Abstracts of Poster Presentations (by session)

Incorporating an Ecosystem Services Approach into Restoration and Coastal Management

The Effect of the Deepwater Horizon Oil Spill on Ecosystem Services in the Gulf of Mexico

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To identify the potential changes to ecosystem services within the Gulf of Mexico before and after the DWH event an Ecopath with Ecosim (EWE) model is being developed that incorporates ecosystem services. This is being accomplished by (1) expanding on the existing Northern Gulf of Mexico Ecospace model and incorporating provisioning, recreational, and cultural ecosystem services into the trophic flow ecological modeling framework, (2) gathering and inputting biomass data pre- and post-DWH event into the model, and (3) running simulations with the model to test how ecosystem services have been changed and to test the resilience and potential recovery of offshore environments. Provisioning, recreational, and cultural ecosystem services will be quantified by modeling things like catch, catch value, biodiversity, and recreational fishing effort.

Marsh Platform Flow, Hydroperiod and Plant Productivity Associates with Natural Infrastructure Barrier Design

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Natural and nature-based infrastructure approaches for shoreline stabilization and resilience purposes are still relatively developing approaches, though currently an advancing field. This presentation highlights the importance of examining the impacts of shoreline management on sheltered coastal environments, and presents an analysis of the flow regime on salt marsh platforms exposed to various barrier designs. The influence of structural design is explored with implications for primary productivity and marsh platform inundation. Single continuous and segmented barriers of varying lengths are simulated, as well as multiple (staggered) barriers. A two-dimensional hydrodynamic model is developed to evaluate flow routing and inundation duration on a salt marsh platform, providing the first steps for examining whether shoreline structures contribute to macrophyte sustainability or degradation, or contribute to platform erosion. Key points examined in the results include the extent of marsh platform flooding, the change in ebb flow with water depth and marsh platform length, the influence of barrier length and segment gaps on ebb flow, and the influence of biomass on inundation. The two-dimensional

model can be coupled with a biomass distribution function to determine the range of structure lengths that will facilitate macrophyte sustainability in relation to the change in hydroperiod.

Physical and Biological Processes of Oil Droplet Dispersion, Transport, Sedimentation and Bio-degradation

Interactions of Passive and Active Marine Particles at the Oil-Water Interfaces

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Accidental release of crude oil to marine environment has severely impacted ecosystems. Although bio-degradation of crude oil by microbes is widely speculated as a key mechanism to rapidly breakdown environmental hydrocarbons, physical evidences are lacking and underlying biophysical processes are less understood. In this paper, we investigate the processes of both passive and active marine particles encountering and subsequent adsorption at oil droplet suspension, to understand the underlying physics of particle dynamics at the oil-water interfaces. To have direct observation, we have developed microfluidic tools to mimic micro environment around a single droplet and applied high speed microscopy to image the dynamic processes. The PDMS micro-channel is manufactured using soft lithography and functionalized to be hydrophilic by Layer-By-Layer (LBL) technique. This allows us to establish stable vertical oil-water interfaces for in-situ experimentation. Three different diameters of oil droplet are used and their interactions with three particles: *Alcanivorax* bacteria and two clay particles (e.g. Hawthorn Fire and Bentonite) are examined. The rate of encounter, adsorption, and contact angle of particle at interfaces will be measured. The effects of interfacial condition on these interactions will also be elucidated in the paper.

Acoustical and Optical Characterization of Marine Snow Layers in the Northern Gulf of Mexico: Layer Types and Mechanisms of Formation

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Marine snow is a ubiquitous yet morphologically and compositionally diverse constituent of the water column that plays a key role in the carbon cycle. Under certain physical circumstances, marine snow can aggregate and form thin layers, potentially serving as “trophic hotspots” of increased grazing activity. If oil is present, then marine snow thin layers and associated grazing can lead to higher rates of exposure to zooplankton, initiating a trophic pathway of increased oil exposure throughout the food web. It is therefore important to describe and ultimately predict when and where these marine snow layers form and to investigate how their optical and acoustical characteristics could influence their impact on the food web through both oil exposure and grazing potential. Using an in situ imaging system and image analysis, we describe the main types of marine snow by extracting the particle size, porosity, area/perimeter ratio, and other particle characteristics to determine that specific morphotypes are associated with layer formation. These types characterized by the imaging system also differed in their acoustic impedance, with highly porous particles entraining less dense fluid, allowing for better acoustic detection. Describing properties of marine snow using multiple instruments will lead to more efficient ways of understanding its impact on grazing and bacterial activity, with the overarching goal of improved understanding of carbon cycle processes and trophic pathways of oil exposure.

Surface Dynamics of Fresh and Weathered Oil in the Presence of Dispersants: Laboratory Experiment and Numerical Simulation

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The laboratory experiment conducted as a part of this work was focused on understanding differences between dynamics of fresh and weathered oil spills and the effect of dispersants. After deposition on the still water surface, a drop of fresh oil quickly spread into a thin film; at the same time, a drop of weathered oil did not show significant evolution. Subsequent application of dispersant to the water surface around the fresh oil film resulted in a quick recoiling of the film into a compact lens; while the drop of weathered oil did not show visible evolution after spraying dispersant on the surrounding water surface. A three-phase, volume of fluid computational fluid dynamics model incorporating surface tension and Marangoni forces was able to explain some features observed in the laboratory experiment, including the initial spreading of fresh oil drops and their recoiling after dispersant application. These laboratory and numerical results are expected to provide a better understanding of oil spill propagation and dispersion in the natural ocean environment.

Crude Oil Biodegradation by Estuarine Sediment Microbial Communities from Diverse Coastal Environments

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The ability of coastal sediment microbial communities to degrade crude oil components is essential after an oil spill that impacts shorelines. Understanding of the kinetics of degradation, and of the identify and function of the microbial groups involved in degradation, is poorly constrained. To address this gap, we conducted microcosm experiments with coastal sediment from a variety of environments (temperate, sub-arctic, arctic) and exposed them to crude oil under differing temperature and nutrient regimes. Oxygen consumption over time was used as a measure of bulk microbial respiration, hydrocarbon degradation was assayed by gas chromatography, microbial community structure was analyzed by 16S rRNA gene sequencing, and microbial functional potential was assessed by measuring different functional genes known to be involved in hydrocarbon degradation. We found that while degradation was slower at colder temperatures, nutrient addition was able to decrease this difference. *Cycloclasticus*, a known hydrocarbon-degrader, was abundant in all samples, demonstrating a generalist oil-response strategy. Other hydrocarbon degrading bacteria, such as *Alcanivorax*, *Oleispira*, *Rhodococcus*, and *Sulfitobacter*, showed differential response to either site or temperature. Alkane monoxygenase was consistently more abundant than other known hydrocarbon functional genes, suggesting this is a primary mechanism for crude oil biodegradation across coastal sediment environments.

Anaerobic Hydrocarbon Degradation Under Iron- and Sulfate-reducing Conditions by Sedimentary Microorganisms from the Northern Gulf of Mexico

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This study investigates the rates, pathways, and microbial communities that catalyze anaerobic hydrocarbon degradation in areas of the Gulf of Mexico seafloor that were impacted by the Deepwater Horizon blowout. Sediment samples were collected on research cruises in the northern Gulf from 2012 to 2014. Enrichment cultures were initiated and pure cultures were obtained under iron- or sulfate-reducing conditions with hexadecane, or phenanthrene as the sole carbon source. Microbial activity was confirmed by quantification of electron acceptor utilization and microbial communities were characterized using next generation sequencing of 16S rRNA gene amplicons. Results indicate that sediment from shallower water depths stimulated faster growth of hydrocarbon degraders than sediment from the deeper sites. Members of the Deltaproteobacteria showed a high relative abundance in all enrichment cultures studied. Desulfobacteraceae were highly enriched, showing up to 50% relative abundance, in sediment-free cultures under sulfate-reducing conditions. Known sulfate-reducing groups such as Thermodesulfovibrionaceae and Desulfobulbaceae were enriched under iron-reducing conditions. Evidence suggested the potential for syntrophic hydrocarbon degradation under sulfate-reducing conditions. All isolates enriched with phenanthrene under sulfate-reducing conditions were deeply branched within Deltaproteobacteria, clustering with *Desulfovibrio* and Pelobacteraceae.

Observations of Natural Gas Seep Site MC118 in the Northern Gulf of Mexico during GISR Cruise G08, 2015

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To extend our understanding of the behavior of natural gas seep plumes below the hydrate stability zone, a new field expedition (GISR Cruise G08) was carried out at MC 118 during April 2015. During this cruise, we returned to one of the deepwater seeps observed during the GISR G07 cruise in July, 2014. In 2015, we found the venting area to be shifted from the previous emission site (known as Sleeping Dragon) to several new regions close to the previous vent. Strong temporal and spatial variations of bubble size and gas flow rate were found in this area. Quantitative images showed the bubble sizes were larger than that measured during G07. Gas flow rates were also higher compared to the previous measurement. The high-speed image data confirmed the formation of clathrate hydrate skins on the bubbles, observed as a rigid bubble-water interface. The bubbles shrink as the plume rises high in the water column, and the evolving bubble size distribution was measured up to 400 m above the seafloor using the camera system. The rise velocities measured using imaging data were also consistent with that measured with acoustics.

High Resolution Measurement of Droplet Size Distribution Resulting from Breaking Waves impacting on Oil Slick

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Breakup of crude oil slicks into droplets by breaking waves is a major contributor to the dispersion of oil spills. Systematic data on the droplets size distribution (DSD) shortly after breakup and their dependence on dispersant concentration are still lacking. This study provides a comprehensive database on effects of wave characteristics (plunging & spilling breakers), oil viscosity, and dispersant concentration on the time evolution of DSDs. The experiments have been performed in a wave plume, and included oils with viscosity ranging from 9.4 to 306.5 cst, as well as MC252 surrogate crude oil premixed with a Corexit-9500A dispersant at varying dispersant to oil ratios (DOR). Data have been acquired for both a single and continuously generated waves. The physical processes involved, e.g. intrusion depth of oil-containing structures, have also been visualized. To cover the entire spectrum of droplet sizes, they have been measured using in-situ digital holography at resolutions of 11.1 and 1.1 µm/pixel, and by examining samples using fluorescence microscopy at 0.2 µm/pixel. Results indicate that immediately after breakup the DSDs are bimodal, but the smaller mode corresponding to larger droplets decays rapidly, whereas the primary mode is sustained for longer periods. Increasing the DOR drastically reduces the size corresponding to both modes, with the primary one falling well below 10 µm and a substantial fraction falling in the submicron range for DOR of 1:25, and 1:100.

