Stratigraphic and Geoacoustic Characterization of the Outer New Jersey Shelf

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LONG-TERM GOALS

As a participant of the ONR Shallow Water Acoustics experiment conducted on the outer New Jersey shelf during the summer of 2006 (SWA06), the long term goal of this project is to understand the interaction of acoustic energy, at both medium and low frequencies, with the seabed.

OBJECTIVES

The objectives of this work are to (1) incorporate existing geological, geophysical and geoacoustic data into a seabed properties model applicable to the SWA06 experiment region, and (2) geologically interpret additional chirp seismic data that were collected as part of SWA06 (Altan Turgut, PI), and incorporate into existing interpretation based on analysis of prior data (primarily from the ONR Geoclutter program).

Expected products include:

(1) A structural/stratigraphic model of the subbottom, along primary acoustic propagation pathways of the SWA06 experiment and regionally with existing and newly collected chirp seismic data.

(2) A geologic interpretation of the regional stratigraphy based on both new and existing chirp seismic data and available ground truth information. This interpretation will focus on the outer shelf wedge (OSW) that forms the seafloor substrate over most of the SW06 experiment region.

(3) A geoacoustic rendering of the structural model based on predictive relationships between such properties and the stratigraphic/geologic interpretation. Available physical property measurements will be used to constrain such relationships.

APPROACH

Seafloor and subseafloor data readily accessible to the PI (Figure 1) are listed below:

(1) Swath bathymetry and backscatter data were collected in 1996 as part of the STRATAFORM program (Goff et al., 1999) and more recently as an add-on to the Geoclutter program. The backscatter data derived from 95 kHz acoustic frequency. Ground truth data demonstrate that, in this region, these

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14. ABSTRACT

The objectives of this work are to (1) incorporate existing geological, geophysical and geoacoustic data into a seabed properties model applicable to the SWA06 experiment region, and (2) geologically interpret additional chirp seismic data that were collected as part of SWA06 (Altan Turgut, PI), and incorporate into existing interpretation based on analysis of prior data (primarily from the ONR Geoclutter program).

15. SUBJECT TERMS

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data are primarily responsive to the coarse content at the seabed (Goff et al., 2004). Combined analysis with chirp data has also revealed how the seabed morphology can be used to infer the locations of significant seabed erosion (Goff et al.,2005).

