Remote Sediment Property Estimation From Chirp Data Collected During the Geoclutter Experiment

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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 procedures.

OBJECTIVES

1) Deploy the chirp sonar in regions where geoclutter has been detected during acoustic propagation experiments off the coast of New Jersey and to generate high resolution subsurface images of the geologic features that may be causing geoclutter. University of Texas will use the chirp sonar imagery to generate 3D maps of buried river channels and other geoclutter features. Maps of buried geologic features will be compared to acoustic geoclutter to determine the cause of geoclutter.

2) Compare remote chirp measurements of impedance, attenuation, acoustic velocity and phase dispersion with properties measured by other investigators conducting acoustic experiments and coring surveys.

APPROACH

The technical approach for the Geoclutter surveys 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 antennae 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.

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

WORK COMPLETED

During the Geoclutter cruise from 12 August until 10 September 2001, the chirp sonar was deployed off R/V Endeavor to generate images of subsurface features causing Geoclutter in 60 to 80 meters of water along the continental shelf off New Jersey. The sonar operated in a dual pulse mode alternating between 40 msec 1.5-4 kHz FM and 10 msec 1.5-15 kHz pulses. The sonar vehicle was tracked with a SSBL system to provide the position accuracy needed for constructing 3D maps of subsurface features. Vehicle heave was measured using a high accuracy pressure sensor. An example of the heave compensated imagery is shown in Figure 1.

Three array line hydrophone channels were added to the sonar vehicle to allow measurement of acoustic sound velocity. Data was continuously collected from the 3 array channels during the entire cruise to provide a data set for completing the development of the remote velocity measurement technique and establishing its accuracy. During the survey measurements were made over sites where Larry Mayer had performed insitu velocity measurements on an earlier cruise. This data will be compared with the remote predictions during next years effort.

RESULTS

Analysis of chirp sonar images collected during the Geoclutter survey suggest that the potential causes of geoclutter are 1) pockets of gravel like material and boulders 2) gassy sediments and 3) the walls and fill of buried river channels that were formed during the last low stand. Figure 1 shows examples of subsurface targets with high target strengths that may be causes of geoclutter.

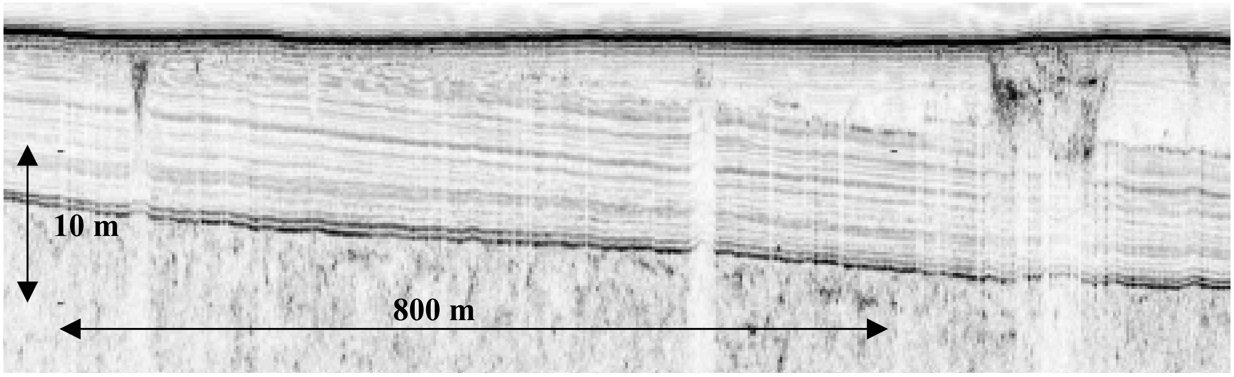

Figure 1 Chirp subbottom profile collected in phase 1 survey area in 80 meters of water off New Jersey coast . The image was generated using a 40 msec 1.5-4 kHz FM pulse. The image shows potential causes of geoclutter including buried river channels and gassy sediments indicated by acoustic whiteouts and early arrival times of reflections under the gassy features.

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.

TRANSITIONS

The chirp sonar collected during the 2001 Geoclutter survey has been delivered to Institute of Geophysics investigators at University of Texas who are generating 3D maps of river channels.

RELATED PROJECTS

"Remote Sediment Property Estimation From Chirp Data Collected During ASIAEX," ONR G&G Grant. The chirp sonar was used to remotely predict sediment properties in the East and South China Seas using the same techniques as described in this report.

PUBLICATIONS

1. "Techniques for estimating sediment properties from chirp sonar data," S. G. Schock, JASA, Vol 109, No. 5, Pt 2, Chicago, May 2001 (invited paper).