Stability of Submerged Crude Oil and Petroleum Hydrocarbon Aggregates over Time

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The aim this study was to examine the change in the aggregated volume of HLs over time through estimation of dissolution rate constants for selected HLs and South Louisiana crude oil. To evaluate the significance of salinity, two series of experiments (34 ‰ salt water and deionized water) were performed. HLs we used were the main constituents of the crude oil: alkanes (decane, tetradecane, and hexadecane), aromatics (BTEX group: benzene, toluene, ethylbenzene, and m-xylene), and 2-chlorotoluene. The size and number of globules formed were estimated every three days during 10-day (benzene and toluene were monitored every day during the first four days). The experiments were performed four times, twice with salt water and twice with deionized water. Fine quartz sand (passing sieve No. 40 with openings 0.425 mm) was applied in amount of 1 g per 0.5 mL of a HL, floating on the water surface in 120 mL Erlenmeyer flask. Dissolution rate constants were obtained and showed that benzene and toluene completely dissolved from the aggregated globules within 3-4 days after the aggregation, while the other HLs exhibited relatively small change in the globule size over time. South Louisiana crude oil did not show visible changes over time. Salinity of water did not affect the aggregation rates of HLs but slightly decreased the dissolution rate constants for some HLs. Stability of the aggregated with granular material crude oil is the matter of concern in the process of the oil spills treatment method development. The method may find its use in the coastal areas where dispersant application is limited.

Production of Oily Marine Aerosol by Raindrop Splashing

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We examine oily marine aerosol generated when large raindrops falling near terminal speed impact crude oil slicks. The effects of layer thickness, oil properties (viscosity, density, interfacial tension, and surface tension), and premixing the oil with dispersant (Corexit 9500A) on the splash processes are classified in terms of dimensionless variables involving the Reynolds, Weber and Froude numbers. High speed imaging and holographic microscopy are used to elucidate the aerosol formation mechanisms at varying splash phases, and to measure the size and spatial distributions of airborne droplets. Thousands of microdroplets (< 25 μm) are produced during early phases (<0.3 ms after impact), as the ejecta sheet generated initially breaks up. The presence of a high viscosity, low surface tension crude oil layer maintains this sheet intact for longer periods, followed by generation of long micro-ligaments, which then break up into droplets. In later splash stages, droplets are shed from ligaments emanating from the splash crown and show a bimodal distribution with peaks at 50 and 225 μm. The small droplets (50 μm) are ejected at shallow angles within the first 100 μs after impact, as early micro-ligaments extending from the developing crown fragment. The large droplets (225 μm) are ejected later, as predominantly vertical ligaments protruding from the crown break up in a process that also generates small satellite droplets. Dispersants increase the production of small droplets.

Monitoring Bacterial Attachment to Array of Microscale Oil Droplet

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Hydrocarbon degrading microorganisms play an important role in the cleansing of oil polluted marine environments. It has been suggested that dispersants tend to enhance biodegradation by increasing the surface area. Hence, the study of bacterial attachment on micro-scale oil droplets is critical for unveiling the mechanisms governing the biofilm formation and oil consumption of indigenous bacteria. The study of bacteria-oil interaction in micro scale is restricted by the lack of techniques to generate uniform droplet size and to provide in-situ monitoring of biofilm formation. This work implemented a microfabrication technique allowing us to pattern microfluidic devices with the array of micro oil drops to investigate the interaction of bacteria at the oil water interface. The array of oil drops was printed on glass by micro transfer molding/printing employing PDMS stamps. The printed micro-drops have dimensions ranging from 5μm to 50μm. Non-circular shapes, such as square and triangle, can also be printed without the loss of shape and be maintained for weeks as well. This is a violation of the Young Laplace equation. This phenomenon is, feasibly, allocated to the presence of diverse complex structures in the crude oil which allows the different state of equilibrium than what was stated by the Young Laplace equation. The exact topography and interfacial structure of droplets was characterized by atomic force microscopy (AFM) and later on confirmed with interferometry. With the developed surfaces, the effects of oil drop sizes and interfacial structures on biofilm formation are studied. Real-time observations were performed on film formation and growth using hydrocarbon degrading bacterial isolates, e.g. *Pseudomonas* sp., *Alcanivorax borkumesis*, and *Marinobacter hydrocarbonoclasticus*, as well as naturally occurring microbial consortia from Gulf of Mexico. The changes in film morphology are characterized with in-situ interferometry. The degradation rate will be estimated.

Biodegradability of Dispersed Heavy Fuel Oil at 5 and 25 °C

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Fuel oil is produced by blending heavy residual oils with a lighter oil to meet specifications for viscosity and pour point. Compared to lighter oils, the high density and viscosity of fuel oil make it less susceptible to dispersion and biodegradation. Hence, heavy fuel oil spills could cause more serious damage to the environment and be more difficult to clean. The environmental impacts include coating of wildlife that dwell on the water surface, depleting oxygen in the receiving environment, exposing aquatic species to toxic substances, and sediment contamination. Laboratory experiments were conducted to study the biodegradability of Intermediate Fuel Oil 120 (IFO-120) dispersed by Corexit 9500 (C9500) at 5 and 25 °C. The biodegradability of alkanes and aromatics in IFO-120 at both temperatures was studied in the presence and absence of dispersant. When compared with IFO-120 alone treatments, data indicated that the depletion rate of alkanes at both temperatures was unaffected by the presence of dispersant. Conversely, C9500 significantly improved the uptake of aromatics as its presence shortened the lag phase at 25 °C from 4 to 2 days and increased their removal extent from 81 to 86%. At 5 °C, the addition of C9500 also improved the overall removal of aromatics from 79 to 85%. Such enhancement effect could be explained by the promotion of dissolution of soluble aromatics in the presence of surfactants.

Direct Numerical Simulations of Oil Plumes in Water and Raindrops Impacting Oil Slicks

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Investigation of oil/water mixture behaviors associated with oil spilled in ocean has been conducted in the scope of collaboration between the LML laboratory, France, and Johns Hopkins Univ. in the US. Direct numerical simulations have been performed in two particular configurations: an oil jet rising in water while submitted to a cross flow, and a rain drop falling on a deep pool of water on which a thin layer of oil is floating. In the first case, attention is focused on the effect of chemical dispersant on the jet atomization and final size of oil droplet, while in the second case, the effect of the oil layer thickness on aerosol formation and oil spill dispersal is investigated. The numerical simulations have been found in good agreement with the behavior observed in the experiments. The time evolution of the plume dispersion in the first configuration, as well as the break-up of the oil layer and the mixing of the raindrop with the sea water in the second case, is correctly reproduced. The mechanisms related to these different phenomena are discussed on the basis of the present numerical results and the high speed videos obtained at Johns Hopkins University.

Sedimentation of Oil in Association with Diatom Aggregates

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A significant fraction of the oil spilled during the Deepwater Horizon incident settled to the seafloor. The mechanisms responsible for this sedimentation include interaction with suspended sediments to form oil-mineral aggregates, incorporation into zooplankton fecal pellets, and formation of oil-containing

marine snow, each of which allows for rapid sinking of particles along with any associated oil. The formation and sinking of phytoplankton aggregates--a common type of marine snow--is known to play a significant role in the ocean's biological pump by transporting carbon from surface waters to the seafloor. Incorporation of oil into phytoplankton aggregates thus represents a potentially important pathway for the vertical transport and ultimate sedimentation of spilled oil. Data from time series sediment traps and laboratory experiments are combined with a simple aggregation model in an attempt to estimate the effectiveness and importance of this particular oil transport mechanism. The ultimate goal of the work is to enable estimates to be made of oil sedimentation rates as a function of phytoplankton abundance and oil concentration.

Experimental Study of the Time and Space Scales on the Dispersant-Oil Droplet Interaction

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Using dispersant as one of several mitigation strategies for reducing the environmental effects of oil spills into the oceans has been practiced for many years. Historically, dispersant is used to treat oil slicks on the water surface but during the Deep Water Horizon accident, dispersant was injected into the source of blow out for the first time. The idea behind it was to capitalize the available mixing force of the turbulent jet rising from the sea floor to promote for formation of smaller droplets. To study the droplet-scale dispersant-water-oil interaction, a series of tests were performed at were performed at the Hawaii Natural Energy Institute of the University of Hawaii at Manoa. The objectives of these tests were studying the effect of turbulence on the mixing of dispersant and oil, and measuring the time scale of oil dispersing process in presence of dispersant. The first series of tests injected single oil droplet into premixed water and dispersant solution with different concentrations. The preliminary data showed injecting oil in the premixed solution does not initiate oil dispersing and the behavior was the same as for untreated water. In the second series of tests, dispersant and oil were injected simultaneously from two capillary pipes with two configurations, side to side and coaxial. Data from these experiments showed simultaneous injection could cause oil dispersion close to the outlet, but farther from the outlet, untreated oil droplets and remaining dispersant did not mix. These tests help to better understand the effects of time and space scales on the dispersant-droplet interaction, as well as, the role of dispersant dilution in the entrained water of the jet.