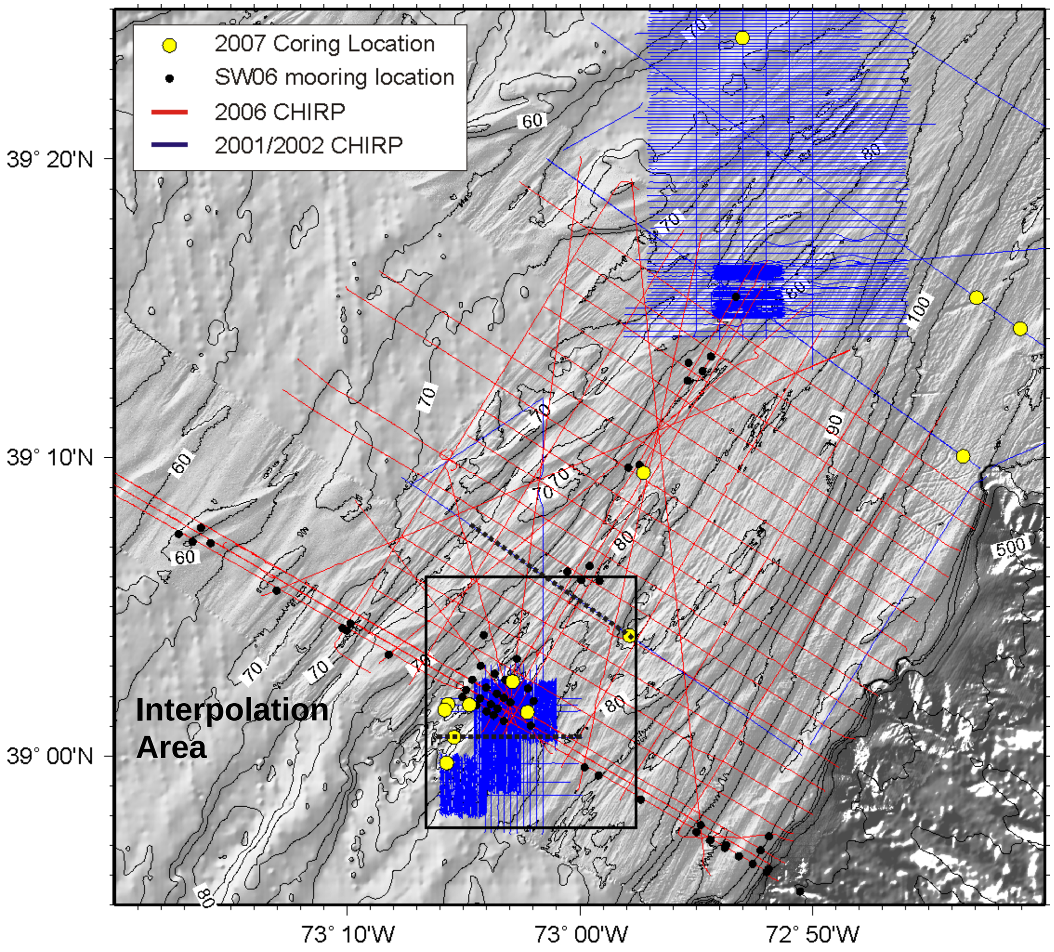

Figure 1. Location of recent chirp seismic reflection data and core locations, superimposed on multibeam bathymetric map of the NJ outer shelf. The region of the SW06 experiment is defined by the mooring locations

(2) Chirp seismic reflection data were collected in 2001 and 2002 for the Geoclutter program (Nordfjord et al., 2005; Gulick et al., 2005). These data have been interpreted structurally (Figure 2). Furthermore, along main dip transects of the 2001 data set, Dr. S. Schock (FAU) has derived seafloor impedance values for 1-4 kHz data (Goff et al., 2004).

(3) Grab samples were collected as part of both a JOI site survey augmentation grant (Goff et al., 2000) and the Geoclutter program (Goff et al., 2004). These samples have been analyzed for grain size distribution.

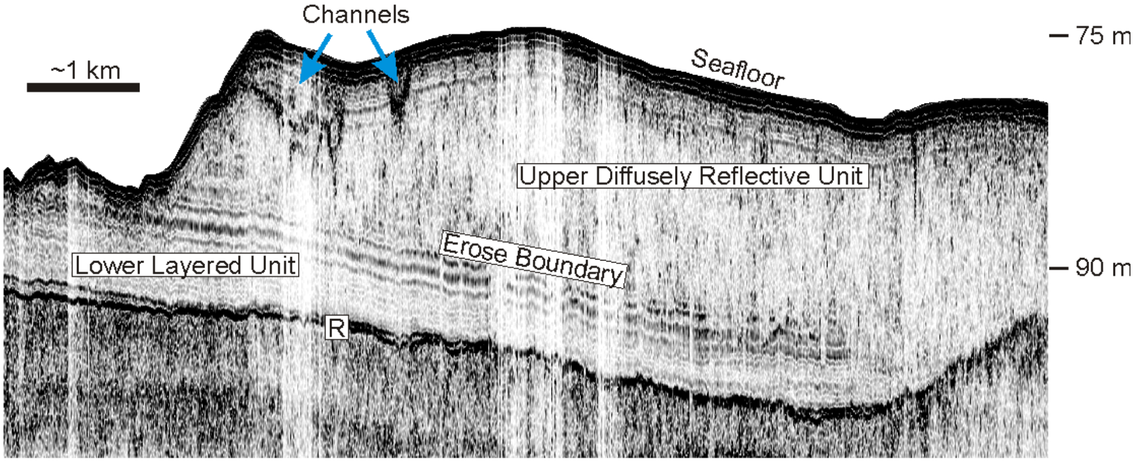

Figure 2. East-West CHIRP seismic dip profile, from the 2001 Geoclutter chirp survey, crossing the New Jersey outer shelf through the "interpolation region" in Figure 1. This figure illustrating primary stratigraphic components of the outer shelf wedge underlying the SW06 experiment region.

