Geophysical and Geological Reconnaissance for the ONR Geoclutter Program

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LONG-TERM GOALS

The long term goals of the ONR Geoclutter program are to (1) to understand, characterize, and predict lateral and vertical, naturally-occurring heterogeneities that may produce discrete acoustic returns at low grazing angles (i.e., "geologic clutter") in a mid-outer shelf test site off the U.S. (New Jersey), and then (2) to conduct precise acoustic reverberation experiments at this site to understand, characterize, and potentially mitigate the geologic clutter, so that the false alarms, or detects, of tactical sonar systems encountered in this marine geologic environment around the world can be characterized properly.

The premise for this work is that, in any littoral area, buried geologic features can contribute significantly to acoustic reverberation, which affects tactical ASW sonar systems. Proper acoustic processing, coupled with quantitative geologic models, can be used to distinguish these buried features from real (man-made) targets. Complexity arises from STRATAFORM studies on the continental shelf off New Jersey that have shown the general lack of predictability of the shallow subsurface using seafloor imagery, even with 100% coverage of the seafloor and the subsurface to depths of 10-15 m (Duncan et al., in press).

The primary goal of the Geoclutter program will be to assess geologic clutter/reverberation issues in a seismically and geologically well-characterized shallow-water environment. The mid-outer continental shelf off New Jersey (Figure 1) provides such an opportunity, because both bathymetry (a known and prominent cause of backscatter) and portions of the shallow subsurface have been mapped in detail as a result of STRATAFORM. The Geoclutter program will consist of three field program phases: (I) an acoustic reconnaisance survey utilizing Navy gray ships and assets to identify potential geoclutter hot spots; (II) a full bistatic acoustic experiment focusing on the chosen areas, and (III) the focus of this proposal, detailed geologic and geophysical surveys of the hot spots identified in Phases I and II.

OBJECTIVES

The objective of this grant is to provide geophysical and geological reconnaissance of the areas of primary interest for the ONR-sponsored “Geoclutter” program. Acoustic field experiments will be held off the U.S. east coast in the Spring of 2001. These experiments are expected to identify localities at and/or below the seafloor that are sources for geoclutter. Once identified, our task, with field work scheduled for the latter part of the Summer of 2001, will be to characterize, as completely as possible, the structure and geotechnical properties of the geoclutter sites. We will employ swath bathymetry and sidescan data, high resolution seismic, and velocity probe data as well as long core, short core and grab samples to formulate our site characterizations.