A Tale of Two (Mega) Spills: Comparison of DWH and IXTOC-1 Scenarios, Fates and Effects

Comparative Records of Planktic Foraminiferal Mass Accumulation Rates following the 2010 DWH and 1979 IXTOC Blowout Events: A Microfossil Indicator of Marine Oil Snow Sedimentation

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Marine Oil Snow Sedimentation and Flocculent Accumulation (MOSSFA) increased dramatically in the Gulf of Mexico (GOM) following the Deepwater Horizon (DWH) event (2010). Increased concentrations of 16S RNA associated with chloroplasts and lipid biomarkers of planktonic microbes both confirm that material within the surface sediment was primarily derived from near-surface waters. This study seeks to determine the proportion of surface derived marine oil-snow deposited in the sediment using planktic foraminiferal tests and their mass accumulation rates (MAR). Initial results in the northern GOM directly after the DWH event show a 2-to-4-fold increase in planktic foraminiferal MAR during late 2010 and early 2011 and confirm a planktic foram contribution to the MOSSFA event. While the pulse of marine oil-snow has been well documented following the DWH event in the northern GOM, the occurrence and extent of the depositional pulse in the southern GOM following the Ixtoc event (1979-80) remains unknown. This ongoing research will utilize planktic foraminiferal MAR to delineate similarities and differences between the depositional processes following these two prominent oil spill events in the northern and southern GOM. The Ixtoc event can potentially be used as an analog to validate whether MOSSFA processes are common following submarine oil releases as well as predict ecosystem recovery from the DWH event.

Comparison of the 2015 Abkatun (Mexico) and 2013 Hercules-265 (USA) Blowout Events in the Southern and Northern Gulf Using Benthic Foraminifera as Environmental Proxies of Hydrocarbon Pollution

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In April 2015, the Abkatun oil-processing platform in the southern Gulf of Mexico (GoM) exploded, causing seepage of petrochemicals into the surrounding environment for five days. During the remediation effort, the released petroleum was burned; likely resulting in the sedimentary deposition of high molecular weight (HMW) PAH's . A similar event occurred in 2013 when the Hercules-265 gas-rig exploded in the northern GoM and burned for approximately 30 days. Sediment cores were taken at three sites along an 8 km transect NW of the Abkatun platform and on a 20km transect SE of the Hercules-265 rig. These transects followed the path of the surface slick based on satellite imagery. Comparison of sediment cores from sites along each of the transects were used to: A) quantify the presence of petrochemicals and B) determine their effect on the biodiversity of benthic foraminifera (BF) and determine spatially-related impacts of the two events. Initial results from the Hercules survey have shown a decrease in the biodiversity of BF corresponding with an increase in HMW PAHs in the surface sediments near the rig. There was also an increase in the abundance of the indicator species *H. germanica* in the surface sediments near the rig defining a recognizable benthic impact footprint even from such a short-term and comparatively small well explosion. Spatial and depth variability in petrochemicals from Abkatun and Hercules-265 will be compared to BF diversity and the density of proven indicator species. This study tests the efficacy of foraminifera as short-term pollution indicators. Population changes of low-trophic level organisms, like BF, can directly affect higher-level consumers and impact the structure and function of the ecosystem.

Sustainable Coasts and Human Impacts on Marsh Food Webs in the Gulf of Mexico

Potential and in-situ Denitrification Rates in Oiled and Unoiled Louisiana Salt Marsh Sediments following the Deepwater Horizon Spill

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We investigated salt marsh sediment denitrification rates seasonally (April, July, and October 2014) in 3 regions of Terrebonne Bay, Louisiana. From each location, we sampled a marsh which had been visibly oiled following the Deepwater Horizon spill and a nearby marsh with no visible oiling (total of 6 sites). Samples for potential denitrification were taken at both 1 m and 10 m from the marsh edge. Potential denitrification was evaluated in slurries using two different methods; 1) by adding 15N-NO3 in sealed tubes and measuring the accumulation of 29 and 30N2 over 36 hours, and 2) in a shorter term denitrification enzyme activity (DEA) assay. We did not observe a significant difference in potential denitrification rates between marsh edge and interior locations nor did we observe a consistent seasonal pattern. The two different methods of measuring potential denitrification in slurries gave similar but not identical results and suggested that oiled sites have either similar or higher rates than non-oiled sites. We compared these measurements to whole cores measurements (at 10m locations only) made using the isotope pairing technique. In whole cores, potential denitrification rates were consistent with potentials in slurries (higher rates in oiled sites). However, whole core measurements of in-situ denitrification did not show a consistent overall oil effect and were quite variable. Information on DNRA and molecular data on nirS will also be presented.

Highly Variable Biogeochemical Process Rates across Salt Marsh Soil Subhabitats: Implications for Scaling-up Plot Level Measurements

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Salt marshes are important sites for retention and transformation of carbon and nutrients. Much of our current marsh biogeochemistry knowledge is based on sampling at times and in locations that are convenient, most often vegetated marsh platforms during low tide. Wetland loss rates are high in many coastal regions including Louisiana which has the highest loss rates in the US. This loss not only reduces total marsh area but also changes the relative allocation of subhabitats in the remaining marsh. We examined three marshes in Cocodrie, LA (June 2015), for variations in biogeochemical processes associated with greenhouse gas (CO2, CH4, N2O) production, denitrification, nitrification, iron reduction, and phosphorus sorption, as well as microbial community diversity and soil properties at six marsh subhabitats: *Spartina alterniflora* dominated platforms, depressions, higher elevation *Juncus roemerianus* patches, subtidal edges, tidal creeks, and ponds. Spatial patterns in biogeochemical rates, microbial diversity, and soil properties across subhabitats were similar at all three marshes indicating results are robust across the region. However, individual biogeochemical rates differed in their hotspot

habitat(s) across the marsh. For example, iron reduction was highest within both vegetated habitats, but nitrification was highest in only *J. roemerianus*. Phosphorus sorption rates were highest at ponds and creeks and lowest at *S. alterniflora* and edge habitats. Distinct subhabitat spatial patterns for biogeochemical processes and microbial communities may influence the roles that marshes play in retaining and transforming nutrients in coastal regions undergoing erosion or being affected by oil inundation or other stressors. These results also highlight the importance of subhabitats when scaling up plot level measurements to landscape or regional scales.

A Coupled Ocean-Wave Model for the Barataria Bay, Louisiana

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A new coupled ocean-wave model is being developed and tested for the Barataria Bay, Louisiana in order to simulate hydrodynamic condition and oil particle transport pathway from northern gulf continental shelf to the estuarine environment. The modeling system is comprised of the Finite-Volume Coastal Ocean Model (FVCOM) and the FVCOM-SWAVE, an unstructured-grid variant of the third-generation surface wave model SWAN (Simulating WAves Nearshore). Both ocean and wave models employ the same finite-volume numerical algorithm and the same unstructured triangular mesh grid, making it easier to couple them and without introducing interpolation error. The ocean model has been modified to incorporate the effect of the Stokes drift current, wave radiation stresses due to horizontal gradients of the momentum flux of surface waves, enhancement of bottom drag in shallow water, and enhanced vertical mixing due to Langmuir turbulence. The wave model ingests surface currents and water levels from the ocean model. In this poster the results of some initial numerical experiments are reported in which the two models are run individually. For future research it is planned that the coupled ocean-wave modeling system is to be used to drive the finite-volume sediment transport model to study oil deposition in the wetland sediments and possible re-suspension process during tropical storm and cold-front passage events.

Tracing Carbon Flow from Primary Production to a Gulf Coast Salt Marsh Consumer, the Seaside Sparrow (*Ammodramus maritimus*)

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Determining the relative contributions of primary producers to salt marsh food webs is fundamental to understanding how these systems are structured. Biomarkers such as bulk carbon isotopes (13C/12C) and fatty acids have become popular tracers of trophic dynamics, based on the principle that the composition of biomarkers in consumer tissues is a reflection of the composition of these same biomarkers in a consumer's diet. However, the use of bulk stable isotope and fatty acid analyses to assess carbon flow in food webs is often hampered by confounding factors such as isotopic fractionation and fatty acid modifications that can occur between trophic levels. In contrast, compound-specific stable isotope analysis of amino acids may offer a more precise tracking of carbon flow through complex food webs. This is because the isotopic values of essential amino acids in consumer tissues are assimilated largely unchanged from their primary sources at the base of the food web. The aim of this study was to test the consistency of three different methods (bulk carbon stable isotope, fatty acid and compound-specific stable isotope analyses) while examining the carbon source pool underlying the diet of a common marsh consumer, the seaside sparrow (*A. maritimus*). This comparison allows us to gain a

better idea of the relative merits of these analytical methods and contribute to a clearer model of overall trophic dynamics in a salt marsh food web.

Reactive Nitrogen Sinks in the Water Column of a Large Coastal Hypoxic Area, the Gulf of Mexico "Dead Zone"

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Excess nitrogen in coastal environments leads to many adverse consequences such as eutrophication, harmful algal blooms, habitat loss, oxygen depletion and reductions in biodiversity. As such, biological nitrogen (N) removal through the microbially-mediated process of denitrification acts as a critical ecosystem service that can mitigate the negative consequences of excess nitrogen loading. However, denitrification can produce nitrous oxide, a potent greenhouse gas, as a byproduct under some environmental conditions. To understand how excess nitrogen loading impacts denitrification and nitrous oxide production, we measured rates of this process in the water column of the Gulf of Mexico "Dead Zone" three times over the summer of 2015. The Dead Zone is generated by excessive nitrogen loading from the Mississippi River co-occurring with strong water column stratification, which leads to a large summer-time hypoxic/anoxic area at the mouth of the river and along the coast of Louisiana. Rates of denitrification ranged from 31 to 153 nmol L-1 d-1. Dead Zone waters are also enriched in methane and aerobic methane oxidation rates ranged from 0.1 to 4.3 nmol L-1 d-1. Maximal denitrification rates were observed at stations with the lowest oxygen concentrations and highest methane oxidation rates, suggesting a potential coupling between nitrate reduction and methane oxidation which both scrubs reactive N and methane from the system, thus performing a duel ecosystem service.

Application of Otolith Microchemistry to Understand Utilization of Subhabitats by Salt Marsh Fishes

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Killifishes are often sentinels species because they are dominant in marshes, play an important role in marsh food webs, and have limited home ranges. However, patterns of habitat use can vary among species, life history stages, and individuals. Therefore, it is important to consider the temporal and spatial distribution of these highly localized fish within different marsh subhabitats (marsh edges, creeks, ponds, and depressions) when evaluating their potential as sentinel species. Our recent work indicates the four most abundant killifish in Louisiana marshes (*Fundulus grandis*, *F. xenicus*, *Cyprinodon variegatus*, and *Poecilia latipinna*) are highly abundant in ponds and depressions, but only a small portion (<1%) occur along the marsh edge. In these subhabitats, fish can be exposed to varying levels of temperature, salinity, and trace metal concentrations, three factors controlling the daily uptake of trace elements into otoliths, therefore providing a record of the fish's chemical environment. Our objective was to determine if otoliths of fish from different subhabitats have distinct elemental signatures. Fish from these four species (n=200) were collected across marsh subhabitats near Chauvin, Louisiana, and the chemical compositions of their sagittal otoliths were analyzed. Element concentrations in were quantified using laser ablation with highly sensitive mass spectrometry. We discuss multi-elemental differences across subhabitats, species, and stages of ontogeny.