(4) At the locations of the 2001 grab samples, measurements of in situ velocity at 65 kHz were collected by colleagues at the University of New Hampshire. These values were shown to be correlatable to the mean grain size determined from the grab samples and to the seafloor impedance values derived from the chirp data (Goff et al., 2004).

(5) Three long cores were collected in 2002 using the AHC-800 drilling system. These cores are located within the chirp seismic data. They were analyzed for geologic structure and logged for the geoacoustic properties of velocity and density (Nordfjord et al., 2006).

(6) Additional cores were collected summer 2007 on the New Jersey outer shelf under a separately-funded ONR grant (Figure 1). These cores were located within the context of the Geoclutter and SW06 chirp surveys, and logged for velocity and density.

The primary objective of this work is to develop a structural model of the seabed and subsurface along the SWA06 propagation pathways, and to populate that model with measured and predicted geoacoustic properties. The structural model will be based upon the interpreted seismic horizons derived both from the 2001/2002 Geoclutter and 2006 SW06 chirp data. Most of the 2001/2002 Geoclutter chirp data have been interpreted by UTIG colleagues, and exist, along with seismic data, within a Geoframe (a commercial seismic interpretation software package) data bases that reside at UTIG. The 2006 chirp data have been processed and also loaded into the same Geoframe project, and will be interpreted in the same context.

The new chirp data should provide an important geologic product: a structural connection between the northern and southern sectors of the 2001/2002 chirp data (Figure 1). Populating any structural model with geoacoustic properties will pose a significant challenge, given the constraints on collecting new ground truth data for the SWA06 project. Physical property measurements, of course, will be used as much as possible. These include: *in situ* measurements at the seabed, core logs, geoacoustic inversion (Holland et al., 2005), and impedance values estimated from chirp seismic data. However, available measurements are limited, particularly along the planned dip and strike lines for the SWA06 experiment, and also particularly at depth below the seafloor. Some form of prediction will be required. The expectation here is that the geologic interpretation of the stratigraphic structure will guide the prediction. Guided by available ground truth and inference from chirp seismic, the PI will, in close collaboration with SWA06 participants, seek to formulate geoacoustic model for the primary geologic units that takes into account spatial variability (both laterally and with depth) as well as mean properties. This model will then form the basis for filling the structural model with geoacoustic properties.

WORK COMPLETED

Turgut and Goff successfully completed the SW06 chirp survey in July of 2006. The survey utilized the NRL-owned Edgetech 1-16 kHz chirp system during a 9-day cruise aboard the *R/V Sharp*. Completed survey lines are displayed in Figure 1, along with locations of the primary acoustic deployment. Two priorities were identified for the planned track lines: (1) along primary acoustic propagation pathways for SW06 experiment (phase 1), and (2) a regional grid survey (phase 2) to enable the SW06 region to be placed within the geologic and stratigraphic context of our understanding of Areas 1 and 2. Despite some technical difficulties with the main tow cable in the beginning of the survey, we successfully surveyed all the phase 1 track lines and all but three of the phase 2 lines.

Stratigraphic interpretation of the chirp data are being conducted by Goff and a student of the University of Texas, Manasij Santra, who is working on this project for his thesis. Major structural horizons have been completed, and characterization of the internal stratigraphy of the OSW is nearly complete. Some of these results were detailed in the previous progress report.

The most significant accomplishment over the previous year has been the formulation of a 3-dimensional structural model of the subsurface stratigraphy. Initial modeling work focused on the "interpolation region" identified in Figure 1, which will be detailed below, but we have since expanded the model to include the larger SW06 region. The structural models have been used by a number of SW06 acousticians in their work: Knobles, Dahl, Ballard, Chapman, Frisk and Potty. Goff has co-authored papers with Knobles and Dahl, and another with Ballard is being planned.

New geoacoustic logging results are also now available from the 2007 coring cruise.

