Remote Sediment Property Sediment Classification and Property Estimation

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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. Signal processing techniques were developed to estimate vertical profiles of impedance, attenuation and volume scattering coefficients. The Biot model is used to estimate the physical properties of the seabed from the acoustic measurements. 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 procedures.

OBJECTIVES

1) Measure the normal incidence acoustic impulse response of the seabed at locations where insitu or core data is collected
2) Compare remote chirp sonar estimates of the acoustic and physical properties of the seabed with measurements made by other investigators conducting insitu acoustic experiments and coring surveys to determine the accuracy of acoustic remote sensing

APPROACH

The technical approach is to collect normal incidence FM reflection data with a towed chirp sonar using a dual pulse mode where the sonar alternately transmits 40 msec 1.5 to 4 kHz and 10 msec 1.5-15 kHz FM pulses providing images of the top 40 meters of sediments and generating wideband data sets that can be used for predicting vertical profiles of acoustic sediment properties needed by scientists for 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.

Three line arrays, oriented across track, were mounted under the sonar vehicle using an interarray spacing of 2 meters, thereby providing 3 receiver channel offsets from the projector. The difference in reflector arrival times will increase as the array offset and the angle of incidence increases. The seawater and sediment velocity can be calculated from the arrival time after corrections are made for vehicle attitude and seafloor slope.

A supershort baseline sonar is used to measure the position of the sonar with respect to the surface ship. A DGPS antenna is mounted on the over the side SSBL transceiver pole to provide the absolute reference position. This positioning system provides approximately 10-meter accuracy in measuring sonar vehicle absolute position during the survey in up to 100 meters of water.

The Biot model is used to estimate the physical and acoustic properties of the seabed from reflection coefficient and attenuation measurements made with the chirp sonar.

Dr. Schock supervises the research program including graduate and undergraduate students and at sea experiments. Jim Wulf is the lead engineer who designs and implements sonar modifications, and attends at sea experiments.

WORK COMPLETED

Chirp sonar data sets, collected in the South China Sea, New Jersey Shelf and Fort Walton Beach, were processed to generate profiles of sediment properties using the Biot model and chirp sonar data. The estimates were compared with insitu and core data collected during the respective cruises

The reflection profiles of the chirp sonar data sets collected during the Martha's Vineyard survey in support of the Mine Burial Program were posted on the web site http://www.oe.fau.edu/CHIRP/

RESULTS

Geoclutter program data analyses showed that the chirp sonar could accurately estimate the compressional wave velocity and porosity of surficial sediments using the reflection coefficient measurements and the Biot model. Figure 1 shows a plot of insitu measurement stations and 2001 chirp sonar track lines 903, 905, 907, 909, and 910 along the New Jersey shelf. The insitu and chirp sonar data were collected as part of the Geoclutter program. The reflection coefficient measurements were processed using the Biot model, which provided estimates of compressional wave velocity and porosity of surficial sediments. Figure 2 shows the favorable comparison between the insitu compressional wave velocity measured at 65 kHz using UNH insitu probes and the chirp/Biot model estimates of compressional wave velocity for 65 kHz. The figure also shows that porosities, calculated from University of Delaware insitu resistivity probe measurements, agree with estimates of porosity from chirp sonar reflection coefficient measurements using the Biot model.