Denitrification Rates in Deepwater Horizon Impacted Saltmarshes

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Oil spills result in significant changes in physiochemical and biological processes in sediments and can have long lasting effects on ecosystems functions. The importance of the microbially-driven nitrogen (N) cycling in salt marsh ecosystems is well known. What is less known is the impact of the DWH oil spill on microbial populations involved in N cycling, particularly denitrifiers, in northern Gulf marsh ecosystems. The objective of this study was to investigate N cycling and microbial populations in marsh and subtidal unvegetated sediments at the Chandeleur Islands (29.864039°N, -88.842443°W) that were previously exposed to hydrocarbons following the DwH accident. Denitrification, a microbial process by which nitrate is converted into dinitrogen and nitrous oxide, is a key ecosystem function that contributes to nitrogen removal in nearshore marine ecosystems. Denitrification rates were measured by the isotope pairing technique and microbial populations will be determined via metagenomics-based methods. Measurements were conducted in July, August and September 2015 and will continue monthly. Denitrification ranged from 4.2 to 30.5 µmol N m^{-2} hr^{-1} in July and 3.6 to 129 µmol N m^{-2} hr^{-1} in August and 5.1 to 92.7 µmol N m^{-2} hr^{-1} in September with the highest rates measured in marsh sediments. Potential denitrification rates measured at depths of 0-2 and 5-7 cm ranged from 2.9 to 322 µmol N m^{-2} hr^{-1} with highest rates measured in nitrate treated surficial marsh sediments. Temporal determinations of N cycling populations through in-depth sequencing coupled with rate measurements will provide insights and greater knowledge of the microbial responses, particularly with regard to N cycling, in response to major oiling events such as the DWH incident.

One Health: Unraveling the Interconnectedness between Human and Ecosystem Health through the Lens of Oil Spills

Five Years Later: Determining Public Perception of Community Recovery and Post-crisis Management following the Deepwater Horizon (DWH) Oil Spill

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In April 2010, an explosion aboard the Deepwater Horizon oilrig, owned by British Petroleum (BP), caused the largest accidental oil spill in history. The spill released approximately 210 million gallons of oil into the Gulf of Mexico. After the oil spill, the National Institute of Environmental Health Science (NIEHS) established the "Deepwater Horizon Research Consortia." As part of the consortia, the grant project "Healthy Gulf, Healthy Communities" (HGHC) was established to research community resources, individual and community resiliency, and seafood safety. As the five-year anniversary of DWH oil spill approached in April 2015, it was important to develop a better understanding of Gulf coast residents' perceptions of their community's recovery in order to communicate with them effectively regarding project results. Therefore, this research sought to describe effected community residents' perceptions of community recovery and disaster management. A telephone survey was developed and administered to Gulf coast communities from Levy County, FL to Baldwin County, AL. The survey was developed using Tony Jaques' Issue and Crisis Management Relational Model as a theoretical guide. Purposive nonprobability sampling was utilized yielding 444 viable responses. The survey was administered in January 2015. Results indicate that Gulf coast residents continue to perceive long-standing needs and gaps in their communities following the Deepwater Horizon oil spill with 39.4% of respondents dissatisfied or very dissatisfied with leaders in their communities after the DWH oil spill and 42% disagree or strongly disagree that their community is stronger after the DWH oil than it was before. Results from this study provide a foundation in which to communicate research results. In addition, it provided researchers and community partners with next steps and programs/practices that will help improve future post-crisis management to man-made and natural disasters.

Rapid and Sensitive Assay Screening Reveals Multiple Potential Hormone Disrupting Activities in MC252 Crude Oil and Different Dispersants

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Environmental contaminants known as endocrine disrupting chemicals (EDCs) include many plasticizers, pesticides and flame-retardants. EDCs alter hormonal signaling in humans and wildlife and may lead to metabolic (e.g. obesity, diabetes), reproductive and other major health disorders. Thus, identifying novel EDCs is important for public and environmental health. Given the magnitude of the DWH oil spill and future spills anticipated, we tested Corexit dispersant, a novel food grade two-component dispersant (LT) and water accommodated fractions of MC252 oil and these dispersants (CWAF and LTWAF, respectively) for EDC activities. Our rapid and sensitive screening was performed via transactivation assays of multiple nuclear receptors, including estrogen receptors (ERα and ERβ), retinoid X receptor alpha (RXRα), progesterone receptor beta (PGRβ), androgen receptor (AR), glucocorticoid receptor (GR) and thyroid hormone receptor (TRα and TRβ). Highlights of our results include: that components of oil are estrogenic, dispersed oil and Corexit activate RXRα, DOSS, a Corexit component and putative obesogen, displays PGRβ antagonist activity and that LT is relatively free of these activities. Going beyond toxicity and acute impacts, identification of EDCs present in oil and dispersant will help predict

potential long-term adverse health effects and prepare us for future oil spills via development of potentially safer dispersants.

From Oiled Stem Cells to Pregnant Women: Methodically Navigating Between Complex Environments and Human Health

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Environmental endocrine disrupting compounds (EDCs) have been implicated in most major health concerns, including obesity. In addition to diet and lifestyle, there is increasing evidence that environmental exposure to a class of EDCs known as 'obesogens' may promote obesity. The massive environmental contamination resulting from the Deepwater Horizon (DWH) oil spill including oil dispersant use warranted investigation to determine if potential obesogens or other EDCs exist in the contaminants. Sensitive methods to identify and quantify EDC activity in dispersed oil were the first major step, and advanced lipidomic and genomic/epigenomic approaches to identify biomarkers of exposure and persistent effect are the second major step. Because embryos carry the lion's share of stem cells, they are arguably the most sensitive to EDC exposures regarding current and life-long health trajectories. Thus, human stem cell-based tools to identify and measure obesogens/EDCs are an avenue of investigation, as are clinical investigations of in utero exposures. In addition, stem cell-based and in utero exposure studies in sentinel animal models, alligators and marine mammals, are underway. This talk will describe novel technologies that can be used to identify and measure obesogens/EDCs in Gulf of Mexico crude oils, dispersants and extracts thereof. With knowledge of the most potent oil/dispersant derived compounds, targeted measures can be developed to mitigate their effects and develop obesogen-free dispersants. Combined with epidemiology and other human health resources, these endeavors promise a healthier environment for humans and other Gulf inhabitants.

Public Health Consequences of Oil Spills and Overfishing

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Top-down and bottom-up controls of petrochemical and other poisons, trophic cascades, and nutrient-limitations determine annual amounts of wind-borne aerosols of toxic algal and recycled mercury poisons from the seas. Before the Deepwater Horizon oil spills during 2010, biomass of zooplankton herbivores on the West Florida shelf (WFS) had already declined ten-fold from 1965-1966 to 2001-2002. Consequently, reduced grazing pressures on all phytoplankton favored ten-fold increments of dominant harmful algal bloom (HAB) purveyors of asthma triggers, in the absence of upwelled nutrients to instead fuel diatoms. Between 1965 and 2002, HAB aerosol fluxes in sea sprays amounted to ~31% of carbon sequestration each year by WFS HABs. Such aerial export was traced in 2007 as part of asthma hospitalization rates over the SE United States, with corollary deposition of co-travelling mercury aerosols in surface soils since 1965. After loss of fecal pellet vectors of carbon to the sea bottom, increments of lytic algicidal bacterioplankton also occurred between 2001 and 2010, with a shift in loci of HAB lysis and nutrient recycling from the sea floor to near-surface waters. Globally, marine HAB triggers caused about 13%, i.e. ~40 million, of asthma attacks in 2004. Yet, intensified Loop Current

upwelling in 2010 allowed oil-tolerant diatoms to outcompete HABs, despite removal of retrograde benign diatoms to depth by oil-aggregated marine snows.

Follow-up Measure of Oxidative Stress Biomarkers in Residents 1.5 and 6 Years after the Hebei Spirit Oil Spill

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The Hebei Spirit oil tanker had an accident and spilled 12,547 kl of crude oil in 2007 in Korea. Results based on the baseline survey which was performed 1.5 years after the oil spill, showed an exposure-response relationship between the exposure to crude oil and oxidative stress biomarkers. The aim of this study was to investigate the changes in the levels of oxidative stress markers in residents on the follow-up survey 6 years after the oil spill. Urinary 8-hydroxy-2'-deoxyguanosine (8-OHdG) and urinary malondialdehyde (MDA) levels were measured as indicators of oxidative DNA damage and lipid peroxidation, respectively. The oxidative stress biomarkers were measured in 819 residents 1.5 years after the accident. The follow-up measure was conducted in 304 residents 6 years after the accident. The geometric mean (GM) of urinary 8-OHdG were 5.33 and 5.32 μg/g creatinine 1.5 and 6 years after the oil spill, respectively. The GM of urinary MDA were 3.31 and 2.14 μmol/g creatinine 1.5 and 6 years after the oil spill, respectively. Levels of MDA significantly decreased as time passed after adjusted for covariates in linear mixed model. There was no significant change in 8-OHdG levels between the baseline and the follow-up survey. Although time passed, urinary 8-OHdG levels were not recovered during the follow-up period. The 8-OHdG might relate to risk factors for long-term adverse health effects. Health effects due to the oil spill exposure need to be more concerned in the future.

