**Responses of Benthic Communities and Sedimentary Dynamics to Hydrocarbon Exposure in Neritic and Bathyal Ecosystems: Phase II**

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**Continuing Study Objectives:**

1. Determine if oil from the Deepwater Horizon spill has reached the seafloor at any depth below the intertidal zone, from shelfal to bathyal depths, including sites down slope from the well site and at depths of documented mid-water oil plumes.
2. Determine if hypoxia - known on the Mississippi shelf centered on 10-m isobaths - has been exacerbated, extended to other regions or has been reduced beneath the known extents of the surface cap of oil.

**Long-Term Objectives Served by this Project:**

1. Quantify total petroleum hydrocarbon (TPH) fluxes to the sea floor throughout the impact area via time series sampling and analysis.
2. Quantify petroleum hydrocarbon degradation rates at the sea floor throughout the impact area via time series sampling and analysis.
3. Quantify impacts to and responses of benthic meio- and macro-faunal communities throughout the impact area via time series sampling and analysis.

**Phase II Justification:**

1. Suitability:
   1. This project is categorized as contributing to both the “observe” and “understand” research clusters, and will contribute to addressing several of the BP-GRI themes, including in particular:
      1. The physical distribution and ultimate fate of contaminants associated with the Deepwater Horizon incident.
      2. The chemical evolution and biological degradation of the contaminants.
      3. The environmental effects of the contaminants on Gulf of Mexico ecosystems, and the science of ecosystem recovery.
   2. This project will contribute directly to addressing the central question of NGI Phase II, “Did the Macondo 252 Oil Spill result in large scale perturbation of the northern Gulf of Mexico (NGoM) ecosystem structure or function?”, while supporting and synergistically interacting with several other NGI, NSF and cooperative projects by other regional institutions.
2. Phase I Productivity:
   1. This project has established cooperative links between USM- and National Institute of Undersea Technology (NIUST)-led (Ray Highsmith, University of Misssissippi; Andreas Teske, University of North Carolina) sampling and research initiatives and those from other groups (Mandy Joye, University of Georgia; Joe Montoya, Georgia Institute of Technology). Taken together, this multi-institutional cooperative possesses one of the most extensive academic time-series data sets available.
   2. This project coordinated ship-based sampling efforts which served multiple Phase I NGI projects, multiple NSF-RAPID projects, and established additional cooperative sampling and research partnerships (Patrick Louchouarn, Texas A&M University at Galveston; Jeff Chanton, Markus Huettel, Florida State University). These efforts resulted in the sampling of numerous stations in the Mississippi Sound, Chandeleur Sound, the continental shelf, and continental slope, from 2 to 2,530 m water depth, generating approximately 3,500 sediment samples alone. Water column sensor data, water, and suspended particulate matter (SPM) samples were also collected. It is essential that both the ongoing analyses of these samples and additional time series sampling be supported.

**Summary:**

Oil spilled in the marine environment can be incorporated into sediments in several ways. Aside from that oil which can be added directly to sediments in the intertidal zone (i.e., Barth, 2003), some 10-30% of spilled oil can adhere to suspended particles and subsequently sink to the sea floor, a process most active in particle-rich coastal waters (Lee and Page, 1997; Patin, 1999; Sun and Zheng, 2009) like those of the Chandeleur Sound, the Mississippi Sound, and the Mississippi Bight. Emulsified oil can also be processed by filter feeders and the oil components added to bottom sediment with the deposition of their fecal pellets and lysed or senescent cellular materials (Patin, 1999). Finally, weathered tar balls can become dense enough to sink to the sea floor (Patin, 1999; Franco et al., 2006). Once weathered oil is mixed into oxygen-poor or anaerobic sediment, its rate of microbial decomposition slows dramatically. The oil can linger in the subsurface for months to decades (Kingston, 2002; White et al., 2005), adversely affecting the benthic biota and their services to the marine environment.

