

Repeat Surveys to Evaluate Seasonal Variability in Seafloor and Shallow Sub-surface Acoustic Properties, Shallow Water Gulf of Mexico

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LONG-TERM GOALS

To investigate the seasonal variability in seafloor and shallow sub-bottom acoustic properties in the shallow water Gulf of Mexico. We have chosen three sites for this purpose. The sites, and their primary objectives, are:

MURI Fluid-Mud site, Louisiana. Acquisition of a baseline geophysical data set along the two primary transects identified as the focus of ONR-sponsored research as part of the Fluid-Mud MURI. Groundtruthing of the acquired acoustic/geophysical data with extensive coring, including additional sites where our colleagues from NSP/SIO deployed their waves/pressure sensors. The direct sampling measurements (grain size, viscosity) will add to their wave model. We will acquire survey data over the same areas surveyed previously in Nov/Dec 2008, with additional survey lines over new MURI instrumentation sites.

West Delta area, Louisiana. An area tightly related to the offshore industry, we have chosen the West Delta / South Pass area offshore the Mississippi River birds foot delta for our study. Specifically, a survey conducted in the area of the West Delta 109 pipeline, which broke during the 2005 hurricane season, imaged numerous mud flows, with some areas characterized by 6 to 10 m of net accumulation over a 20 year period. The SSS Virginia shipwreck occurs in the field area, and had been mapped previously on three occasions, showing that the mud flow in WD109 moved more than 400 m in the 2005 event. Previous mapping in the area did not extend to a hypothesized source of the mud flows at the West Pass channel outlet and/or the designated Corps of Engineers dredge dump location. Our goal at this site was to determine seasonal variability due to Mississippi River sediment delivery and to examine the connection between the previously mapped mud flows, possible sources, and the connection to anthropogenic influences. Note that as of this writing, it is believed that the mud flows in WD109 moved again during the 2008 Hurricane season (Gustav, Ike). If so, we hope to document the temporal changes between the 2005/2006 industry survey, the 2007 ONR survey, and our planned survey in Nov/Dec 2008.

Panama city, Florida. Previous studies in the SAS Target Area test bed offshore Panama City, Florida, have documented changes in the ability to 'see' targets placed in the field area. The causes of this variability to map targets, and the causes of the seasonal variation in acoustic properties, are unknown, and are the focus of our research. Groundtruthing of the acquired acoustic/geophysical data with

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extensive coring. We will acquire survey data over the same areas surveyed previously in Nov/Dec 2008.

OBJECTIVES

Our objective in all study areas is to increase our understanding of the variability of seafloor and shallow sub-surface acoustic properties that impact the ability to identify anthropogenic objects in the nearshore environment. Specifically, the present work is relevant to enhancing ONR's understanding of surface and subsurface seafloor geological characteristics, including geoacoustical and geotechnical properties. We are interested in determining differences in seafloor acoustic signatures between frequencies (same area, same time), and between seasons (same area, same frequency, different time). Our areas of interest are shown in Figure 1.

