DEEP-C: DEEP SEA TO COAST CONNECTIVITY IN THE EASTERN GULF OF MEXICO

Consortium Director – Eric Chassignet

ADMINISTRATION

1) Contract Activity

- Requested approval from Ocean Leadership for carryover of year 2 funds and continuation of funding in year 3.
- Requested approval from Ocean Leadership to make two "significant changes"
  - To reallocate $6,700 to FSU's subcontract amount to facilitate the payment of internships offered by the Northern Gulf Institute (NGI) Diversity Internship program. This does not reflect is a change in Deep-C's scope of work. It does, however, shift fiscal responsibility for support of NGI interns from FSU to DISL.
  - To base the number of NGI interns sponsored each year on the availability of positions directly related to Deep-C's mission and mentored by a Deep-C scientist. The scope of work – providing real life research experiences for undergraduates through internships – would remain the same, but the method of delivery would be based on the suitability of mentors and project topics as they relate to Deep-C's mission.
- Worked with all subcontractors to have them adjust budgets to accurately reflect their actual and anticipated spending in year 2. In cases where significant modifications were made, written justification was required and is included in Deep-C's Q3 financial reports. Note: While GoMRI does not expect to see salary as an obligation, based on their recommendation that institutions use their own interpretations, our reporting for FSU and UNF does included salaries as an obligation. For the fourth quarter report, we anticipate that most subcontractors will also choose to report salaries in that column (with few, if any, obligations in other categories).

2) Risks and Impacts

- Delays in the execution of the prime agreement in year 1 meant that sub agreements and research activities were also delayed. While the gap between scheduled and actual spending has decreased steadily, these initial delays will result in under-spent budgets by the end of year 2. We anticipate as of December 31, 2013 we will have an unobligated amount of approximately $2 million. ***Corrective Actions:*** *We continue to monitor the overall project and subproject burn rates in order to efficiently expend any budgets that remain underspent.*

RESEARCH

1) General progress update

a. Accomplishments

Task 1: Geomorphology and Habitat Classification

- Completed combined benthic ecology and geomorphology cruise on RV Weatherbird II. Successfully recovered 12 piston cores from erosion channels on northern slope of De Soto Canyon. Successfully deployed MILET at five Deep-C study sites and piston core sites. Added chirp sub-bottom profile capability to MILET. Conducted sidescan sonar surveys of paleo shorelines and shelf break area near Deep-C benthic sampling sites.
- Authored and published online (Deep-C website) a paper titled "Geologic Beginnings of the Gulf of Mexico with Emphasis on the Formation of the De Soto Canyon" by Hine, Dunn, and Locker.

Task 2: Physical Transport of Particulate and Dissolved Material from the Deep Ocean to the Coast

- Production of processed float data and mooring data from the experiments.
- Completed processing and QA/QC of mooring and cruise data.
- Data processing for all the SailBuoy data recovered in May 2013, the Acoustic Doppler Current Profiler (ADCP) data from our moorings recovered in May 2013, and for all the C, T, P loggers.
- Collected the Acoustic Doppler Current Profiler (ADCP) data from all Deep-C cruises aboard the Weatherbird II.
- Combined Airborne EXpendable BathyThermographs (AXBTs) from the demonstration project from the U.S. Air Force WC-130 with those acquired from the NOAA WP-3D prior, during and subsequent to Hurricane Isaac. Conducted a research flight on August 20 investigating the large cold pool suggested by Jason-2 altimeter data in the eastern Gulf of Mexico extending from the Yucatan Shelf to the northern Gulf from the NOAA WP-3D.

Task 3: Geochemistry, hydrocarbon chemistry, and isotope tracing

- Using natural abundance radiocarbon as a tracer of petroleum input we calculate that 2.9 ± 1.7% of the oil that issued from the 2010 spill was deposited on the Gulf sea floor. This was accomplished by determination of surface sediment 14C content of seafloor organic matter which varied from -500‰ to -140‰ on the DELTA 14C scale. We produced a contour map of 14C values collected from 62 core samples collected in 2010 and 2011.
- Publication in *Environmental Science and Technology* of the first demonstration of compositional characterization of the Macondo oil spill for the 60% of the material not accessible by conventional gas chromatography, and in *Analytical Chemistry* of the first use of principal component analysis based on ultrahigh-resolution mass analysis to discriminate between two sources of oil spill contamination, in both the

original oils and their environmental contaminants up to two years after the spill.

