Remote Sediment Property From Chirp Data Collected During ASIAEX

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LONG TERM GOALS

The long term research objective is to develop a cost effective technique for mapping the top 20 meters of sediment properties using acoustic remote sensing. In previous years, a chirp sonar was developed to provide quantitative, wideband reflection measurements of the seabed with a vertical resolution of 10 cm. Neural network and fuzzy logic techniques have been used to automatically detect subsurface layer interfaces and to find the boundaries between sediment layers. Signal processing techniques were developed to estimate vertical profiles of impedance, attenuation and volume scattering coefficients. The procedures for remotely estimating sediment properties are being verified using core data and insitu measurements. New signal processing techniques have been developed that allow several sources transmitting simultaneously in different bands to build a wideband FM pulse in the far field. That wideband data is being used to improve the accuracy of the remote acoustic sediment property prediction.

OBJECTIVES

1) Conduct chirp sonar surveys to provide imagery of sediment layering and acoustic sediment properties needed by ASIAEX investigators modeling acoustic propagation in the South and East China Seas.

2) Compare remote chirp measurements of sediment properties with direct property measurements made from cores to determine the accuracy of remote predictions.

3) Deliver reflection profiles, sediment impedance and attenuation data to ocean acoustics investigators modeling sound propagation.

APPROACH

The technical approach for the ASIAEX surveys is to collect normal incidence FM reflection data with a towed chirp sonar over the range of 1.5 to 4 kHz providing images of the top 50 meters of sediments and vertical profiles of acoustic sediment properties for use by ASIAEX scientists modeling acoustic propagation. The multiband chirp technology allows the collection of normal incidence reflection data over a band of 1 to 15 kHz while the towed vehicle emulates a point acoustic source. The point source is emulated using 2 piston sources that operate over different but overlapping frequency bands. Each single piston source has a wide beamwidth (greater than 40 degrees) over its band of operation. Multiple transducers can be driven simultaneously with chirp pulses with different bands to generate the wideband chirp pulse in the water that appears (in the far field) to emanate from a point acoustic source. Multiple rectangular receiving arrays of various sizes are used to control receiving beamwidth and scattering by spatial filtering. The bandwidth of the sonar provides subsurface imagery with 10 cm vertical resolution. The enhanced bandwidth also improves the accuracy of attenuation and phase measurements needed for impedance inversion and dispersion measurements.

Dr. Schock supervises the research program including graduate and undergraduate students and at sea experiments. Jim Wulf is the lead engineer on the project.

WORK COMPLETED

During survey of the South China Sea, chirp data was collected along tracks corresponding to the across shelf and along shelf acoustic propagation lines. Due to the high attenuation of the sandy seabed, a 50 msec 1.5 –4 kHz FM was used to generate the chirp data sets instead of the proposed band of 1.5 to 15 kHz thereby ensuring subsurface penetration was adequate for imaging the subsurface sediment layering in the sandy seabed. The time series data was filtered into 8 pass bands to generate 8 images with center frequencies of 1 kHz spacing starting at 1.6 kHz and ending at 4 kHz. The rolloff of the attenuation function of the uppermost sediment layer is estimated by dividing the average reflection amplitude of the sediment layer interface echo from the base of the surficial layer by the average amplitude of the sediment-water interface echo for each bandpass image. The amplitude ratios are plotted as a function of frequency. The slope of a line fitted to the frequency function in a least squares sense is called the attenuation rolloff.

RESULTS

For the across shelf propagation line, the slope of the attenuation function varied from about 0.4 dB/m/kHz near the receiver arrays at the shallow end in about 120 meters of water to a minimum of 0.12 dB/m/kHz in about 250 meters of water to 0.40 dB/m/kHz near the source in 340 meters of water. For the along shelf propagation line the attenuation rolloff varies between 0.51dB/m/kHz and 0.11 dB/m/kHz. Figures 1 and 2 summarize the attenuation measurements by plotting the attenuation rolloff as a function of water depth/