Epigenetic Mechanism is Involved in the Transgenerational Toxicity of Iranian Heavy Crude Oil in the Nematode, *Caenohabditis elegans*

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In December 2007, the Hebei Spirit, which was carrying 260,000 tons of crude oil, spilled about 10,800 tons of oil on the Yellow Sea of Taean, South Korea. Recent evidence suggests that the epigenetic effect of the environment evoke heritable changes in gene expression without changes in DNA sequence. We investigate transgenerational effects of crude oil in nematode *Caenorhabditis elegans* (*C. elegans*). *C. elegans* was exposed using passive dosing in order to maintain concentration of volatile and adsorbent chemicals, and then growth and reproduction of worms were measured using COPAS (Complex Object Parametric Analyzer and Sorter) for several generations. We found that reproductive capacity was decreased dramatically in *C. elegans* exposed to crude oil. To investigate underlying mechanism of transgenerational toxicity, the changes of histone methylation and related gene expression were

observed. We believe that the current study will contribute to further elucidations on the epigenetic effect of transgenerational toxicity in *C. elegans* exposed to crude oil.

Coastal Seafood Consumption Post-DWH is >200 Fold Higher than National Estimates: Opportunities for Improved Risk Assessment in Seafood Safety

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Seafood consumption patterns in Gulf coastal communities were discerned to address public health risks associated with seafood consumption following the Deepwater Horizon oil spill. We developed and implemented a food frequency questionnaire to analyze seafood consumption and body weights from households of seafood workers, fishers and other residents in Gulf coast communities in Florida and Alabama. Data from over 900 individuals revealed that seafood consumption in Gulf coast communities is higher than national estimates based on 2003-2010 NHANES data (FDA levels of concern for PAH contaminants in seafood are based on NHANES national consumption and body weight estimates). Upper percentile seafood consumption of our study participants were 231 and 298% higher for finfish, and 536% and 984% higher for shellfish (shrimp, crab and oyster), than upper percentile national estimates for adults and youth, respectively. The marked differences between community-specific seafood consumption and NHANES estimates underscore the need to consider local and regional consumption rates when developing risk assessment models. Further, seafood consumption patterns varied substantially between communities based on local heritage, fisheries and economics. These outcomes provide important perspectives that bridge environmental and public health, and underscore the utility of community-based science to define more protective estimates of risk.

Global DNA Methylation Status in the Subjects with Exposure to Hebei Spirit Oil Spill due to Long Term Clean-up Work

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In the present study we aim to accomplish the status of global DNA methylation as we all as its relationship with oxidative stress due to exposure of Hebei Spirit oil spill. We examined the global DNA methylation (5-mc) status and its distinct trend over 5 years in the participants of cleanup works. The global DNA methylation was measured with commercially available DNA 5-mC quantification Kit (Epigenetek) in the DNA extracted from whole blood. The global DNA hypomethylation (1.46 ± 0.5) was observed in exposed group compared to control (low exposed group, 2.69 ± 0.26). Moreover, significant ($p < 0.001$) DNA hypomethylation trend was also evident with time (2009 to 2014). In addition, positive correlations, however statistically non-significant, were found between the oxidative stress markers (8-OHdG, MDA) and global DNA methylation. Hence, our future perspective is to evaluate the gene specific DNA methylation to explain the prolong existence of high level of oxidative stress markers. Taken together, our preliminary results indicate that global DNA hypomethylation trend possibly play significant role in oil spill exposure induced oxidative stress and in turn other related diseases.

Seafood Consumption in the Women and Their Children's Health (WaTCH) Study after the Deepwater Horizon Oil Spill

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As a result of the Deepwater Horizon Oil Spill (DHOS) between 1,000 and 60,000 barrels of crude oil flowed into the Gulf of Mexico daily for approximately five months. The cleanup response included the use of approximately 1.8 million gallons of dispersant chemicals. As a result of the release of oil and subsequent use of dispersants, there was widespread concern over the safety of Gulf seafood. Eventually, after substantial tests by independent investigators, gulf seafood was deemed safe for human consumption. However, the general public remained concerned about seafood safety despite reassurance from the experts. It is possible that the public perception of seafood safety is affected by individual economic and physical exposure to the DHOS. The goal of the current analysis is to assess if exposure to the DHOS in a population of women residing in the seven coastal parishes of Louisiana is associated with seafood consumption post-DHOS. Data on sociodemographic factors, oil spill exposure, and seafood consumption patterns prior to and following the DHOS were collected via telephone interviews between 2012 and 2014. Approximately, 31% of women reported consuming less seafood at the time of the interview than they had prior to the DHOS. Preliminary analyses support an association between exposure to the DHOS and a decrease in seafood consumption. Also, more recent data from follow-up interviews (2014 to present) will be examined to evaluate if seafood consumption patterns have changed since initial data collection and if seafood consumption remains associated with exposure to DHOS.

Correlations between Pulmonary Function and Children Asthma 5 years after the Hebei Spirit Oil Spill

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It was shown that respiratory symptoms in children were existed at the point of 1.5 and 3 years after the Hebei Spirit oil spill accident. This study was conducted correlations between pulmonary function and asthma among child in affected area of oil spill. Pulmonary Function test was conducted from October 2013 to November 2013 on 506 elementary school students. Information of asthma symptoms and asthma diagnosis were obtained by International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire. As %FEV1 and %FVC of child of the high exposed area are 85.81% and 82.61%, respectively, and those of the low exposed area are 88.27%, 85.05%. High exposed and low exposed area children were not significantly different. FEV1 of with asthma children was significantly lower than without asthma children ($p < .05$). It is possible that poor pulmonary function in children with asthma is due to related to oil spill exposure even 5 years later. Children are very sensitive to the environmental disaster. Further study should be conducted to investigation the additional pulmonary function effect.

Oil Spill Clean-up Work and Incident Coronary Heart Disease in the GuLF STUDY

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Background: Workers who cleaned up after the 2010 Deepwater Horizon oil spill were exposed to chemical, physical and psychological stressors that may contribute to coronary heart disease (CHD) risk. We evaluated associations between measures of spill exposure, including characteristics of clean-up experience and proximity to the spill, and incident nonfatal CHD. **Methods**: The Gulf Long-term Follow-up Study (GuLF STUDY) includes 32,608 adults who participated in clean-up after the Deepwater Horizon disaster or completed safety training but were not hired. Data come from baseline telephone interviews completed in 2011-2013, 1-3 years after the spill. We estimated risk ratios (RR) and 95% confidence intervals (CI) for the associations of estimated total hydrocarbon exposure, work timing in relation to capping of the oil well, duration of cleanup work, and residential proximity to the spill with self-reported diagnosis of nonfatal CHD myocardial infarction (MI), angina or any CHD) since the oil spill, adjusting for age, gender, income and smoking. **Results**: Of the 31,609 English and Spanish-speaking participants included, 77% had clean-up jobs. Incident CHD was associated with working before (vs after) the oil well was capped (RR 1.67, 95% CI 0.97-2.85). Working >30 days (vs 1-30 days) was associated with significantly increased risk of MI and all CHD combined. Living in a coastal county affected by the spill was also associated with increased CHD risk compared to living further away (RR 1.62, 95% CI 1.15-2.29). Although there was not a monotonic dose response, the RR for those in the highest level of estimated THC exposure compared with non workers was 1.91 (95% CI 1.11, 3.28). **Conclusions**: This is the first study to assess the relationship between oil spill cleanup work and CHD. Additional research is needed to determine if the observed associations are related to chemical exposures during cleanup work or other stressors associated with the spill.

Correlation of Toxicity Outcomes in Rats of Crude Oil from Different Sources with GC/MS Spectral Fingerprints to Identify Active Constituents

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Anticipated health effects of crude oil are generalized from those of prior releases, although compositional differences from different sources indicate effects should vary. We determined ranges of values for several toxic effects of acute exposure to LA sweet, Nigerian, and Iraq crude oils (ONTA, Toronto), and Deepwater Horizon (DWH) crude oil samples A010G4 “Surrogate”, A0083Q “MASS Aug 15” and A001EP/EQ “SOB MAY 22” (AECOM, Fort Collins, CO). Female SD rats treated with 2 daily doses (2.5, 5 ml/kg, p.o.) were bled 48h later for hematology, clinical chemistry and serum 8-isoprostane (8-IsoP). Bone marrow cells were assayed for myeloid progenitors (CFU-GMs). All oils had elevated serum alkaline phosphatase and liver weights. Spleen weights decreased for high dose Nigerian, Iraqi, EQ and 3Q. Granulocytes increased with high dose of Iraqi and DWH oils and 8-isoP increased with all but Nigerian and Iraqi oils. CFU-GMs decreased and increased with high dose LA sweet and Nigerian oils, resp. To test whether partial least squares (PLS) regression can identify chemical constituents in situ within crude oil mixtures active in mediating a toxic effect, we regressed peak areas of chromatograms from GC/MS (HP-5 column) on serum 8-isoP values and relative spleen weights. Among 48 peaks with non-negligible range, n-heptane and toluene were most influential for 8-isoP outcome and xylene and 1,2,3- and 1,3,5-trimethylbenzene for spleen weight. These data emphasize that toxic effects of any

given crude oil is unique and demonstrate feasibility of predicting those effects with multivariate regression of content of constituents from analytical chemical fingerprints.

Oceanographic Controls of Oil Transport and Microbial Hydrocarbon Biodegradation in the Water Column: from the Surface to the Deepsea

Deep Layer Circulation, Transport and Mixing in the Northern Gulf of Mexico: Deep Phenomena and Dispersion over the Continental Slope

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This study examines the circulations along the continental slope in the northern Gulf of Mexico at depths greater than 1000 m focusing on transport and mixing across the water column. The investigation is performed using a regional model run at 1.6 km, over a three-year period, from January 2010 to December 2012. A passive dye is released near the Macondo Prospect, at MC297, and at the largest known natural hydrocarbon seep in the northern Gulf, GC600 and is followed for one year. Ageostrophic submesoscale eddies, and vorticity filaments populate the continental slope. They are formed from horizontal shear layers at the edges of highly intermittent, bottom-intensified, along-slope boundary currents and in the cores of those currents when they are confined on steep slopes. The first site is characterized by weak mean currents and by intense, long lasting submesoscale eddies that form to the west of the Macondo Prospect near the ocean bottom. GC600, on the other hand, is surrounded by a complicated bathymetry, and its flow is strong and highly variable and characterized by short-lived submesoscale eddies. The trapping exerted by the submesoscale eddies and vorticity filaments near the rig constrain the spreading in the vicinity of the Macondo Prospect. The tracer released at GC600, on the other hand, is dispersed much more effectively due to enhanced near-bottom turbulent mixing. Finally, Lagrangian tracers are used to sample other regions in the northern Gulf in a simulation at 3 km horizontal resolution and to characterize horizontal and vertical dispersion in the deep layer.