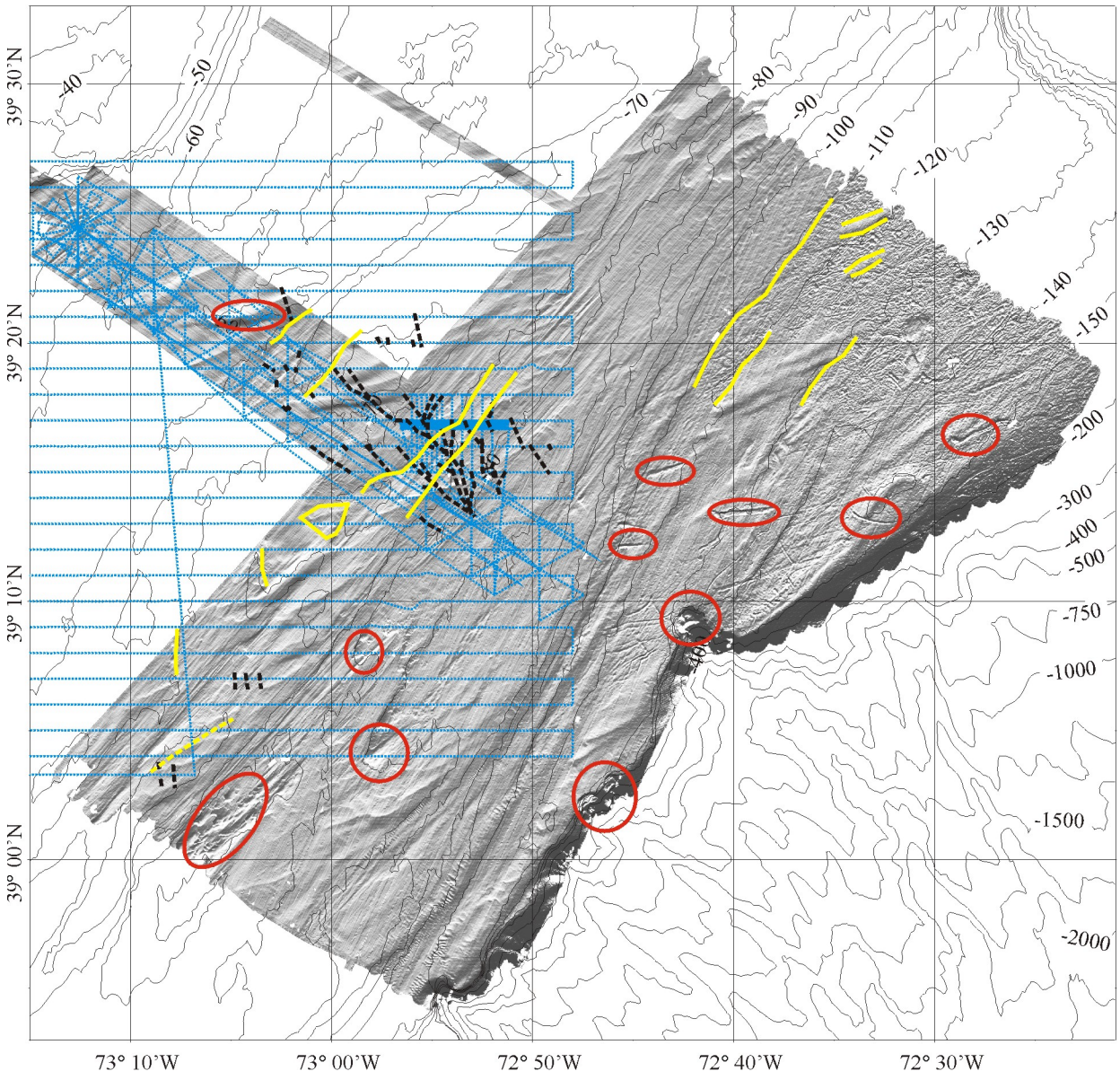

Figure 1. Possible geoclutter targets identified from swath map and ultra-high resolution seismic reflection data. The STRATAFORM swath bathymetry data are displayed with artificial illumination from the north. Contours in meters are from regional data compiled by NGDC. Light blue lines indicate tracklines for available Huntec ultra-high resolution seismic reflection data. Three different types of possible geoclutter targets are identified: red ovals indicate bathymetric targets; yellow lines indicate important changes in sedimentary properties at or near the seafloor, as inferred from backscatter data or by outcrops of prominent subsurface reflectors; black dashed lines indicate shallowly buried (< 10 m) channels

In addition to supporting the requirements of acoustic modeling within the Geoclutter area of interest, the geophysical and geological data proposed for collection will augment scientific inquiries being conducted offshore New Jersey already by both ONR's STRATAFORM and the Ocean Drilling Program. Foremost among the avenues of research we plan to take will be an investigation of the

stratigraphic responses associated with the latest sea level fall and rise over the last ~35 kyrs. Because the extent of overlapping multi-frequency seismic coverage to be collected is simply unprecedented, we anticipate solutions to contentious and vexing scientific problems that persist, despite decades of attention to this particular area. For example, when did the extensive system of shallow subsurface channels observed on both 2D and 3D Huntec surveys over the outer shelf form? What was their source? How and with what succession(s) of sediments were they filled? What constraints do they place upon the sequence of events associated with the latest sea level lowstand and the ensuing Holocene transgression? We anticipate that the proposed seismic stratigraphic and coring data will provide strong constraints on the events associated with the latest sea level rise, particularly in terms of documenting episodicity which STRATAFORM studies have hinted at.

The seafloor characterization component of this proposal will provide information relating to two important scientific objectives: (1) understanding modern sedimentation processes on the mid- and outer shelf and (2) quantifying the relationships between high frequency acoustic backscatter and sediment properties. The mid- and outer shelf areas of the New Jersey margin exhibit particularly interesting bathymetric morphology and backscatter patterns, as revealed in the STRATAFORM swath mapping data. Features include ribbons, ridges, dunes, erosional scour pits, high backscatter regions and, most enigmatic of all, preserved iceberg scours. Beyond an adequate characterization of their morphology, the key to understanding the processes that produced and continue to modify these features is a comprehensive sampling and analysis of the sediments that constitute them.

APPROACH

Although the precise areas of focus are not yet known, we have generated a preliminary plan based upon reasonable expectations. We anticipate that the reconnaissance and full bistatic acoustic experiments will identify particular localities – perhaps on the order of hundreds of square meters to square kilometers in extent – that are sources of geologic clutter. Our goal is to characterize the physical significance of these areas as completely as possible – i.e., their stratigraphic architecture in three dimensions and physical properties – within the limitations of our survey resources. Furthermore, we anticipate that these areas will be complex (the very nature of geoclutter requires it!). Full 3-D characterizations will be needed.

