MIDDLE ATLANTIC BIGHT FIELD STUDY: SUS COMPONENT

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LONG-TERM GOALS

Our long term objective is to investigate the feasibility of using broadband explosive sources such as SUS charges for inversion of oceanographic fields and sediment parameters. We are assessing the performance of linear inversion schemes based on perturbations and non-linear inversions using a combination of global search methods (Genetic Algorithm) and local least squares optimization schemes (Levenberg - Marquardt). The inverted oceanographic fields are coefficients of empirical orthogonal functions of the sound speed field in the water column and the spatially-varying bottom parameters such as sound speed and layer thickness. Also, source/receiver positions are estimated using matched field techniques. We are also estimating the spatial resolution and error properties of the inverted fields and parameters.

SCIENTIFIC OBJECTIVES

The S&T objectives of this work deal with the effects of a complicated shelfbreak front and sloping bathymetry on acoustic propagation. Low frequency acoustic propagation in areas with varying bathymetry is affected by the presence of oceanographic features like frontal zones, internal waves and solitons. The effect of these features on the acoustic propagation in this severely range dependant environment is studied in the Primer Field Study. The analysis of the data collected using the tomographic sources are being carried out at WHOI, NPS and MIT. At URI we are analyzing the broadband data collected during the SUS operations.

BACKGROUND

This research project is part of the integrated acoustic-oceanographic Shelf Break Primer field study in the Middle Atlantic Bight. This work is complimentary to the work being conducted at the Woods Hole Oceanographic Institution, Naval Postgraduate School, and Harvard University. The overallgoal of the field study is to understand the propagation of sound from the continental slope to the continental shelf including the effects of shelf-break frontal features and seasonal stratification. In this project, we have used the broadband low frequency SUS signals to extract information on the oceanographic and sediment parameters. URI tasks relate particularly to the design and execution of the SUS

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experiment, initial data reduction and analyses and inversion for the oceanographic and geoacoustical parameters.

APPROACH

Hydrophone array time series of the shot data from the Shelf Break Primer Experiment (summer component) was modeformed using a background sound speed profile from Sea Soar temperature and salinity data as a function of frequency from 20-100 Hz for modes 1-4. The time-frequency dispersion curves for the mode arrival patterns were determined by short-time fourier transforming this data. The group velocity values were peak picked as a function of mode number and frequency. Interesting features in the spectrogram include a very low frequency precursors to the water borne arrival, 10 seconds of significant reverberation, complicated structure in direct blast including nulls from either the SUS spectrum or propagation, and evidence of modal dispersion.

A signal from one of the SUS charges, deployed near the North West corner of the experimental area, received at the North East VLA was analysed and used for inverting the sound speeds in the water column and the sediment. Nonlinear optimization was perfomed using the combination of a global scheme (Genetic Algorithm) and a local least squares method (Levenberg-Marquardt). This Hybrid approach has the advantage of reducing the computational time since the local method employs a guided search. Forward modelling was done using range independant normal mode theory. The objective of this inversion was to estimate the water column sound speed and sediment compressional sound speeds that match the experimental group velocities determined earlier.

ACCOMPLISHMENTS AND RESULTS

SUS drops were made in the July, 1996 and in February, 1997 during the Middle Atlantic Bight Field Study. Over 80 individual MK-64 SUS were deployed on tracks parallel and perpendicular to the isobaths in the region. These tracks were chosen to maximize the observability of the 3-D effects and the measurement of the optimal frequency.

All of the acoustic data from the WHOI 2 VLAs has been initially processed and edited in the Matlab compatible files. The 2 WHOI VLAs were named SHARK and BUOY. The SHARK array had a telemetry and onboard storage capability while the BUOY array had only an onboard storage capability. The SHARK array had 8 phones working on the day of the SUS deployment while the BUOY array has 16 phones in good order. This data has been made available to the P.I.'s from WHOI, NPS, and NAWC on the URI anonymous ftp site.

We have nearly compleated the analysis of the analysis of the first SUS signal received at the North East VLA from the SUS explosion at 40 deg.22.01 min. N ,71 deg. 9 min W. The propagation path of this signal is of uniform water depth and hence treated as range independant. The water column sound speed and sediment compressional sound speeds were inverted and are shown in Figure (1). We were able to compare these values with the compressional speeds calculated using Biot-Stoll model at a nearby Atlantic Margin Coring Project site (AMCOR - 6012). This site is located near the South West corner of the experimental site at a distance of approximately 75 Km from the propagation path. We atribute the differences between the AMCOR data and the inversion to the distance. We are planning to take a number of gravity cores along the propagation path in January, 1998 to further validate our inversion results. In addition to this linear pertubation methods also were employed to inversion results to further improve the quality of results. It was observed that the linear method modifies the solution only in the top 10-20 m of the sediment.