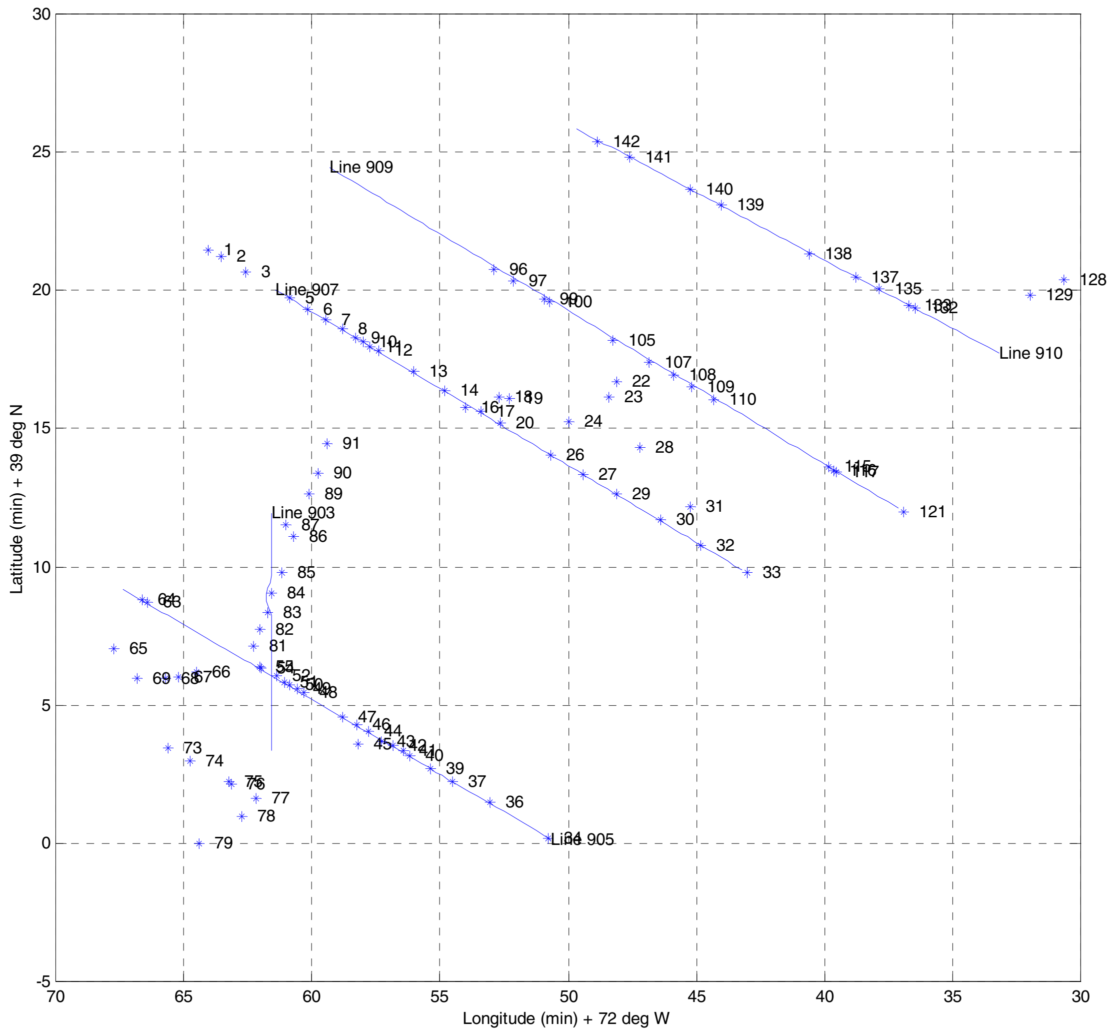

Figure 1 Chirp sonar tracklines and insitu measurement stations for the 2001 Geoclutter survey