Prediction of Surface Oil Slick Transport Using the 3D Baroclinic ADCIRC on High-resolution Unstructured Finite Element Grids

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Accurate simulation of ocean currents near coastal regions can be used for the prediction of oil spill transport in such areas. Information from these predictions can help emergency responders make informed decisions regarding the clean-up process. In coastal regions, due to the considerable variation of bathymetry, and also discharge of fresh water from the rivers, the character of the fluid flow is three-dimensional. During this presentation, we will discuss the application of the three-dimensional baroclinic ADCIRC model to the Deepwater Horizon oil spill event. ADCIRC utilizes an unstructured grid that allows it to accurately capture high-resolution bathymetry. For stability, this high-resolution bathymetry needs to be smoothed in regions where it varies drastically. These regions are identified by computing two different grid-roughness indicators, and are locally smoothed until certain conditions are satisfied. We will also discuss recent improvements made in ADCIRC for computing the baroclinic pressure gradients and the horizontal transport-diffusion terms for density-driven flows. We will show simulation results of the northern Gulf of Mexico during the DwH oil-spill event and compare them with observations at buoys. To investigate the influence of baroclinicity and vertical mixing, we compare these results against a two-dimensional barotropic simulation. Next, by representing surface oil slicks due to the oil-spill

event as Lagrangian particles, we compute their transport due to ocean currents, and compare them with satellite observations.

Light Rare Earth Element Depletion during Deepwater Horizon Methane Consumption

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Substantial quantities of hydrocarbons accumulated in submerged plumes during the Deepwater Horizon (DWH) blowout and were largely consumed by a subsequent microbial bloom. It has been unclear whether nutrient availability might have limited the rate of this hydrocarbon consumption. Other work has shown that nitrate and phosphate were measurably removed, but probably not limiting. Dissolved Fe and Cu appeared not to have been depleted, though their levels may have been so low as to limit methanotrophic growth at high methane concentrations. Recent work in volcanic mudpots revealed that light rare earth elements (REEs) are required by an extremely acidophilic methanotrophic microbe and other work indicates a number of methanol dehydrogenases contain REE cofactors. We thus re-examined samples collected in the vicinity of DWH during May/June 2010. Our analyses reveal depletion in the light REEs in highly CH4-enriched waters. Additionally, mesocosm incubation experiments with CH4-inoculated seawater and naturally CH4-enriched seep water from the Gulf of Mexico were carried out. These incubations exhibited decreases in light REEs, further indicating uptake by methanotrophic activity and have enabled a quantitative relationship with methane oxidation. Although availability of the light REEs probably didn't limit methanotrophic growth during the DWH blowout, our observations confirm the biological importance of this group of elements previously viewed as bio-inactive.

Near-Bottom Currents and Dispersal at GC600 and OC26

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Between 2012 and 2014 the GoMRI ECOGIG consortium deployed Acoustic Doppler Current Profilers (ADCPs) to collect two time series of ocean velocity in the northeastern Gulf of Mexico. The ADCPs were moored close to the seabed at the very active GC600 seep site (3 consecutive deployments, 25 months of data) and at the OC26 site near the 2010 Deepwater Horizon oil spill location (2 consecutive deployments, 14 months of data). Here, we present fundamental properties of the currents observed at both sites, with particular emphasis on dispersal on time scales from hours to months. Analyzed flow properties include means with uncertainties, dominant frequencies of temporal variability, vertical shear, polarization of internal-wave motion, etc.

Use of Autonomous Platforms to Study the Hydrography around Natural Hydrocarbon Seeps in the Gulf of Mexico

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Autonomous platforms equipped with bio-optical sensors can be used to make high-resolution measurements that complement and extend shipboard surveys spatially and temporally. In May-June 2015, we deployed two Lagrangian Autonomous Profiling EXplorer (APEX) floats. One float (LOBO) was equipped with a Seabird Conductivity, Temperature, Depth (CTD) sensor, Anderaa Oxygen Optode, and a Wetlabs FLBBCD that measured chlorophyll and Colored Dissolved Organic Matter Fluorescence and backscattering due to particles. The other float (HOBO) was equipped with a similar CTD, oxygen optode, Wetlabs FLBB and in addition had a pair of Satlantic four channel radiometers to measuring downwelling irradiance and upwelling radiance at four wavelengths (412, 443, 490, 555 nm). LOBO was programmed to continuously profile from the surface to 1200m and made 28 profiles of the water column between 30 May and 18 June 2015 while HOBO was programmed to profile the water column from the surface to between 300 and 750m and acquired 99 profiles during the same period before it was lost. The floats operated under both near zero and gale force winds and we will present the effect of wind speeds on near surface hydrography and discuss insights afforded by the high spatial and temporal resolution measurements.

A Multi-scale Large-eddy Simulation Study of the Oil Transport in the Ocean Mixed Layer

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Oil plumes being transported in the ocean mixed layer experience the action of shear turbulence, Langmuir circulations, Ekman transport and submesoscale quasi-geostrophic eddies. The response of oil plumes to these processes is highly dependent on the oil droplet sizes. As a consequence, oil plumes with various droplet sizes display complex features across a wide range of length scales. These features can impact the effectiveness of dispersant applications and the rates of oil biodegration. Accurately reproducing the fate of multiple-size oil droplets in all scales using computer simulations is a challenging task. In this study, the Extended Nonperiodic Domain LES for Scalar transport (ENDLESS) is proposed as a multi-scale approach to tackle this challenge while being computationally affordable. The basic idea is to simulate the shear turbulence and Langmuir circulations on a small horizontal domain with periodic boundary conditions while the resulting transport velocity field is replicated periodically following adaptively the large-scale plume as it evolves spatially towards much larger scales. This approach also permits the superposition of larger-scale quasi two-dimensional flow motions on the oil advection, allowing for coupling with regional circulation models. Several validation cases and sample applications to oil plume evolution are presented in order to demonstrate key features and computational speedup associated with the ENDLESS method. The evolution of large-scale plumes with different droplet sizes is studied and implications for surface application of dispersants are discussed.

Role of River Discharge on the Hydrography and Circulation in the Coastal Waters of Alabama, Northern Gulf of Mexico

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River discharge is a key player in the physical transport of material, including oil and oil-derived substances, in the Mississippi Bight of the Northern Gulf of Mexico. Opportunistic observations as well as long-term data sets of shelf hydrography, circulation, and ocean color are used to capture the coupled estuarine-shelf interactions of the Alabama coastal region during periods of low and high river discharge. The system response to discharge at the synoptic, seasonal, and interannual timescales is demonstrated. The major changes generated by individual discharge events from Mobile Bay are shown using approximately two weeks of observations from a surface advected plume. During this time period differences in shelf circulation were directly linked to the discharge plume as a 'bulge' region with anticyclonic circulation identified at times throughout the event. The influence of wind forcing, even during very low wind (<3.75 m s-1) and large outflow (~7,000 m3 s-1) conditions, was apparent, as a result of the shallow and wide characteristics of the plume. At seasonal timescales the cumulative effect of discharge events was primarily observed west of Mobile Bay as a thin surface layer consistent with the event-based observations. The seasonal expression of discharge appears to be primarily limited to the spring/summer and limited data on interannual patterns suggest the seasonal signal is negligible during a spring season with very low discharge. Consequently, the river discharge plays a key role in the hydrography and circulation at a range of time scales and as a result has significant implications on the transport of materials in the coastal zone.

Gulf of Mexico Water Mass Characterization Using Stable Carbon and Nitrogen Isotopes of Particulate Organic Matter

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Particulate nitrogen and carbon concentrations and isotopic compositions were measured in the water masses throughout the Gulf of Mexico in 2013. In addition to the mixed layer (ML), sampled water masses included Subtropical Underwater (SUW), Antarctic Intermediate Water (AIW) and North Atlantic Deep Water (NADW). Mesoscale features included a recently formed anticyclonic ring (ACR), a decaying ACR which coalesced with the slope in the southwestern Gulf of Mexico, the northern edge of Bay of Campeche cyclonic circulation, and slope waters of the western and northern Gulf. These features were characterized in terms of particulate organic carbon (POC) and particulate nitrogen (PN) concentrations, C:N molar ratios, and stable isotopes of carbon and nitrogen (d13C and d15N). Mixed layer POC and PN concentrations were inversely proportional to the depth of the mixed layer with highest concentrations in those regions and features where shoaling of the thermocline introduces new nitrogen for production, and lowest concentrations in anticyclonic rings. In the water column, the C:N ratio of particles and their d15N signature increased with depth suggesting that PN is less refractory than POC as depth increases. In the mixed layer, the d13C signature of particles increased with latitude; this pattern was also evident at deeper water masses reflecting that particle flux is such as to allow for geographical isotopic segregation with depth. Although POC and PN are non-conservative properties, the size and dynamics of the Gulf of Mexico allow for the isotopic characterization of particles in its water masses. This isotopic baseline can be used to trace alterations resulting from external inputs of C and N to the system.

High Resolution Analytical Techniques for the Analysis of Methane Oxidation in Mesocosm Experiments

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Several studies of microbially mediated aerobic methane oxidation in oceanic environments have examined the many different factors that control the rates of oxidation. However, there is debate on how quickly methane is oxidized once a microbial population is established and what factor(s) are limiting in these types of environments. These factors include the availability of CH4, O2, trace metals, nutrients, and the density of cell population. Limits to these factors can also control the temporal aspects of a methane oxidation event. In order to look at this process in its entirety and with higher temporal resolution, a mesocosm incubation system was developed with an ultra-clean and gas tight storage reservoir as well as a Dissolved Gas Analyzer System (DGAS) coupled with a set of analytical tools to monitor aerobic methane oxidation in real time. With the addition of newer laser spectroscopy techniques (cavity ringdown spectroscopy), stable isotope fractionation caused by microbial processes can also be examined on a real time and automated basis. Cell counting, trace metal, nutrient, and DNA community analyses have also been carried out in conjunction with these mesocosm samples to provide a clear understanding of the biology in methane oxidation dynamics. This poster will detail the techniques developed to provide insights into the chemical and isotopic kinetics controlling aerobic methane oxidation. Proof of concept applications will be presented from seep sites in the Hudson Canyon and the Sleeping Dragon seep field, Mississippi Canyon 118 (MC 118). This system was used to conduct mesocosm experiments to examine methane consumption and isotopic fractionation, O2 consumption, trace metal consumption, nutrient consumption, and biomass production.

