAR experimental site with results presented at the March 2006 SW06/LEAR workshop in Seattle. Key individuals involved in this effort (all from APL-UW) included Russ Light (electrical engineering and engineering lead), John Elliott (software), Vern Miller (mechanical engineering), Pete Sabin (electrical engineering), and Jeewoong Choi (acoustic simulation).

WORK COMPLETED

Preparation for LEAR was completed on schedule and the experimental measurements were undertaken between August 7-18, from the R/V Knorr operating near 39° N, 73° W (Fig. 1). By all measures the 14-day field effort (12 days of measurements) was a success. Some preliminary results are discussed below.

In addition to this field effort, revision and modification of two manuscripts was completed; these were published in the May issue of the *Journal of the Acoustical Society of America*, (entitled: "Measurement and simulation of the channel intensity impulse response for a site in the East China Sea") and the June issue (entitled: "First-order and zeroth-order head waves, their sequence, and implications for geoacoustic inversion").

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RESULTS

Figure 1 depicts the overall scale of the field effort. Our work, involving mid-frequency acoustic measurements and associated environmental measurements, was largely confined to a 4 km square area close to the large field of environmental and acoustic moorings deployed by other SW06 participants in the weeks before our experimental leg.

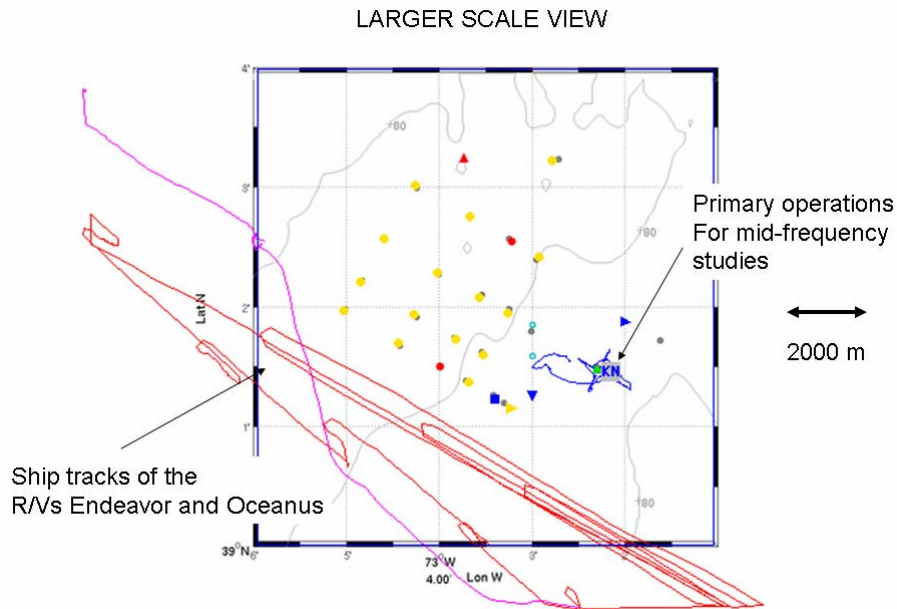


Figure 1. Large scale view of SW06/LEAR experimental area showing primary operations of mid-frequency studies involving the R/V Knorr. Ship tracks of other R/Vs are also shown.

Figure 2 depicts a smaller scale view of the mid-frequency experimental area. The central point of this area is defined by the mooring location of the MORAY1+ VLA and HLA system.

This system received signals from a source deployed from the R/V *Knorr* while the vessel precisely held station at specified points using dynamic positioning. Data received by the MORAY1+ (Figs. 3 and 3) at various ranges, along with sea surface, sea bed, and water column environmental measurements from LEAR, will be used in the coming year to study the following environmental acoustic topics:

- Bottom loss estimated as a function of frequency and grazing angle, results inverted for a meter-scale look at the seabed
- Effects of Internal waves on mid-frequency propagation
- Horizontal and vertical spatial coherence in mid-frequency, shallow water propagation
- Bistatic bottom and sea bed scattering