Oil pollution can devastate the sea floor by causing major disruptions to biogeochemical processes. Oil can cause selective and even mass mortality of the benthic meio- and macrofauna (Olsgard and Gray, 1995; Montagna and Harper, 1996; Yanko et al., 1999; Ernst et al., 2009; Martínez-Colon et al., 2009), either directly by surface coating or hydrocarbon toxicity (i.e., Gomez-Gesteira and Dauvin, 2005), indirectly by overloading the system with organic carbon and driving enhanced microbial respiration, or by shutting down ventilation of coastal waters, leading to the rapid development and persistence of hypoxic or anoxic conditions at and above the sea floor. Additionally, reductions in benthic biomass will reduce physical mixing of the sediment by suppression of the major bioturbators. Because benthic environments of the continental margin are highly productive, it is absolutely critical that the supply, impacts and fate of petroleum hydrocarbons on the benthos be quantified, as immediate ecological changes are expected and are likely to result in long term, ecosystem-scale adjustments throughout the water column.

We propose to continue what has been a very successful survey study to determine if and where oil has reached the seafloor below the intertidal zone and if at these sites it has affected benthic fauna. Oil has been observed over large areas of the ocean surface and has been reported in thin, discrete layers on subsurface isopycnals. However, at this point there are only qualitative observations indicating that some oil may have reached the sea floor at neritic to the bathyal depths.

**Analyses and Sampling:**

We propose to continue analyses of those samples collected during Phase I, initiate planning and execution of a second round of sampling, followed by continuing analyses of samples collected in Phase II. Analytical elements include:

* Total petroleum hydrocarbons (TPH) will be determined, and more detailed analyses of hydrocarbon signatures will be conducted if TPH concentrations indicate that oil is present above background levels. Selected samples will also be analyzed for concentrations of polycyclic aromatic hydrocarbons (PAHs).
* Sediment textures and bulk sedimentary organic carbon (SOC) will be determined.
* Radiochemical analyses to determine a suite of radionuclides (234Th, 7Be, 210Pb, 137Cs) will be conducted on selected cores to derive quantitative information on sediment mixing, accumulation and chronology (essential to derive estimates of both hydrocarbon fluxes to and degradation rates within near-surface sediments).
* The macrofauna and benthic foraminifera (meiofauna) will be sampled, stained with rose Bengal to identify living specimens (Bernhard, 2000), and identified to compare species distribution and community structure of oiled and pristine samples. (Note that benthic foraminifera often dominate the meiofauna from bathyal and abyssal depths [Coull et al., 1977; Cornelius and Gooday, 2004; Bernhard et al., 2000]. Also note that baseline data on live foraminiferal assemblages from the NGoM are available [Phleger and Parker,1951; Parker, 1954; Reynolds, 1982; Sen Gupta and Aharon, 1994; Sen Gupta et al., 1997; Robinson et al., 2004; Bernhard et al., 2005])

Using information derived from our first round of sampling, data made available to us through our cooperative institutional partners (NIUST, UGA, GA-Tech, FSU, UNC, TAMUG) and in cooperation with both NOAA and the federal multi-agency response consortia (Subsurface Monitoring Unit (SMU), Operational Science Advisory Team (OSAT)) we will plan and execute a second comprehensive round of sampling in Phase II. We will again utilize an Ocean Instruments multicorer[[1]](#footnote-1), which is designed to take undisturbed replicate samples from the sediment-water interface and propose to collect cores from stations located in four regions, including (1) the Mississippi Sound, (2) the Chandeleur Sound, (3) from the inner shelf to the shelf edge along the western Mississippi Bight, and (4) from the continental slope. It is anticipated that stations will include both re-sampling locations (time series) and new locations.

**Project Duration:**

1 year

**Work Plan:**

- February through November, 2011: Sample analyses ongoing.

- February through October, 2011: Cruise planning and cruise(s) completed, all field samples and data collected.

- April through October, 2011: All new samples initially processed and provided to all cooperating laboratories. Digital data processing begun.

- November, 2011 through January, 2012: Sample analyses completed for Phase I and ongoing for Phase II, all digital data processing completed, collation of final report begun.

- February, 2012: Final report completed and submitted.

**Summary Budget:**

PI salaries and fringe benefits: $22,154

Staff and student salaries and fringe benefits: $145,234

Materials and supplies: $41,000

Contractual: $75,000

Travel: $10,000

\*Ship time: $242,000

Indirect costs: $225,705

Total: $761,093

\*As in Phase I, support for coastal and regional research vessels is intended to support both multiple NGI projects funded to USM and to facilitate combined cruises with other institutional partners (e.g., NIUST).

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1. The MC-800 has eight tubes, 10 cm x 70 cm: http://www.oceaninstruments.com/products/multi\_corers/mc\_800.html. [↑](#footnote-ref-1)