Kinetic Energy Spectrum from ADCP Data during GLAD

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Drifter trajectories from the Grand LAgrangian Deployment (GLAD) in the Gulf of Mexico reveal persistent inertial oscillations. Recent analysis of pairs of drifters revealed that these do not impact dispersion, which is nonlocal below the deformation scale. Nonlocal dispersion implies an energy spectrum, $E(k)$, which is at least as steep as k^{-3}. However, the inertial oscillations give the appearance of a shallower energy spectrum, proportional to $k^{-5/3}$. Here we use velocities from ADCP data collected during GLAD to compute $E(k)$ directly, to compare with the drifter results. Work supported by the Gulf of Mexico Research Initiative and jointly done with J.\ H.\ LaCasce (University of Oslo) and A.\ Valle-Levinson (University of Florida).

Changes in the Molecular Composition of a Crude Oil resulting from Microbial Degradation by Pseudomonas aeruginosa

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The ability of microbes to biodegrade crude oil in marine systems is well known. However, research opportunities exist to provide a more detailed chemical characterization of crude oil fractions before or

after bacterial degradation. A pilot project was designed to understand in more detail how *P.aeruginosa* alters the molecular composition of crude oil as it utilizes the carbon as an energy source (bio-degradation). A light, sweet crude oil, similar to Deepwater Horizon crude, will be the carbon energy source for *P.aeruginosa*. The crude oil will be placed in various microcosms with *P.aeruginosa* and incubated over a 20-day period. Pre- and Post-treatment crude oil samples will be characterized using an ultra-high resolution of a Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS) to determine the complex molecular compositional changes occurring in crude oil from microbial degradation. Comparison of pre-treatment and the various post-treatment crude oil samples will show changes in the molecular composition of the crude oil from *P.aeruginosa* bio-degradation with and without sunlight inputs. This pilot study will serve as a precursor to a dissertation research project that investigates in more detail the changes in molecular composition of various types of Gulf of Mexico crude oils (light sweet, medium, and heavy sour) under bio-degradation from various in situ microbial communities present in the Gulf of Mexico.

Dissolved Gas Distribution within Gulf of Mexico Natural Deep-sea Methane Plumes

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Bubble dissolution is one of several processes that influence the transport of volatile hydrocarbons from natural gas seeps and anthropogenic releases. Within the hydrate stability zone, dissolution rates are influenced by the presence of hydrate skins on bubbles. We collected water samples from within natural gas plumes and measured dissolved methane concentrations shipboard during a 2014 cruise (GISR 07) to Green Canyon and Mississippi Canyon methane seeps to improve our understanding of bubble dissolution. Samples were collected by remotely operated vehicle in vertical profiles following bubble streams from the seafloor up to 200 m above bottom. Samples were also collected at constant depth, 100 m above bottom, in horizontal transects across a bubble plume. These samples were co-located with measurements of bubble physical properties derived from high-speed videography. The chemical measurements reveal significantly elevated dissolved methane within gas plumes suggesting quantifiable dissolution despite evidence of hydrated bubbles. At 100 m above bottom, the apparent transfer of volatile hydrocarbons from bubbles to the dissolved phase was sufficient to reach dissolved methane concentrations >15 µmol L-1. Immediately outside the bubble field, dissolved methane concentrations attenuated rapidly to background. Dissolved methane concentrations at the seepage source were significantly greater. These field data are being used to constrain estimates of gas dissolution.

Sensitivity of Storm Surge Predictions to Meteorological Forcing for Hurricane Isaac (2012)

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Hurricane Isaac (2012) was a disorganized storm as it moved through the Gulf of Mexico. Its central pressure was relatively low, but it lacked a well-dened eye, which delayed its classification as a hurricane until only about 12 hr before its initial landfall in Louisiana. This disorganization is a challenge to represent with numerical models, both for the meteorology and its impacts on waves and storm surge. In this study, we examine the relative performance of two meteorological models: a parametric vortex

model based on Holland (1980), and the WRF model included in the University of Miami Coupled Model (UMCM). These models are initialized with the best-track forecast guidance issued by the National Hurricane Center during the storm, to examine their performance in operational conditions, as well as their effects when used as input forcing for models of hurricane waves and surge. The meteorological predictions are then applied within the tightly-coupled SWAN+ADCIRC models on a high-resolution, unstructured, finite-element mesh describing the northern Gulf of Mexico and the floodplains of southwest Louisiana. Model performance is quantified via comparisons with dozens of observations at buoys and gages of atmospheric pressures, wind velocities, and water levels. It is shown that the WRF model predictions were a better match to the storm's track and forward speed, and that the peak surge predictions can have errors of several meters depending on the quality of the meteorological forcing.

Meta-Omics Analysis Demonstrates Biodegradation of MC252 Oil in Sand Patties Originating from the Deepwater Horizon Oil Spill

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Remnants of the DWH spill continue to wash ashore on GoM beaches as weathered sand patties (i.e., oil-sand aggregates). Little is known about the microbial ecology of these small oil systems and whether communities mediate hydrocarbon degradation following deposition. Sand patties were collected from two Alabama beaches, along with beach sand and seawater. GC x GC-FID was used for characterization and fingerprinting of oil extracted from the samples. Microbial community DNA from sand, seawater and patties was extracted for 16S rRNA gene amplicon and metagenomic sequencing. LC-Q/TOF high resolution mass spectrometry was used to survey for metabolites indicative of hydrocarbon degradation. GC x GC-FID analysis indicated that the sand patties contain highly weathered MC252 oil. Analysis of 16S gene sequences indicated that sand patty communities were distinct from those in sand and seawater. Metagenomic analysis revealed the genetic potential for aerobic and anaerobic hydrocarbon degradation via alkane hydroxylases, aromatic oxygenases, benzyl-, and alkylsuccinate synthases. Hydrocarbon-derived metabolites consistent with aerobic and anaerobic processes were also identified in patties (e.g., toluate, benzoate, benzylsuccinates) indicating that degradation occurs in situ, whereas these metabolites were not observed in beach sand. Together, these data suggest the potential for the long-term attenuation and biodegradation of residual MC252 oil.

Molecular Characterization of Organic Indicators of Petroleum Biosouring

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Biosouring, the production of sulfide in petroleum by anaerobic sulfate reducing microorganisms (SRM), is environmentally and epidemiologically hazardous, especially for individuals living in coastal environments such as the Gulf of Mexico. The anaerobic respiration pathway of SRM in petroleum, and whether the activity of SRM could be effectively inhibited using nitrate or perchlorate treatments in confined areas, requires further study. To investigate these processes, we have performed controlled column incubation studies of petroleum saturated sand from an oil reservoir in order to evaluate the activity of SRM in sulfate, nitrate, and perchlorate reducing environments. By using two dimensional gas chromatography with high resolution time-of-flight mass spectrometry coupled to vacuum ultraviolet radiation at the Advanced Light Source at Lawrence Berkeley National Laboratory, detailed chemical characterizations of hydrocarbons from approximately C9-C30 have been completed, separating the

complete oil sample by number of carbon atoms and chemical classes corresponding to petroleum transformations. This recent technological development has never been used to examine microbial processes of organisms utilizing labile petroleum organics. Results demonstrate that the anaerobic pathway of SRM preferentially transforms smaller alkanes and cyclic ring compounds before incorporating a thermodynamically and kinetically favorable fumarate addition to transform heavier polycyclic aromatic hydrocarbons (PAHs) into more easily targeted benzylsuccinate derivatives. This metabolism creates a large number of metabolic products containing either two or four oxygen atoms, in addition to more complex heteroatom containing species. By integrating components of physical chemistry and microbiology, this project aims to aid the development of oil spill remediation policies by understanding the effect of microbial degradation on petroleum. This project also serves to educate the public on the detrimental effect petroleum-based microorganisms can have on coastal environments and human settlements.

Flow through Dog Keys Pass in the Mississippi Barrier Island System

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Direct exchange of freshwater and potential oil and dispersants between the Mississippi Sound (MSS) and the Mississippi Bight (MSB) are primarily limited to flow through 6 different barrier island passes. Dog Keys Pass was measured with bottom mounted ADCPs from Dec. 2011 through Feb. 2012 as part of a renewable energy project. Mean flow was low at approximately 70 m^3/s inflow to the MSS, but one third of the time the actual flow exceeded 1000 m^3/s, reversing with the tides. 85% of the kinetic energy (KE) in the pass was associated with tides with a maximum observed current of 0.92 m/s. The non-tidal component of the flow was also mainly reversing with only 6% of the non-tidal kinetic energy coming from the mean flow and 80% with the depth averaged time varying flow. Surprisingly, even in 6 m of depth, 14% of the non-tidal KE was from depth varying components. In the MSS the percentage of KE associated with tides was only 30%, while the depth varying KE increased to 26% of all KE. CTD casts collected over two days in Dec. 2011 revealed a complex pattern of time varying stratification. Casts done shortly after the outflow (MSS to MSB) show well-mixed waters in the pass and salinity stratified waters in the MSS. Casts done during the beginning of the inflow show highly unstable profiles that are presumably the result of high turbulence. Thus Dog Keys Pass appears to operate both as a freshwater pathway and an effective mixing location between the MSS and MSB.

