Acoustic Imaging of Shallow Water Sediments

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LONG-TERM GOAL

Measuring, imaging, and modeling centimeter-scale, three-dimensional, in situ sediment volume inhomogeneities using acoustic tomography.

OBJECTIVES

Sediment volume inhomogeneity on the centimeter scale has a major impact on the design and application of high-frequency sonar, especially when operated in shallow waters. Yet there is little information available on such inhomogeneities due to limitations on measurement techniques. We are developing an in situ probe system using acoustic tomography to image shallow water sediments to obtain sound speed and attenuation coefficient over space. Long term deployment and repeated measurement of this instrument will yield temporal variability of sediment properties. This instrument can find direct applications in sediment biology and geology.

APPROACH

The in-situ sediment acoustic imaging system consists of an array of needle-like probes, which may be pressed into the sediment, where each probe is a line array of acoustic transducers. The current system consists of three identical probes attached to a sturdy frame. Two probes are oriented vertically and pressed into the sediment about 1 meter apart, and the third is oriented horizontally, just above the seafloor, between the two vertical probes. Each probe contains 20 acoustic transducers, arranged as a line array with 5-cm spacing. Each transducer in every probe is capable of both transmit and receive. The transducers used are free flooded cylinders, with a resonant frequency of 100 kHz with approximately 40 kHz bandwidth. All possible ray-path combinations between the probes are sequentially interrogated. The objective is to accurately estimate the travel time and amplitude from transmit to receive on each ray path.

WORK COMPLETED

Based on the successful deployment of the imaging system in muddy sediment in FY97, a new set of data was collected from a sandy site. The goals are (1) to assess the penetration of the system to sand, (2) to estimate the attenuation coefficient of typical sand to establish the feasibility of using the system in sandy environments, and (3) to measure the sound speed variability in sand. As the previous measurement in mud, a set data in water was also taken to serve as calibration of the system.

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RESULTS

The data show surprisingly high quality signal-to-noise ratio, indicating that in sand the attenuation coefficient is in the typical range of 30 – 40 dB/m @ 100 kHz. Had the attenuation been much higher, the designed source level of the system would not have been sufficient for imaging sandy environments. The preliminary results are shown in Figures 1-3. Figure 1 is a set of raw waveforms. The left panel gives the calibration data and the right panel is data taken in sand. Figure 2 shows the inverted sound speed profile and Figure 3 is the attenuation profile. Full inversions using all data will be performed in the near future.

Figure 1

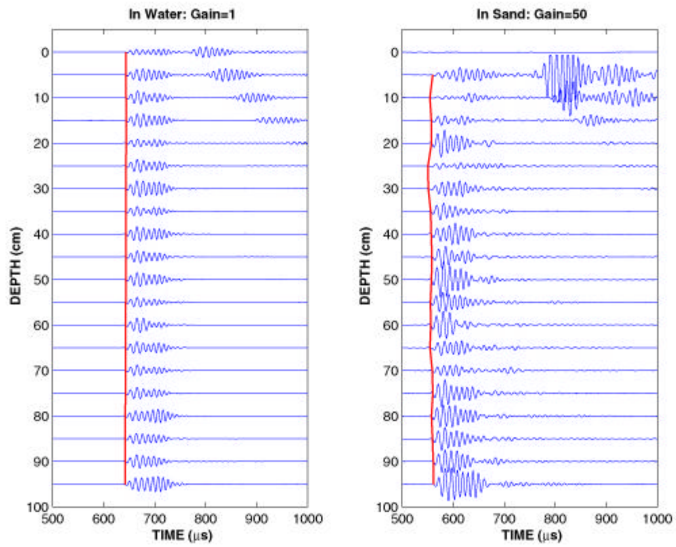


Figure 2

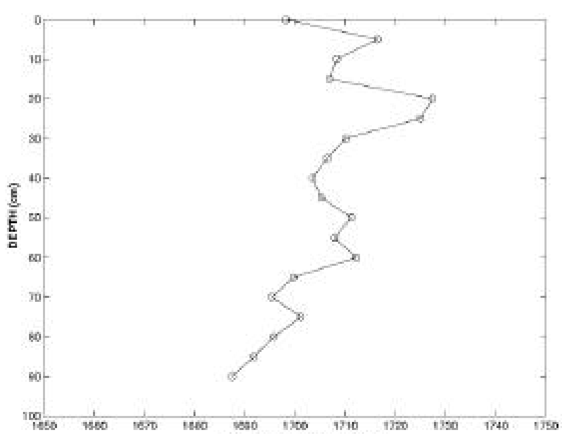
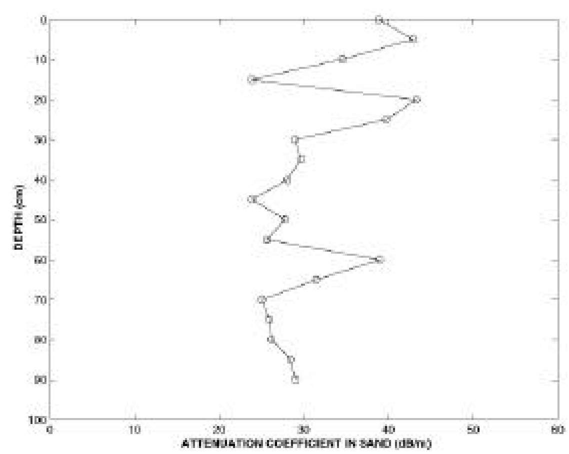


Figure 3



IMPACT/APPLICATION

Since this probe system can measure in situ sound speed and attenuation coefficient of sediments over two-dimensions, its advantage over coring is obvious. In addition to applications to high-frequency bottom acoustics, it can provide much needed information to the marine geology and biology communities. For example, this system can be used to monitor sediment variability over time due to biological activities by taking measurements in one location at a sequence of times. Finally, this system provides an excellent means of measuring in situ acoustic forward scatter in sediments.

RELATED PROJECTS

In the ONR-DRI on High-Frequency Sound Interaction in Ocean Sediments over the next few years, this system could provide sediment volume inhomogeneity data in sandy as well as muddy bottoms, either as a survey tool or as a monitoring system to investigate sediment temporal changes.