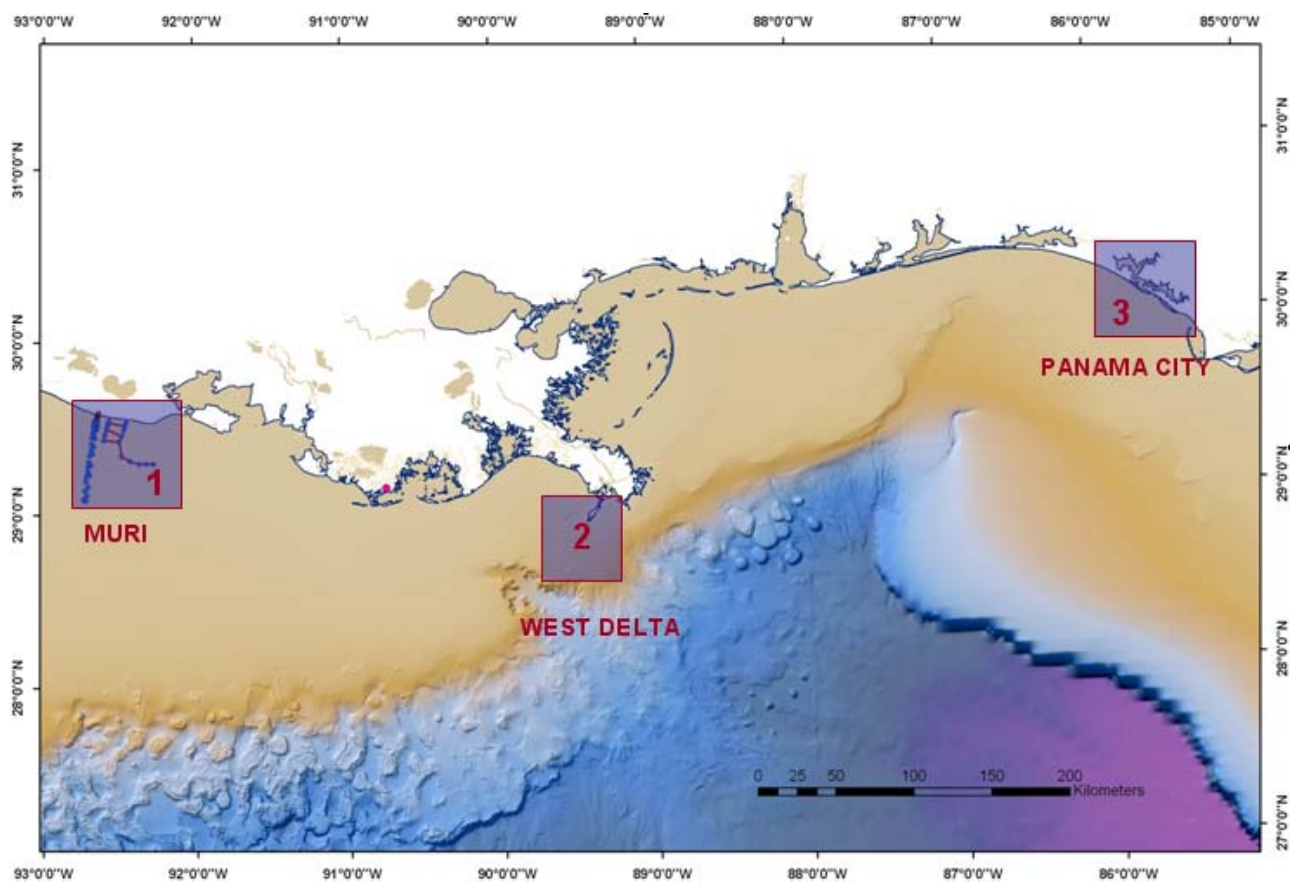


Figure 1. *Surveyed areas in June 2007 in red (and to be re-surveyed in Fall 2008) in the Gulf of Mexico. Area 1 corresponds to the MURI site, Area 2 corresponds to the West Delta site, and Area 3 corresponds to the Panama City site.*

APPROACH

We conducted one acoustic/geophysical field program in June 2007 and three coring programs during February-April 2008. We have planned another acoustic/geophysical cruise in November-December

2008 to re-survey some of the areas. All the geophysical instruments acquire data simultaneously, using the same platform, the same navigation suite, and the same motion reference unit.

We mobilized and demobilized out of the LUMCON facility, where the UNOLS vessel R/V “Pelican” is based. We mounted two multibeam systems of different frequencies (95 kHz, and 300 kHz), both capable of bathymetry and sub-sampled backscatter acquisition, on either side of the research vessel. We towed a dual frequency Benthos Datasonics SIS-1000 with a side scan sonar (90-110 kHz frequency) and sub-bottom profiler (2-7 kHz frequency). The team mounted the EM3002 on the port side and the EM1002 (heavier and bulkier) to the starboard side. Note that we were aware of the possibility of interference/s of all the transducers as they were mounted close to each other and the signature of any interference is being evaluated in post processing. We kept all of the geophysical and vessel parameters as constant as possible in order to measure the variability in the acoustic character of the seafloor and shallow sub-surface between systems (frequency) during the same deployment. We intend to use the same kit (all systems, down to the individual multibeam heads), mounts, motion reference unit, software, etc. during the Nov/Dec '08 follow-up cruise in an attempt to isolate the differences in measured seafloor response between this and the previous survey to the actual variations in seafloor acoustic properties over time.