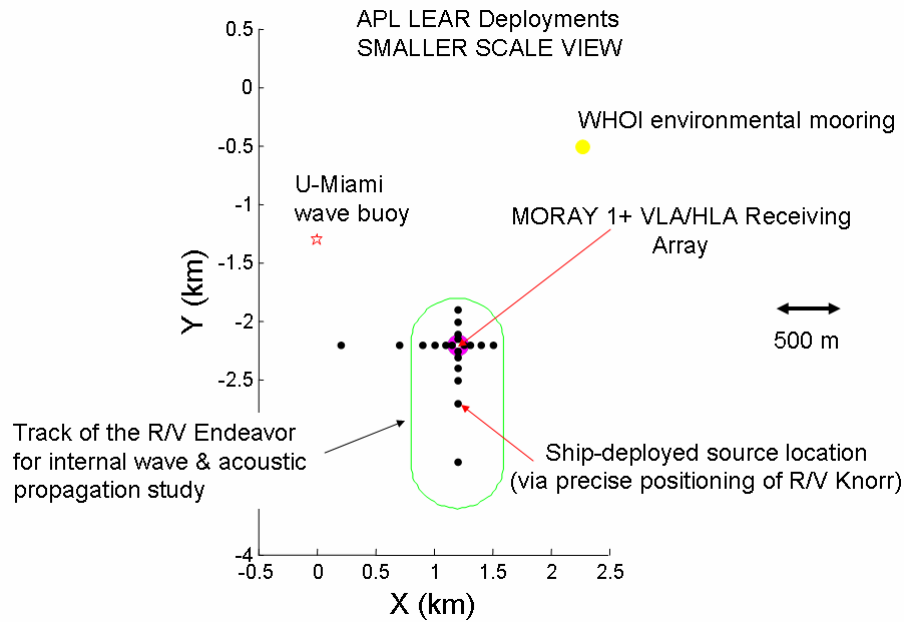


Figure 2. Smaller scale view of SW06/LEAR experimental area showing location of the MORAY 1+ receiving array. Black dots show source locations as defined by the position of the R/V Knorr.

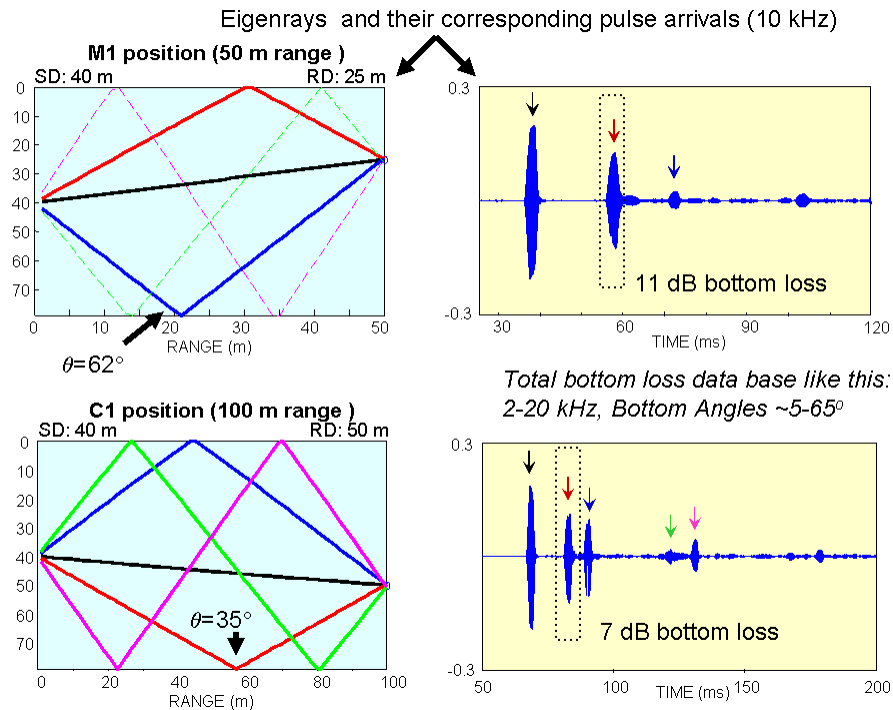


Figure 3. Left side: eigenrays associated with source and receiver depth and range, based on measured sound speed profile. Right side: corresponding arrival structure for 10 kHz CW pulse and estimate of bottom loss for path interacting with the seabed.