Stratigraphic Architecture

We will characterize stratigraphic architecture using ultra-high resolution seismic reflection imaging, in both two- and three-dimensions. In particular, we will make use of a state-of-the-art CHIRP seismic reflection system developed by Dr. Steven Schock, a collaborator on this effort, with sponsorship by ONR. The CHIRP sonar is a towed, digital, wide-band, FM sonar that generates extremely high resolution images of shallow sediments beneath the sea floor and also provides high quality sediment acoustic data that can be used to characterize sediment properties. This system is robust and well-tested. With a controlled source ranging from 1-15 kHz, a match-filtering procedure results in deep penetration (30 m or more) and high resolution imaging (to decimeters) in the sandy sediments expected offshore New Jersey. We cannot reasonably conduct a fully 3-D CHIRP survey over the entire area of Geoclutter interest (3-D at this spatial scale requires 10 m profile spacing, while the Geoclutter area is roughly 50 km by 50 km). Rather, we will conduct a 3-tiered "nested" survey, to be conducted on the *R/V Endeavor* in August, 2001, with the highest resolution efforts focused on the areas of most intense interest. Our plan is as follows:

• Regional reconnaissance – 6 days
• Focused surveys: two each, 10 km by 10 km boxes at 100 m line spacing – 6 days each
• 3-D boxes within focused surveys: four each, 1 km by 3 km boxes – 3 days each
⇒Total survey time: 30 days.

Physical Properties

Information on the physical properties of the sediment, at the seafloor and at depth, will also be obtained, using a variety of methods. Acoustic modeling of target areas will require that we know or can predict the physical properties throughout the volume of interest. The sediments right at the seafloor are particularly important. Seafloor sediment properties are determining factors for acoustic scatter from bathymetric irregularities. In addition, the water/seafloor interface regulates the amount of energy that gets into the subsurface and is available for scattering from subsurface inhomogeneities. At the low acoustic grazing angles associated with ASW sonar activities, small changes in the difference between water velocity and sediment velocity at the seafloor interface can have a large effect on the amount of acoustic energy entering the subsurface. Therefore, we must characterize the seafloor sediments as accurately as possible. Fortunately, the seafloor is readily accessible, and we can obtain important data on seafloor properties quickly and inexpensively.

The seafloor within the Geoclutter area of interest has already been surveyed with multibeam bathymetry and sidescan backscatter as part of the ONR STRATAFORM program. The backscatter data, in fact, provide substantial information on seafloor sediment properties, but indirectly. We know that backscatter variations are responding primarily to variations in sediment properties, but we cannot know for certain what those variations in sediment properties are. The relationship between backscatter and sediment properties must be established by sediment sampling – particularly for grain size distribution and density - and *in situ* velocity measurements. Measurements of grain size distribution within the shallower portions of the STRATAFORM swath survey (outside the area of interest to Geoclutter) did establish a strong link between grain size and backscatter strength, but for a limited number samples in deeper water depths (in the vicinity of the channels) the connection was ambiguous, evidently because of a more complex grain size histogram (Goff et al., 2000). Many more samples, complimented by velocity and density measurements, will be required within the area of interest to Geoclutter to confidently ascertain the nature of backscatter variations from the surface sediments. Measurement of acoustic velocities *in situ*, using a velocity probe, is critical, since unconsolidated sandy cores will significantly compact from dewatering when brought aboard ship. Therefore, we will conduct a 7-day cruise aboard the *R/V Cape Henlopen* in July, 2001 to obtain short core and grab samples and coregistered *in situ* velocity measurements within the Geoclutter area of interest. We anticipate collecting ~500 samples and velocity measurements. L. Mayer, a collaboarator in this effort, will, with available electronics, design and build a tripod-mounted velocity probe that is appropriate for deployment from a winch wire. The measured surface properties will then be systematically compared against coregistered backscatter measurements to provide a basis for specifying surface properties throughout the Geoclutter area.

Sediment properties at depth will be established both directly, through long coring and borehole logging, and indirectly, through analysis of the multifrequency CHIRP data. We anticipate that long coring will take place as part of the last phase of the ONR STRATAFORM program (Austin is the lead PI for this project and Olson a co-PI). Signal processing procedures have been developed that estimate acoustic impedance and compressional wave attenuation with depth beneath the sea floor. These parameters will be used by Schock to predict grain size and other physical properties of marine

sediments. Comparison against long core and surficial physical properties data will be invaluable for providing ground truth of these procedures, thereby enabling robust inference of physical properties throughout the Geoclutter area of interest.

WORK COMPLETED

Work on this project has not yet commenced.

RESULTS

Results have not yet been obtained for this project.

IMPACT/APPLICATIONS

The goal of the planned field experiments off the U.S. east coast in 2001 is to understand the process of acoustic reverberation from the seabed in shallow water, with the objective of designing physics-based signal processing ("detection") algorithms to distinguish these naturally-occurring features (Figure 1) on the world's continental shelves (e.g., shallowly buried meandering channels (Davies et al., 1997), surface outcrops of reflective horizons, erosion scars (Goff et al., 1999)) from man-made targets of similar dimensions (e.g., submarines).

TRANSITIONS

No transitions yet.

RELATED PROJECTS

The New Jersey shelf was chosen as the focus for the Geoclutter work in large part because of the intensive data collection that has already occurred there as part of both the ONR STRATAFORM program and ODP site survey work. This site is also the focus of the Shallow Water Acoustic Technology (SWAT) experiment.

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