We groundtruthed the indirect datasets with three coring programs between February and April 2008. We used surficial grab samplers and box cores to obtain the samples, described them and took pictures onboard, and refrigerated them until they were sent to the USGS laboratory for the grain size analysis. Some of the samples at site 1 were also sent for viscosity analysis to Johns Hopkins University, which will compliment the wave measurements that the NSP/SIO group is working on. The laboratory sediment analysis datasets are currently being interpreted.

RESULTS-WORK COMPLETED

Fluid-Mud MURI area, Louisiana:

As a common decision between our team and the MURI scientists, two 53 km long lines were acquired approximately perpendicular to isobaths / the coastline, three (3) tie lines, as well as 100% coverage in an area of $\sim 20 \text{ km}^2$ (Figure 2). For the first time the area has been mapped in detail and a set of multibeam bathymetry, side scan sonar and sub-bottom profiler data are available for the scientists to provide a baseline and geophysical context for the ongoing fluid-mud MURI (<http://www.ce.jhu.edu/dalrymple/MURI>). We surveyed the area where WHOI deployed their oceanographic sensors and exchanged our data with them. The preliminary results, although noisy due to interference, provide a good set of baseline information. We will re-survey the area with the two multibeam systems (EM1002 and EM3002) so we can compare seasonal variability (Figure 2). Side scan sonar and backscatter data will be available in the near future. Sub-bottom penetrated up to 25 m (using 1500 m/s as a velocity) and shows a consistent unconformity separating the youngest sediment cover from older deposits. The depth below seafloor of the identified unconformity ranges from 4 to 8 m (using velocity of 1500 m/s).

Two coring programs (March-April 2008) were conducted in collaboration with NSP/SIO (Dr. Tom Herbers group). Our goal was to groundtruth our indirect datasets and also provide the NSP/SIO scientists with direct data for their wave models.

We are planning to re-survey the area in Nov/Dec'08 as well as to survey several new lines (see violet lines in Figure 2) where the NSP/SIO scientists have placed instrumentation following information gleaned from the first deployments.