- Conducted three Benthic Ecology and Geochemistry Cruises to resample stations for sediment work. The goal was to collect sediments from a depth gradient and to incubate those sediments with oil snow and phytoplankton additions and additional radiotracer and hydrocarbon work. Onboard incubations were followed by oxygen, DIC and DOC measurement. Sediments from station were brought back for laboratory analyses.
- Continued flume experiment on the release of hydrocarbons from buried oil and the effect of embedded tarballs on oxygen dynamics in the sediment. Water samples and sediment cores were analyzed to continue the time series. Continued work on fluorescence depth profile in Pensacola Beaches as a high resolution indicator for oil distribution. Scans were calibrated and compiled into data bases.
- Continued to analyze fish tissues and atmospheric samples in order to better describe the mercury cycle. We discovered that different organ fish tissues from the same individuals discovered a systematic, possibly in vivo fractionation between muscle and liver tissues, with a large fractionation factor of $\alpha = 2.04$.

Task 4: The Ecological Pathways

- Hydrocarbon-degrading bacteria (i.e., Alcanivorax and Acinetobacter) collected from oiled sands were cultured, and sequenced genomically to provide a roadmap to metabolic pathways of oil degradation in beach sands. Toxicity testing occurred before and after bacterial degradation using a rotifer assay and a modified liquid-liquid extraction method. This work included a time series on nutrient limitation of microbial communities in beach sediments, revealing that oiled samples contained 8 times more genes for nitrogen fixation than clean sands, indicating that sedimentary microbial communities became nutrient limited when Macondo oil deposited into benthic ecosystems. *(Georgia Tech, USF)*
- Because oxygen controls degradation of hydrocarbons in sediments, oxygen was profiled in cores collected offshore (using a PreSens oxygen optode system); cores also sectioned and archived for microbial community analysis (replicate profiles generated from 15 sites on two cruises. Oxic zone depth in sediments ranged from 1 cm (continental shelf) to 5 cm (slope), and correlated with water depth ($r^2 = 0.54$) , with a weaker correlation was observed being distance from the Mississippi River outflow. These data indicate that marine snow particles from the flocculent blizzard would have been deposited at least initially in a sedimentary environment containing oxygen. *(Collaboration between Deep-C and C-Image; GaTech, FSU, USF)*
- Florida Panhandle Shelf studies include a spatial-temporal series of physical, chemical and biological dynamics investigating changes in microbial community structure (Archea, Eubacteria, Ciliate microzooplankton, Foraminfera) and of the surf zone (taken before, during and after the oil landed on Pensacola Beach.. Studies of pigments reveals differences in association structure between the surface and the deep chlorophyll maximum (DCM). Preliminary analysis of archived net plankton samples from 17 cruises starting in January 2011 suggest possible changes in the dynamics of the association. *(UWF, Valdosta State, FSU)*

- Completed the third Deep-C cruise to investigate the community structure of deep-sea fish assemblages and to collect samples for studies detailed below (collected 477 fishes, 28 species from 41 Deep-C stations).
  Community Structure (162 -2,645 m deep) - analyzed large deep-sea demersal fishes (2,730 fishes, 90 spp.) from 208 longline stations. Results suggest that the fish fauna on the east and west sides of De Soto Canyon are distinct, with faunal assemblages determined primarily by depth and edaphic factors.
  Taxonomy - Genetic samples sent to researchers at five universities to determine species IDs, examine population genetic structure of four groups of sharks, rattail fishes, and hagfishes. The results for smooth hound sharks positively identify three morphologically and genetically distinct species of *Mustelus* in the Gulf that are separated morphologically and genetically. The results from other taxa are pending.
  Biogeochemistry – PAH analyses - up to 3 PAH biomarkers measured in ~ 200 sharks. Results -PAH exposures either below detectable levels or, if quantifiable, within the range of levels found at reference sites (e.g., Phase I biotransformation enzyme Cytochrome P4501a1 (Cyp1a1), while in other cases, PAH exposures either remained the same (e.g., levels in 2012 ≅ 2011 levels for benzo(a)pyrene, a pyrogenic PAH) or increased over time (e.g., levels in 2012 > 2011 levels for Phase II biotransformation enzyme glutathione-S-transferase activity in the shortspine spurdog (Squalus mitsukurii) and the gulper shark (Centrophorus granulosus)), suggesting continued exposure at low levels of PAHs, but at enzyme levels lower than those observed in coastal sharks). A third case involves bile metabolites of PAHs, where pyrene and naphthalene levels in 2012 > 2011). Naphthalene is normally broken down in weathered oil and generally only persists in buried deposits. Its build up over time suggests redistribution of buried oil, which is problematic. *(Fish ecology – FSU/UNF; Biogeochemistry – FSU)*