RESULTS

Principal seismic horizons used to construct a 3-dimensional structural model of the subsurface in the SW06 region are identified in Figure 2. These include (1) the seafloor bathymetry, (2) a channel horizon, which formed by fluvial erosion during the last glacial low stand, and later filled by estuarine sediments, both sand and clay, during sea level rise, (3) an erose boundary between the lower, layered units of the OSW and the upper, transparent unit, and (4) the "R" horizon, which forms the base of the OSW. The wedge itself is primarily a stiff clay, with interspersed sandy clay layers that form the acoustic laminations in the lower unit. A very shelly sand underlies the wedge, forming a high-impedance contrast for the "R" reflector. The fill units within the channel alternate between gravelly sand at the base (fluvial lag), followed estuarine-based clays, and barrier sands at the top. Interpolations of these four surfaces a within the area noted in Figure 1 are shown below in Figures 3-

6. Selected cross sections through the 3-dimensional model are shown in Figure 7. These were used by Megan Ballard in her acoustic modeling work.

The NW sector of the interpolation area (Figure 3) also includes a large Holocene sand ridge that overlies the OSW units. This unit is not shown below in the model plots below, but is included in the structural model over the larger SW06 area.

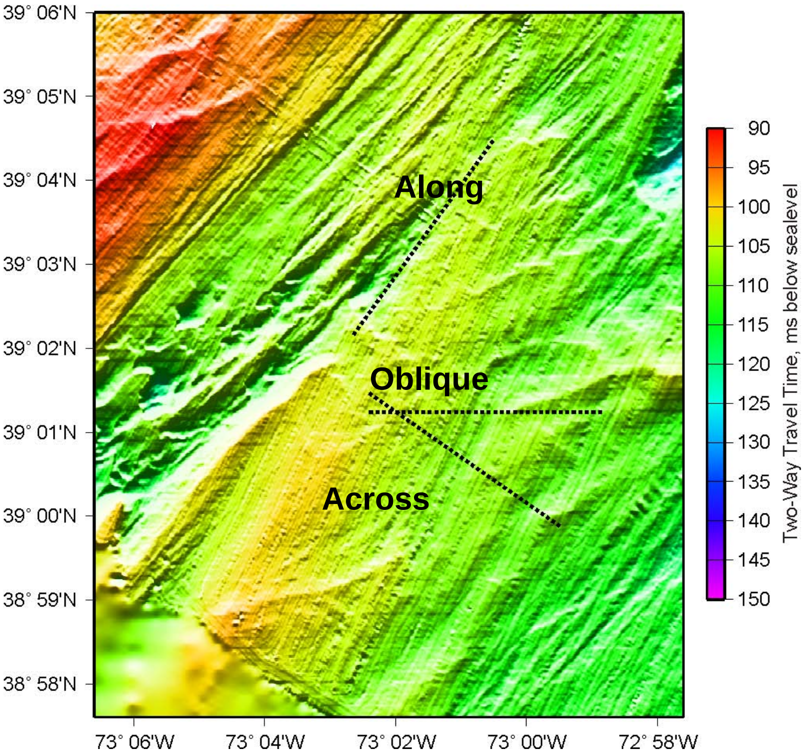

Figure 3. Bathymetry in the "interpolation area" (see figure 1) with the locations of three profiles identified. The cross sections through the 3-D model along each profile will be displayed Figure 7.