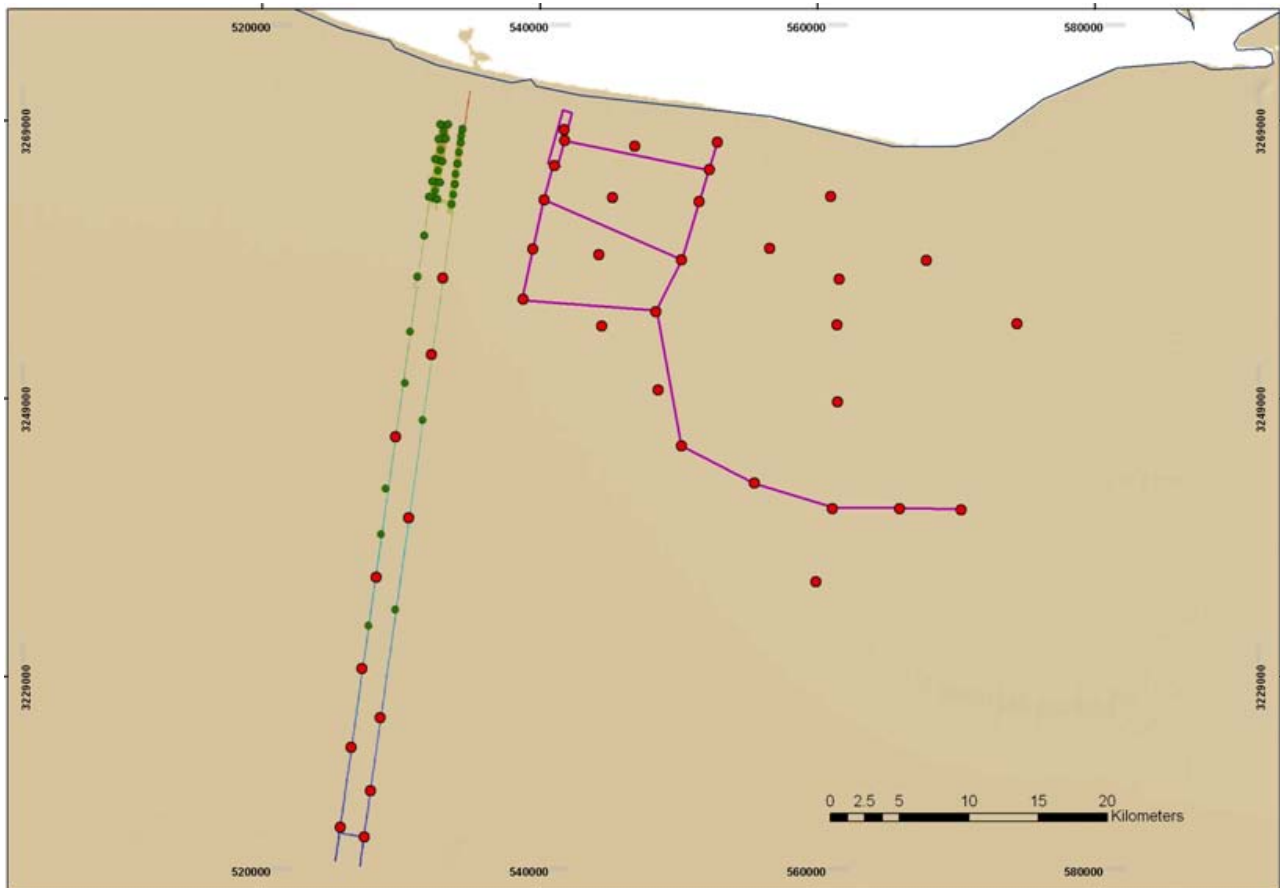


Figure 2. MURI site, Surveyed multibeam bathymetry/sub-bottom/side scan sonar coverage of June 2007 cruise in colored areas. Coring sites as dots; red dots being the samples sent for viscosity analysis and the ones that identify the sensors locations (NSP/SIO group). Violet lines are proposed survey lines for the upcoming fall of 2008.

West Delta site:

We acquired geophysical data in the West Delta / South Pass area of the northern Gulf of Mexico offshore the Mississippi River birds foot delta (Figure 3). Previous industry work in the area following damage associated with the 2005 hurricane season mapped the seafloor south of this area, and identified mud flows that appeared to be associated with pipeline / infrastructure damage. These surveys showed that the region downslope of our survey area was characterized by 6 to 10 m of net accumulation over a 20 year period. A shipwreck identified in the field area (SSS Virginia), and mapped previously on three occasions, showed that the mud flow in WD109 had moved >400 m in the 2005 event (Chevron/AOA Geophysics Inc. internal report). In 2007 we extended the previous industry mapping upslope to investigate the possible link of the mapped mudflows to the hypothesized source of the mud flows at the Southwest Pass channel outflow and/or the designated Corps of Engineers dredge dump location. The seafloor image shows a spectacular seafloor detail of the head of the mud flows.

Preliminary data indicates we found the beginning of one of the flows and also its connection with the dredge dump location (Figure 3).

We also acquired extra detailed data over the known SS Virginia wreck. We found it at 89° 26' 3.26" W, 28° 46' 46.63" N. The dimensions of the wreck are 157 m by 25 m. The movement of the flow, and any change since the most recent industry mapping in '06, is something we are currently evaluating.