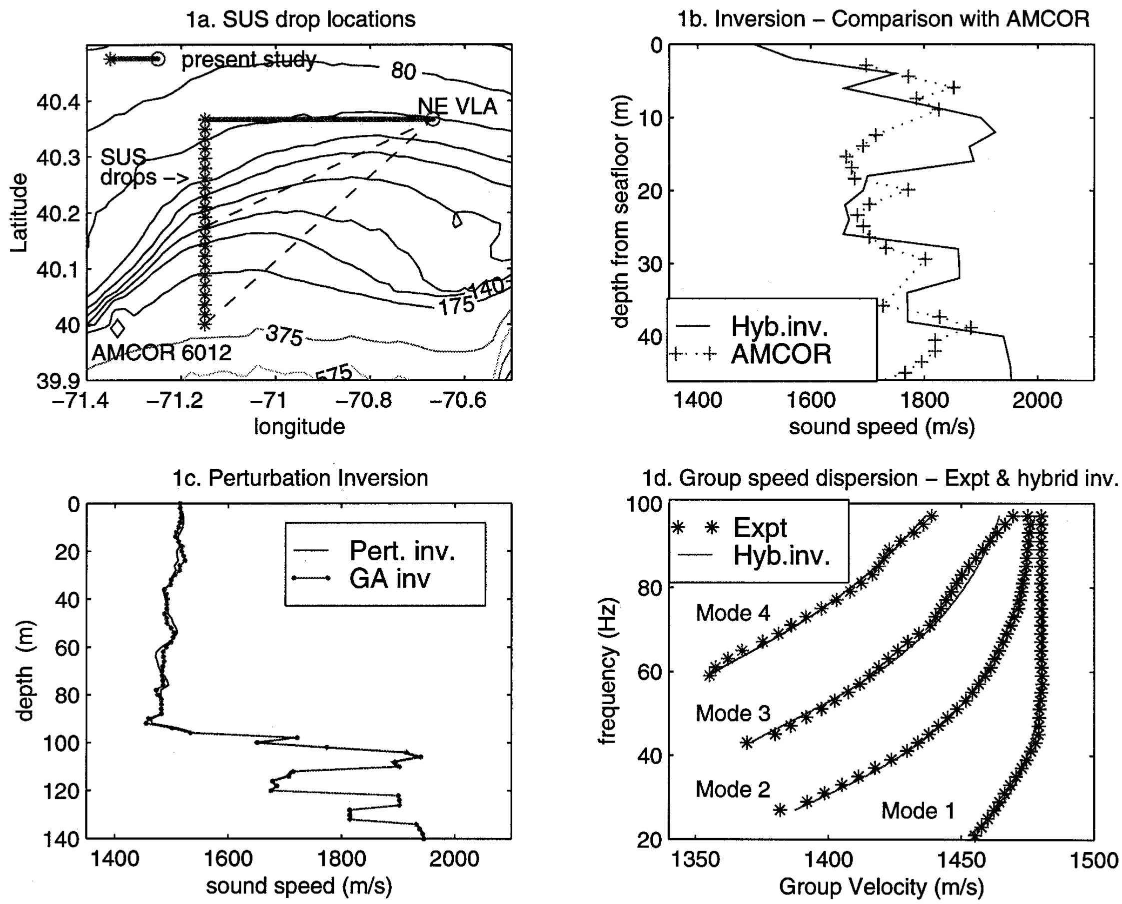
These results were presented at the recent meeting of the Acoustical Society of America at San Diego during 01-05 December 1997.

IMPACT ON S&T

This experiment and subsequent data analysis will have direct and immediate impact on Navy system design, operations and tactics. The ASW problem posed by quiet diesel submarines inshore of Navy assets on the continental shelf poses difficulties for deep water Low Frequency Active Acoustic systems and air-deployed explosive ASW systems. The results from this work will allow systemdesigners to assess system capability in regions of the world with upslope and 3-D propagation, continental shelf and slope, and fronts. Operators will be able to improve system performance by using the optimum frequency analysis from this work. The use of Navy air ASW systems will be affected by the results of this study. In addition, the work may provide a technique for fast and inexpensive estimation of sediment properties in littoral waters to 10's of meters below the sea bottom. We think that once the technique is perfected, only a VLAD sonobuoy and a number of SUS charges could provide range dependent sediment maps with range resolution of a few kilometers and depth resolution of meters.

RELATIONSHIP TO OTHER PROJECTS

This project is directly related to a number of classified Navy projects in SPAWAR, NAVAIR, NRL, and the Submarine Security Office. All of these projects are directed toward the detection, classification, and localization of submarines in a littoral environment. Further information on these projects can be obtained directly from the P.I.



Comparison of inversion results with AMCOR data and Group velocity dispersion.Figure 1a shows the SUS drop locations marked by asterisks and the Northeast Vertical Line Array by a circle. The solid line is propagation path for these inversions. Figure 1b shows the inversion results as a solid line and the Atlantic Margin Coring (AMCOR) site 6012 a plus signs. Figure 1c shows both the water column and sediment inversion, with a solid line for the perturbation method and chain-dots for the Genetic Algorithm inversion. Figure 1d shows the agreememt between the measured and the modeled dispersion for modes
1-4 in the frequency range from 20-100 Hz.