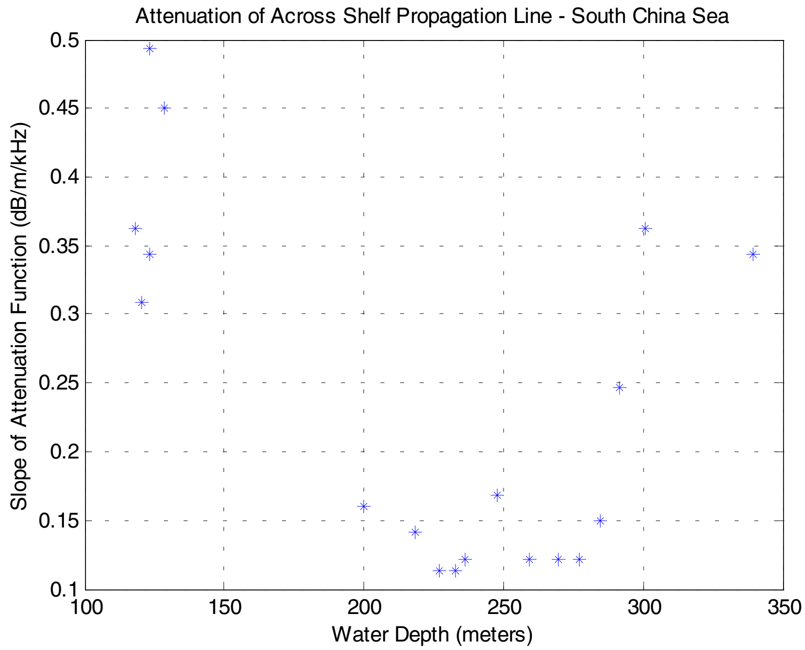

Figure 1. Attenuation rolloff for the frequency range of 1.6 to 4.0 kHz is plotted as a function of water depth for the across shelf propagation line. Note that the attenuation of the sediments is lowest for water depths in the range of 200 to 280 meters. Attenuation increases toward the ends of the across shelf propagation line indicating coarser grain sediments.

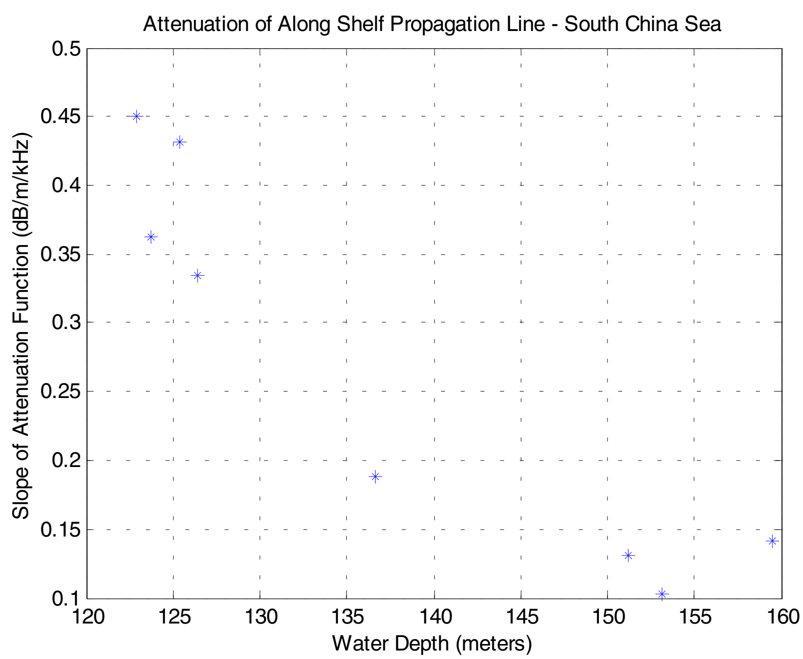

Figure 2. Attenuation rolloff for the frequency range of 1.6 to 4.0 kHz is plotted as a function of water depth for the along shelf propagation line. Note that the attenuation of the sediments is lowest for larger water depths suggesting that finer grain sediments occur in the deeper section of the line.

IMPACT/APPLICATIONS

Instrumentation and sediment classification procedures have been developed to predict the acoustic and physical properties of the seabed using normal incidence reflection data collected by FM subbottom profilers. This development provides a cost effective method of surveying the top 10 meters of the seabed and obtaining vertical profiles of attenuation and acoustic impedance. Physical properties can be estimated from the acoustic properties using empirical methods.

TRANSITIONS

The reflection profiles and attenuation measurements have been forwarded to a WHOI investigator conducting acoustic propagation modeling.

RELATED PROJECTS

"Remote Seabed Sediment Classification and Sediment Property Estimation Using High Resolution Refection Profiles," ONR G&G Grant. The techniques developed under this grant are being used to process data for ASIAEX.

PUBLICATIONS

1. "Remote estimation of seabed attenuation using a chirp sonar during ASIAEX," S. G. Schock, ASA meeting, Cancun, Dec. 2002 (abstract).