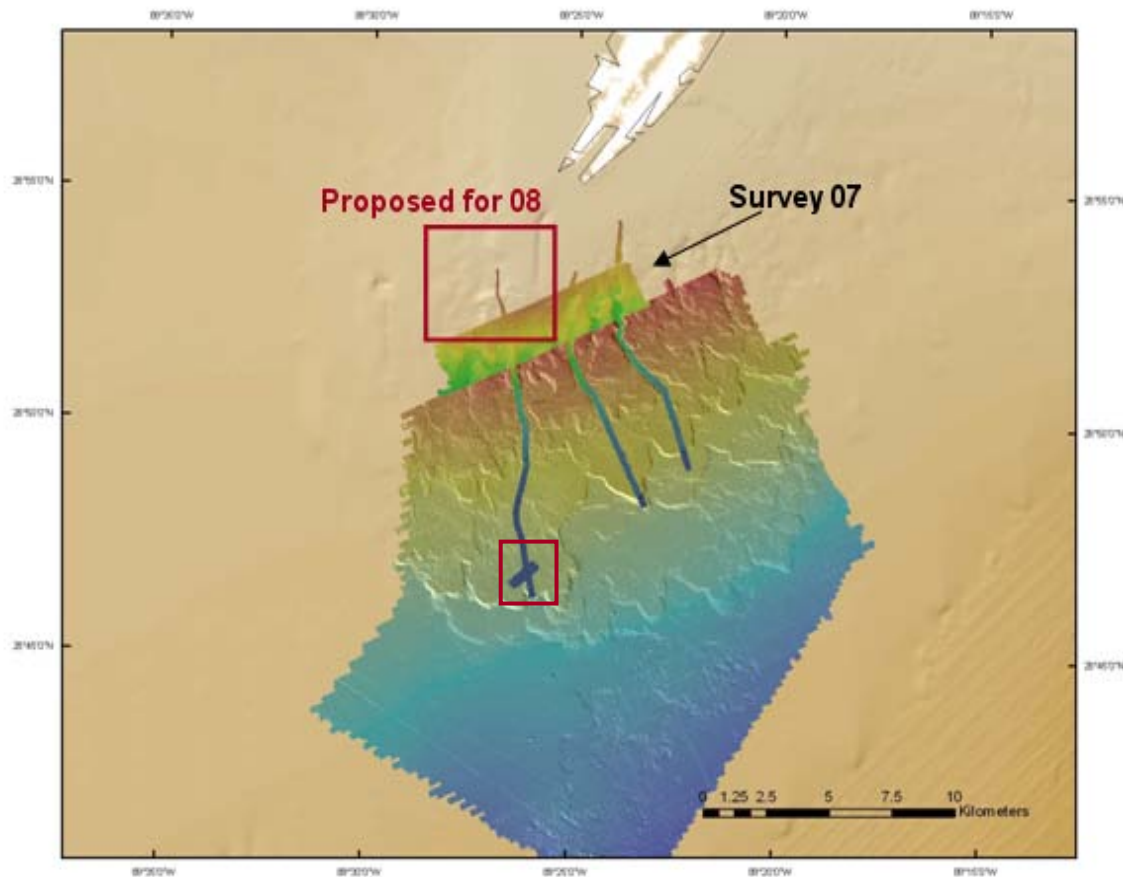


Figure 3. Overview of West Delta site location off the Mississippi River bird foot delta. The June '07 high resolution multibeam survey is indicated, which extended a Dec '05-Jan '06 industry survey. Our proposed survey areas for Nov/Dec '08, indicated by the two red squares, include the Southwest Pass dredge dump site, the shallow water extension of the previously surveyed areas, and a re-survey of the SS Virginia wreck site.

Panama City, Florida sites:

Following discussions with Navy and academic colleagues, we selected several sites for surveying: three inside St Andrew Bay (areas A, B, and C in Figure 4) and two outside the bay (areas D, and E in Figure 4).

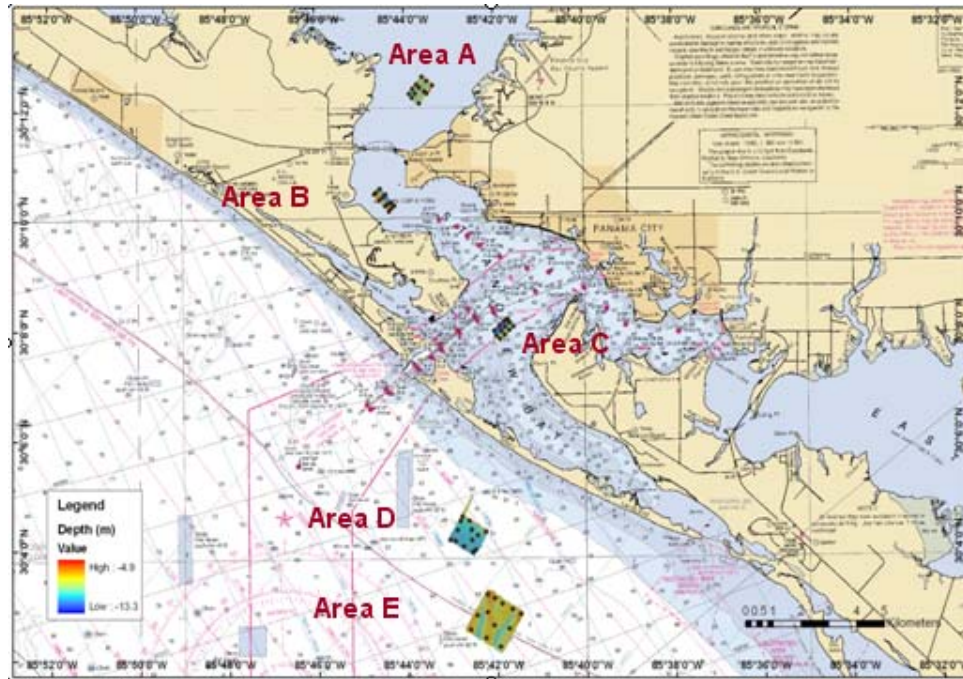


Figure 4. Overview of Panama city (Florida) areas. Nautical charts as background.