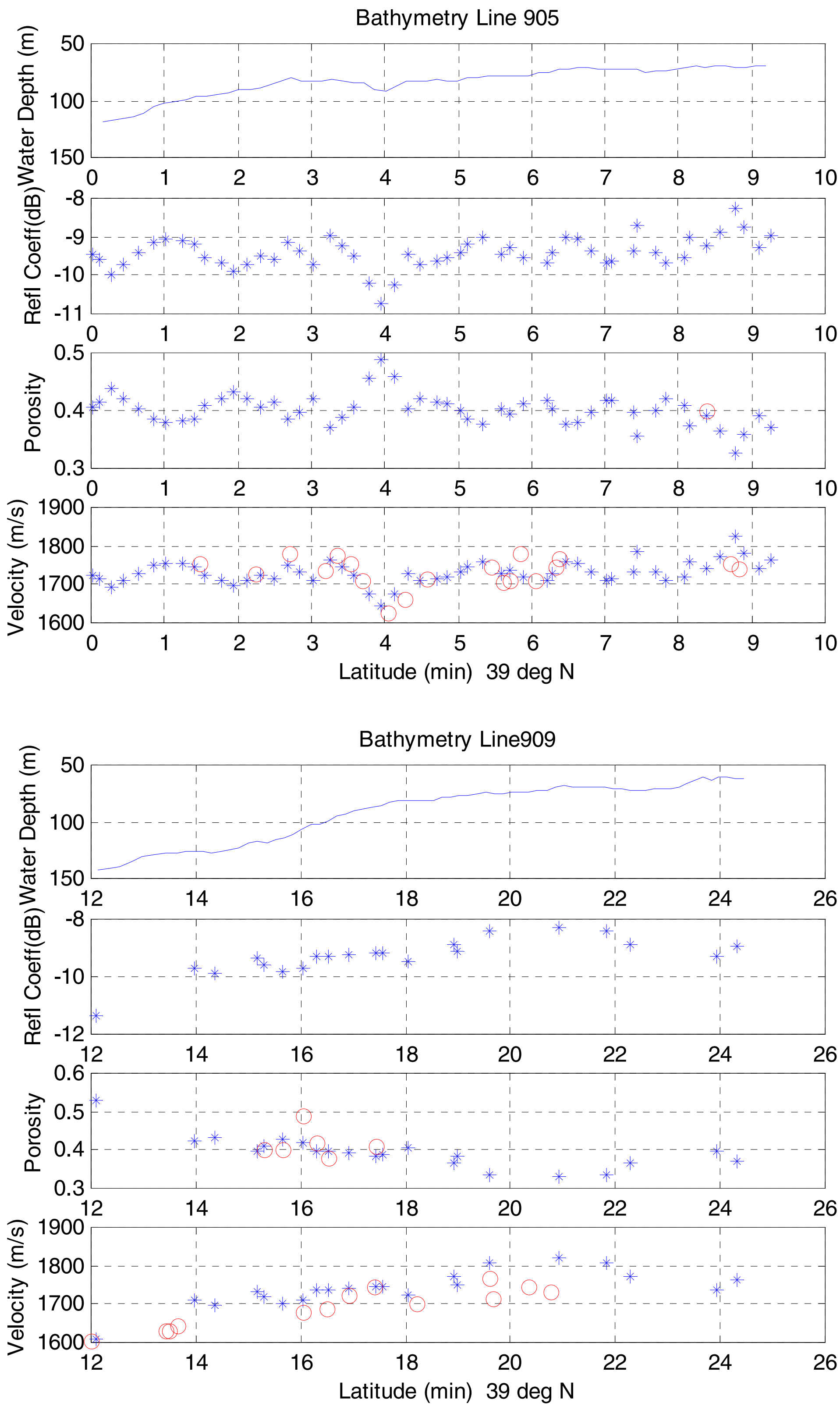

Figure 2 Chirp sonar reflection coefficient measurements at 2.1 kHz and Biot model predictions of fast wave velocity at 65 kHz and porosity for lines 905 and 909. The circles are insitu measurements porosity and fast wave velocity at 65 kHz, respectively.

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 20 meters of the seabed and obtaining vertical profiles of attenuation, acoustic impedance, volume scattering. From these acoustic property profiles, vertical profiles of physical properties such as bulk density, grain size, and porosity can be estimated.

PUBLICATIONS

"A Method for Estimating the Physical and Acoustic Properties of the Seabed Using Chirp Sonar Data," S. G. Schock. IEEE J. of Oceanic Eng.

"Remote prediction of physical and acoustic sediment properties in South China Sea using chirp sonar data and the Biot model, S. G. Schock, IEEE J of Oceanic Eng.

"Seabed characterization on the New Jersey middle and outer shelf: Correlability and spatial variability of seafloor sediment properties" John A. Goff, Barbara J. Kraft, Larry A. Mayer, Steven G. Schock, Christopher K. Sommerfield, Hilary C. Olson, Sean P. S. Gulick, and Sylvia Nordfjord, Marine Geology.

" An estimate of the bottom compressional wave speed profile in the northeastern South China Sea using sources of opportunity" Ying-Tsong Lin, James F. Lynch, Nick Chotiros, Chi-Fang Chen , Arthur Newhall, Altan Turgut, Steve Schock, Ching-Sang Chiu, Louis Bartek, Char-Shine Liu, IEEE J. Oceanic Eng'g Special Issue on Asian Marginal Seas.

"Remote estimation of seabed attenuation using a chirp sonar during ASIAEX" S. Schock, ASA, Cancun Dec, 2002. [published]