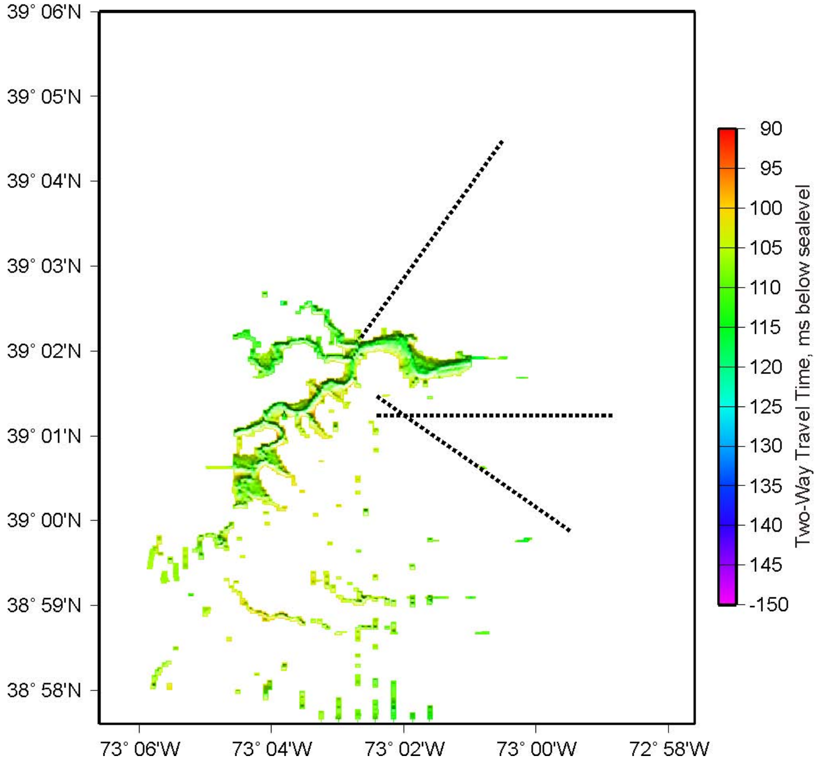

Figure 4. Interpolation of the "Channels" horizon. See Figure 1 for location.