Task 5: The Earth System Model

- The 54-year Gulf of Mexico HYCOM simulation has been analyzed and validated using altimeter observations. A publication has been prepared and submitted to a journal. The model outputs have been uploaded on the Deep-C data server and are available to the general community.
- The Gulf of Mexico Ocean Color Climatology (GOMOCC) bio-optical products are being evaluated and compared against the model output and independent observations. During the evaluation, it was deemed unnecessary to have two, a larger/ coarser (Gulf Wide) and a smaller/finer (DeSoto Canyon) area/resolution, regions. Instead, the GOMOOC will be changed to the native resolution of the satellite sensors (~1Km) and encompass the entire Gulf of Mexico. This product will be showcased at the 2013 GOMRI meeting in Mobile, AL, and transferred to COAPS thereafter.
- The COAMPS5 system was updated with a number of fixes and improvements. One in particular is the ability to run in concurrent mode, meaning each model component (wave, circulation, and atmosphere) can run independently on different numbers of processors, rather than run sequentially.
- A prototype Deep-C Oil Spill Prediction Environment (OSPRE) was developed. OSPRE seamlessly links an advanced oil spill model with stochastic simulation tools

and environmental data sources to rapidly evaluate plausible scenarios and enhance the potential for informed decisions in case of accidents. The OSPRE prototype currently links high-resolution wind, wave and ocean components of the Deep-C's Earth System Model with a newly developed 3D Oil spill model and a GIS – based user interface to track accidental spills in the Gulf. Relevant background geophysical forecasts and statistical analysis of oil drift, spreading, weathering, shoreline impact and subsurface concentrations are made available through dynamic maps, charts and tables. For specific environmental risk assessments, sensitive zones and concentration levels with respect to specific marine organisms can be specified to examine the possibility of contaminants exceeding critical concentration levels.

- Simulations are in progress, focusing on river plume dynamics. Collaboration between FSU and the Norwegian Meteorological Institute (Met.no) is taking place on evaluating model salinity fields around DeSoto canyon with the Sailbuoy data from the summer 2013 Northern Gulf surveys.

b. Obstacles

- None

c. New Collaborations

- Jeff Chanton (FSU) initiated collaboration with Tingting Zhao, Department of Geography Florida State University.
- Dr. Ian MacDonald (FSU) is collaborating with Charlotte Sjunneskog at the FSU Antarctic Research Facility for sediment core preparation.
- Nico Wienders (FSU) initiated collaborations with Darek Bogucki and Kimberly Arnott (USF) on a study regarding internal waves observed in the De Soto Canyon.
- The Data Center is working with Bob Arko at Lamont who is providing guidance on filesets and metadata, and best practices for packaging data sets for submission to the national archives.
- Ian MacDonald's lab (FSU) collaborated with the WAMOST group (funded by BOEM, surface oil spill model on SAR images and oil simulations performed by Norwegian SINTEF groups used to develop skill assessment metrics.
- Dmitry Dukhovskoy collaborated with the University of Colorado CCAR group (B. Leben, C. Hall). Sea surface topography gridded products derived from altimeter observations prepared by CCAR have been used for HYCOM GOMl validation. CCAR algorithms to track ocean fronts have been used in model validation and comparison with observations.
- Tina Miller-Way (DISL) began discussions with the MATE (Marine Advanced Technology Education) Center as a possible regional competition site for Deep-C's annual student ROV competition. Miller-Way attended training institute at the MATE center in July.
- NRL began discussions with the University of Southern Mississippi Center for Excellence on the potential use of the COAMPS-COSINE model being used as a real-time product to support their observational and cal/val efforts.

- Nick Shay (UM-RSMAS) began collaborating with Steve DeMarco (TAMU's GISR Consortium) on Hurricane Isaac for mooring data acquired underneath Isaac.
- David Hollander (USF), Jeff Chanton (FSU), and Joel Kostka (GaTech) collaborated with C-IMAGE on a Hercules 265 Gas-Well Explosion Research Cruise.
- Dean Grubbs (FSU) began collaborating with the N. Hussey, R. Walter (University of Windsor, St. Kessel) on sleeper shark genetics
- Dean Grubbs (FSU) began collaborating with John Gold (Texas A&M University) on smoothound taxonomy
- Dean Grubbs (FSU) began collaborating with Theodore Uyeno (Valdosta State University) on hagfish biomechanics