Preliminary processed bathymetry data (0.5m grid resolution) show in detail a seafloor with evident features. At the present stage only qualitative analyses have been made although our next step is to quantify the vertical resolution so we have a better idea on the differences. Preliminary analyses shows acoustic differences in the areas depending on the frequency used (95 kHz or 300 kHz).

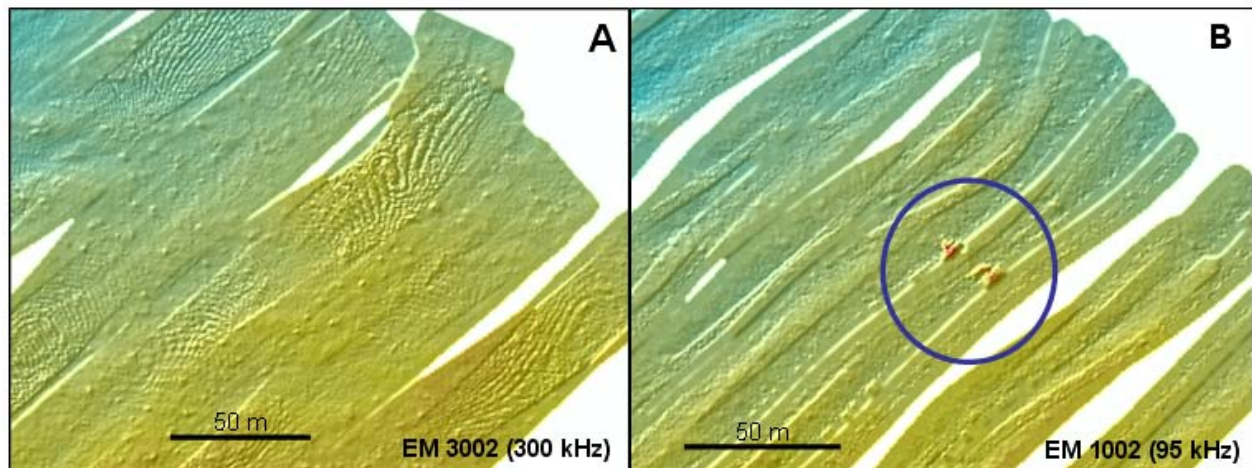


Figure 5. Area C, Detail of the seafloor multibeam bathymetry with (A) EM3002; (B) EM1002. Note the possible features in the center of the image that are imaged on the lower frequency (95 kHz), but that do not appear on the higher frequency (300 kHz). Note that the port side EM1002 data had to be cut due to noise and therefore the coverage is not complete.

See figure 4 for area location.

In at least one of the sites, the lower frequency bathymetric grid shows features that were not imaged in the co-located, contemporaneously acquired higher frequency (Figure 5) survey data. Higher frequency data would be sensitive to shorter wavelength roughness, and more importantly, would have a shallower scattering volume in the sub-surface. Although we have only preliminary ground-truthing data, and no information on the features imaged in the survey, we suggest that the features shown in the lower frequency (95 kHz) data in Figure 5 are buried deep enough to be ‘invisible’ to the 300 kHz multibeam system, or are large enough / smooth enough for the higher frequency system be insensitive to any roughness of these objects. Although preliminary, the difference in bathymetric signature of this ‘feature’ in the grids between these two frequency systems, acquired at the same time with the same boat and the same navigation package, is a first order accomplishment of this program.

Unfortunately the use of the sub-bottom profiling system was not allowed in the Panama City survey area due to concerns over biological impact. The side scan sonar mosaics have recently been completed for this area. The patterns of higher/lower reflectivity match the bathymetry observed in the multibeam images. Processing of the multibeam backscatter is in progress. The laboratory sediment analysis is not yet completed but preliminary data indicates significant differences in lithology between sites. As an example, figure 6 shows area A with mostly muddy material at the seafloor, and area E, with a main sandy component.