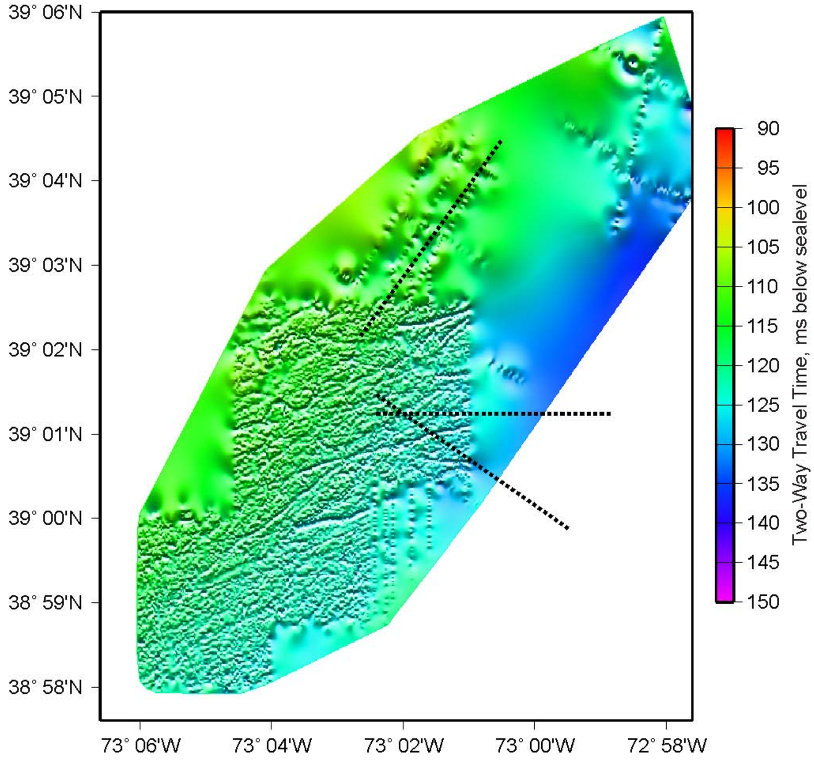

Figure 5. Interpolation of the erose boundary. See Figure 1 for location

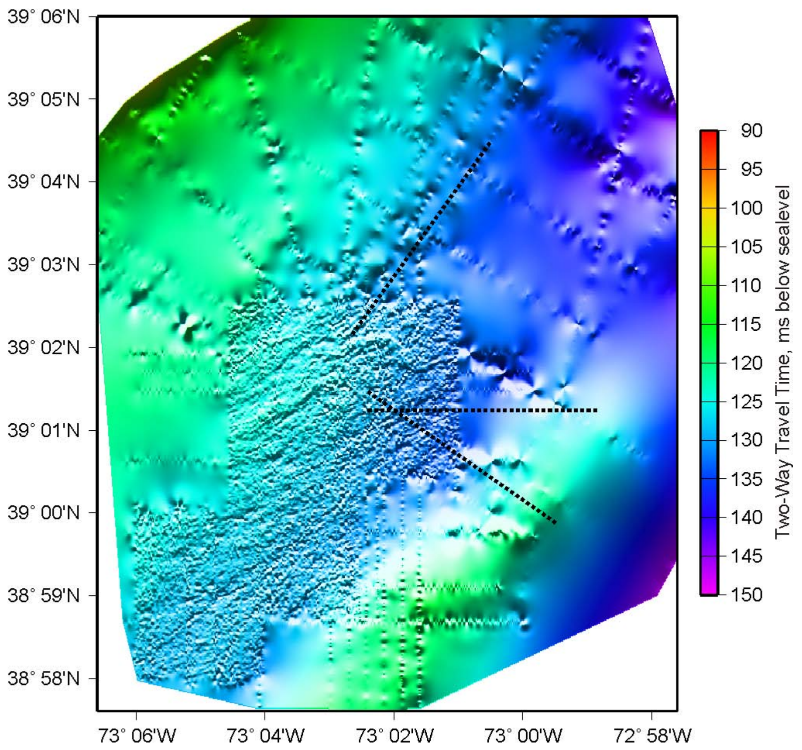

Figure 6. Interpolation of the "R" horizon. See Figure 1 for location

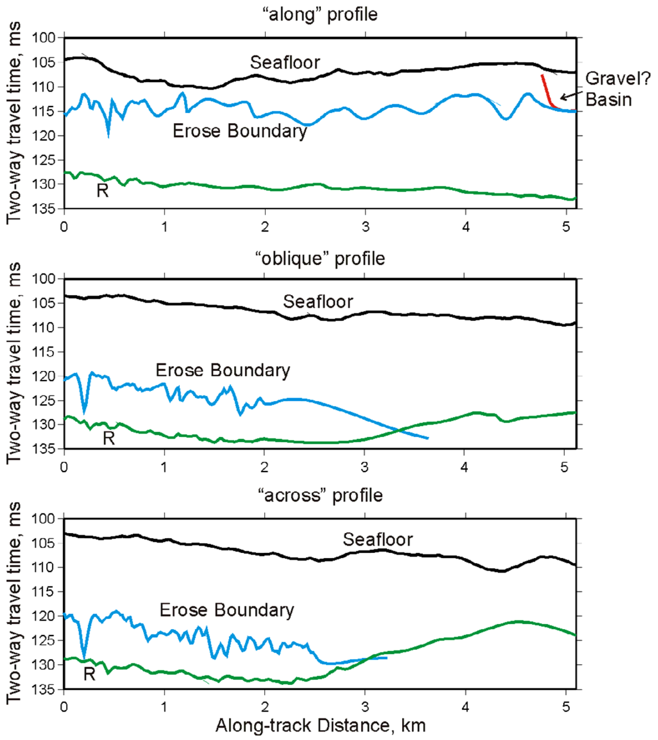

Figure 7. Profile cross-sections through the interpolations shown in Figures 3-6. See Figure 3 for location

Our ultimate aim is to populate the 3-dimensional structural model with estimates of geoacoustic properties. The table below summarized average velocity and density measurements within available cores, both recent (2007) and previously (2002). In the future we expect to work with SW06 acousticians to incorporate geoacoustic inversion results to better flesh-out the full model.

Velocity and Density Core Averages for OSW

	Velocity, m/s	Density, g/cc
Upper Unit:	1639	1.93
	1624	1.92
	1657	2.02
		2.00
Lower Unit	1554*	1.92
	1652*	2.00
		1.87
		1.87
		1.96
Below R	~1850**	2.14

*Single values **Upper range of very erratic measurements

IMPACT/APPLICATIONS

The merged bathymetry and backscatter data will be a direct benefit to acoustic and oceanographic modelers working for the SWA06 project.

RELATED PROJECTS

The ONR Geoclutter, STRATAFORM and Uncertainty in the Natural Environment projects have provide significant data and modeling inputs for this project.

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HONORS/AWARDS/PRIZES

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