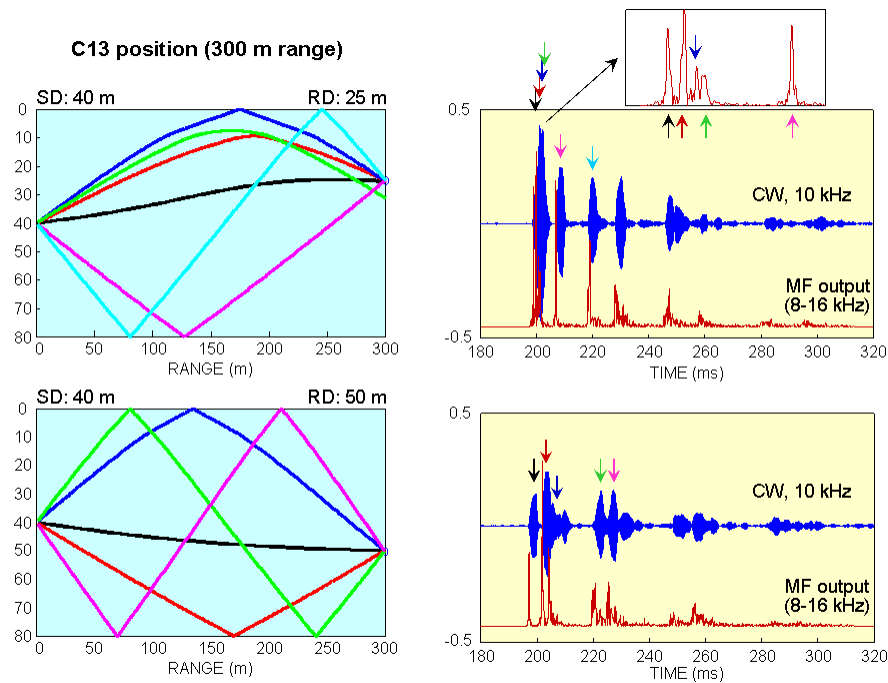


Figure 4. *Left side: eigenrays associated with source and receiver depth and range, based on measured sound speed profile. Right side: corresponding arrival structure for 10 kHz CW pulse and matched filter (MF) output of FM pulse.*

IMPACT/APPLICATIONS

The techniques developed in the paper entitled “Measurement and Simulation of the Channel Intensity Impulse Response for a Site in the East China Sea,” represent a new capability to model the impulse response for shallow-water, multi-path propagation, with direct application to acoustic communication. The ideas developed in the paper entitled “First-order and zeroth-order head waves, their sequence, and implications for geoacoustic inversion,” may lead to a new capability for conducting geoacoustic inversion.

The SW06/LEAR data set, with its emphasis on simultaneous, co-located environment and acoustic measurements, will assist the Navy in making rational decisions on what environmental parameters to measure, to what spatial and temporal scale they should be measured, and how to best select frequencies for sonar design.

RELATED PROJECTS

This research is integrated together with those from several PIs involved in the SW06/LEAR program (D. Tang, APL-UW, M. Badiy, Univ. Delaware). Directional wave measurements (collected by the PI to study acoustic effects of sea surface roughness) will be used by E. Letvin (APL-UW) who is involved in the Non-linear Internal Waves (NLIWI) program.

PUBLICATIONS

J. W. Choi and P. H. Dahl, "Measurement and Simulation of the Channel Intensity Impulse Response for a Site in the East China Sea," *J. Acoust. Soc. Am.*, 119, pp. 2677-2685, May 2006.

J. W. Choi and P. H. Dahl, "First-order and zeroth-order head waves, their sequence, and implications for geoacoustic inversion," *J. Acoust. Soc. Am.*, 119, pp. 3660-3668, June 2006.