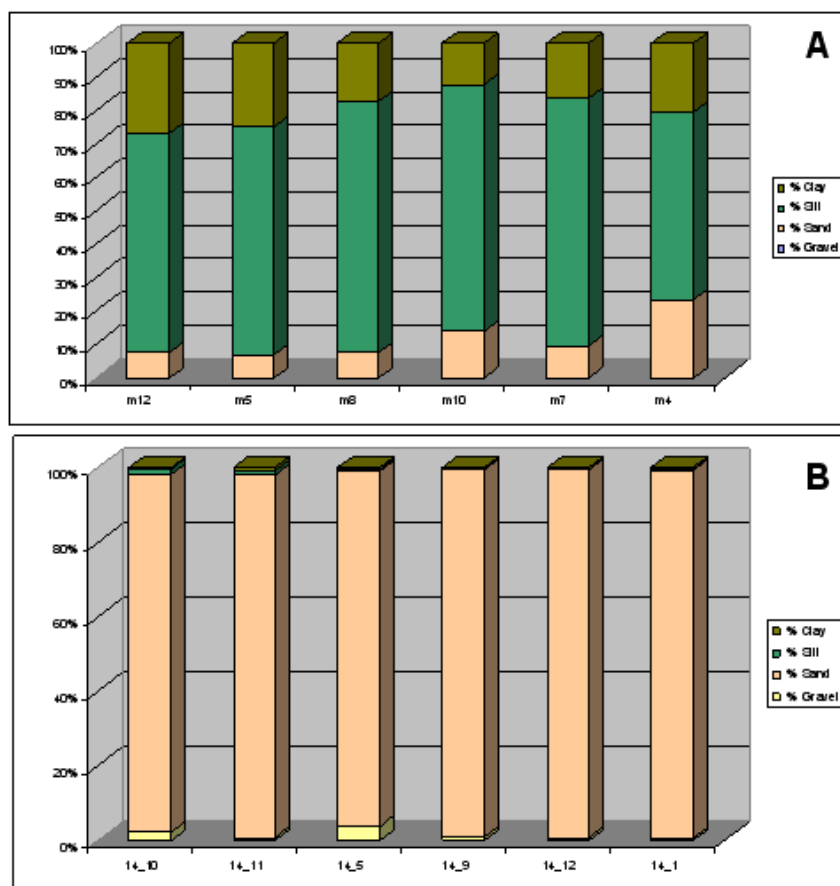


Figure 6. Grain size distribution for the surficial samples in area A (A); and area E (B). Note that area A is mostly clay and silt whilst area E is mostly sand. See figure 4 for areas location.

IMPACT/APPLICATIONS

The impact of the ongoing research is different in each area. In the Fluid-Mud MURI location, the geophysical/acoustic dataset and groundtruthing provide a comprehensive baseline and/or a geophysical context for studies for all MURI scientists. All of the seafloor data are georeferenced, combined with all provided MURI instrumentation locations, and provided to all MURI scientists as a GIS. This GIS is being updated as coring/groundtruthing information comes in, and will be further updated following the Nov/Dec'08 survey activities. As an example of this collaborative effort, multibeam datasets have been shared with WHOI (Dr. Peter Traykovski and colleagues), and the sediment analysis data with NSP/SIO (Dr. Tomas Herbers and colleagues).

The West Delta area has proven to be interesting as we have found a possible anthropologic source/cause for a component of at least one of the mud flows. We hope to get additional information of the shallow area and perhaps survey shallower to reach the head of additional mud flows in our Nov/Dec'08 survey. Also, by revisiting the SSS Virginia wreck we will determine its present location relative to the previously surveyed locations and compare and study its movement as this wreck provides a strain indicator of the mud flow's movement. This will give us an idea of the rate at which these features move so that we can better understand the impact of these flows on existing or future seafloor installations.

The datasets off the Panama city sites have already tentatively shown differences between frequencies. This is a promising start and we are presently working on getting quantitative results and planning the return program during Nov/Dec'08. We expect to integrate all datasets (acoustic/geophysical surveys and coring data) in the upcoming year and have an updated GIS available to share with colleagues at Panama City.

PUBLICATIONS

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