Observations of Inner Shelf Flows Influenced by a Small-Scale River Plume in the Northern Gulf of Mexico

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Recent work has demonstrated that wind and waves are important forcing mechanisms for the inner shelf vertical current structure. Here, the inner shelf flows are evaluated away from an adjacent inlet where a small-scale buoyant plume emerges. The plume's nearshore extent, speed, vertical thickness, and density are controlled by the passage of low-pressure extratropical cyclones that are common in the northern Gulf of Mexico. The colder, brackish plume water provides vertical stratification and a cross-shore density gradient with the warmer, saline oceanic water. An Acoustic Doppler Current Profiler (ADCP) was deployed in 10m water depth as part of an intensive 2-week experiment (SCOPE), which also

obtained wind and cross-shelf temperature, salinity, and velocity. The 10m ADCP remained collecting an additional year of velocity observations. The plume is not always present, but episodically influences the experiment site. When the plume reached the site, the alongshore surface and subsurface typically flowed in opposite directions, likely caused by plume-induced pressure gradients. Plumes that extended into the subsurface appear to have depth-averaged onshore flow above that expected from wind and wave-driven forcing. Observations from SCOPE and the 1-year ADCP are used to describe seasonal full-depth flow patterns influenced by wind, waves, and plume presence.

Changes in Microbial and Phytoplankton Communities in Response to Oil and Nutrients in the Northern Gulf of Mexico: Correlating Experiments with Field Observations

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Natural hydrocarbon seeps account for around 47% of the oil released into the environment, with seeps in the Gulf of Mexico releasing up to 1.1×108 L oil year-1. Our previous work in the Gulf of Mexico has linked natural hydrocarbon seepage occurring at depths exceeding 1000 meters to elevations in surface and sub-surface chlorophyll concentrations in the upper water column via plume-driven upwelling of nutrient rich waters from depth. Nutrients are also supplied episodically by the offshore extension of the Mississippi River Plume and upwelling events associated with loop-current eddies. Subsequent experiments revealed synergistic impacts of oil, nutrients, and microbial predation on surface microbial growth rates and metabolism - suggesting an additional top-down control on surface bacteria and microbes. We conducted a series of microcosm experiments to explore nutrient limitation of native phytoplankton and bacterial communities in surface waters across a range of offshore habitats in the Northern Gulf of Mexico, including regions influenced by natural seeps. We build on our previous findings with results from these microcosm experiments and highlight the influence of nitrate, phosphate, silica, crude oil, and combinations of these treatments on phytoplankton and bacteria in surface waters. Changes in phytoplankton populations and their physiological state, bacterial growth rates, and the subsequent drawdown of nutrients in these microcosms are presented here in context of field measurements made at natural seeps.

Deep Sea in a Can: Aerobic Methane Oxidation under High Pressure

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Methane was the major component of gaseous hydrocarbons discharged during Deepwater Horizon incident. Instead of rising to the surface, it remained dissolved with other gases and oil in the deep-sea plume. Increase of methane oxidation rates and methane monooxygenase gene abundance and radiocarbon evidence suggested that methane was consumed by bacteria, and transferred into the ocean food web. Despite better understanding of methane fate, methane oxidation rate at high pressure has yet to be investigated. Previous studies showed that high pressure has profound effects on biodegradation of crude oil components. Development of high-pressure reactors equipped with online-monitoring systems for methane will allow studies of aerobic methane oxidation under in situ pressure and temperature in the presence of oil and dispersant reflecting scenarios that happened during the blowout.

Biodegradability of Diluted Bitumen Oil by Kalamazoo River Cultures in Freshwater

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Petroleum products derived from the Canadian oil sands are in limelight due to the proposal of the Keystone pipeline expansion to the Gulf of Mexico and major spills (Kalamazoo, 2010 and Mayflower, 2013). Oil sands are unconventional petroleum deposits made of sand, clay, water and highly viscous bitumen. To make this bitumen transportable, it has to be either upgraded (synthetic crude) or diluted with diluents like naphtha, natural gas condensate, lower hydrocarbons (dilbit) or synthetic crude (synbit). Limited literature is available on the fate of dilbit when it is released to the environment thus, a study was conducted to check the biodegradability of dilbit using two types of dilbit, the Western Canadian Select and the Cold Lake at 5 °C and 25 °C. Tests were run for 60 days at 25 °C and for 72 days at 5 °C using cultures isolated from the Kalamazoo River sediments which were enriched on dilbit at 5 °C (cyro) and 25 °C (meso). The resultant samples for both the oils showed similar trends of biodegradation for alkanes and aromatics on analysis by GC-MS. Alkanes were absolutely degraded at both the temperatures. Nearly complete aromatics removal was observed at 25 °C, while more than 50 % removal was achieved at 5 °C. Also, a reduction in the hopane concentration was observed at 25 °C whereas at 5 °C the hopane concentration remained constant. Results of this study will contribute to understand and model the behavior of dilbit when it is exposed to the environment.

Deep Sea in a Can: Changes of the Hydrocarbon Degrading Community under High Pressure

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Up to 25% of the hydrocarbons spilled into the Gulf of Mexico were presumably consumed by microorganisms. The composition of a persistent plume between 900-1300 m depth was characterized by high concentrations of polycyclic aromatic hydrocarbons (PAHs), medium length alkanes, methane and other gases. Further oxygen anomalies were detected which are believed to result from oxidative processes caused by the indigenous microbial community. Field observations detected ecological succession in the bacterial community according to physical-chemical conditions and the evolution of the oil composition, mainly through blooms of genera such as DWH *Oceanospirillales spp*., *Cycloclasticus spp*., *Colwellia spp*. or *Methylomonas spp*. Most recent lab-based research to investigate microbial hydrocarbon degradation under deep sea conditions neglected the impact of elevated pressure on microbial performance. Incubation experiments at according pressure will allow us to investigate degradation rates and community changes ex situ and obtain a better insight into conditions leading to successive blooms during hydrocarbon degradation.

Exploring Microbial and Hydrocarbon Dynamics along a Surface Transect of a Persistent Oil Slick at Taylor Energy

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Oil in surface slicks is subject to a variety of weathering processes, including photo-oxidation, evaporation, and biodegradation. The oil slick sourced from the site of the sunken Taylor Energy platform 23051, located 11 miles southeast of the mouth of the Mississippi River, offers investigators a unique opportunity to explore the co-evolution of oil and microbial communities at the sea surface in an oil-impacted setting. Chemical dispersants were originally designed to expedite biodegradation in surface oil spills, but their impact on the hydrocarbon degrading community and activity in the surface remains poorly constrained. Using microcosm incubations of surface water from 4 sites along a transect at the Taylor site surface slick, we explored how the addition of nutrients, of Corexit 9500, and the joint addition of nutrients and Corexit 9500 altered the microbial community and hydrocarbon degradation rates. We evaluated oil biodegradation efficiency by measuring turnover of radiolabeled hexadecane and naphthalene to carbon dioxide, and further assessment of the incubations through cell counts, nutrient, DOC, and extractable hydrocarbon profiles. We observed temporal and site specific variations in the turnover of naphthalene and hexadecane, with the in situ percent turnover/day of both hexadecane and naphthalene highest at the site farthest away from the leaking source. Our current results indicate that the surface slick is a dynamic system that exhibits varying responses to nutrients and dispersant additions.

Drifter Observations of an Ebb Tidal Plume Dispersion and Circulation in a Critical Estuary-Shelf Environment, Main Pass, Mobile, AL

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An ongoing research effort, the Consortium for Oil Spill Exposure Pathways in Coastal River Dominated Ecosystems (CONCORD) is investigating the influence of offshore oil spills on ecosystems dominated by pulse driven fluvial plumes in coastal systems. Tidal inlets, separating barrier islands, are common throughout the Northern Gulf of Mexico and often exhibit discharge plumes that deliver pulses of buoyancy, nutrients, and sediments to the adjacent coastal zone. These tidal inlet exchanges have a major impact on the overall fate of the material transported to the shelf. In order to better understand the circulation patterns at these critical estuarine-shelf interfaces, a Lagrangian experiment was conducted using surface drifters during the Fall of 2015. It quantified the flow patterns associated with the ebb tidal plume exiting from Mobile Bay, a major source of river discharge to the Mississippi Bight. Each "Davis Drifter" included GPS, conductivity, and temperature measurements, and was deployed with consistent temporal and spatial intervals at the mouth of the bay on ebb tides under light wind conditions for 6-24 hours. The drifters experienced significant dispersion after passing through an ebb-flow delta system. At the mouth, maximum speeds of 1.3 m s-1 were observed by the drifters along the thalweg of the shipping channel and the ebb tidal front extended approximately 15 km offshore. The flow trajectories were asymmetric, favoring the downshelf westward direction which was consistent with the intermediate Kelvin Number, O(0.5-1.0). This suggests that under low discharge conditions Coriolis forcing is important to the ebb flow dispersion at the mouth. Additional drifter releases are being conducted through the fall of 2015 and other analyses of the flow structure of the near-field plume are under way. The study is expected to characterize the dispersion patterns and salt

entrainment of the near-field under a wide range of environmental conditions. The findings from this study will significantly enhance our ability to respond and mitigate spill events like the Deepwater Horizon release in 2010.

Temperature, Salinity, Mixing, and Plankton Variability East of the Mississippi Delta in Autumn

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The shelf-break region to the east of the Mississippi Delta at the southwestern corner of the Mississippi Bight has been shown in numerical models to be an important pathway for offshore waters to enter the Bight. As shown by remote sensing of chl-a concentrations, this region is also a preferred pathway for episodic eastward excursions of the Mississippi River plume. Additionally, the broader Mississippi Bight region is impacted from the Mobile Bay outflow and from numerous smaller rivers, creating an area of complex three-dimensional physical oceanography interactions that vary quickly in time. The southwestern shelf break could potentially serve at different times both as a barrier or entryway for oil and dispersant system that could come from offshore or from the numerous nearby oil wells. As part of the CONCORDE effort we instrumented this area with five line moorings capable of quantifying mixing using χ-pods instruments equipped with fast thermistors and pitot tubes. The χ-pods are complimented by several other instruments on the line, measuring temperature and salinity variations. Nearby are bottom moorings with Acoustic Doppler Current Profilers that measure current fluctuations throughout the water column that will be recovered this spring. Surveys with a LIDAR, tow-yo CTD, and digital plankton imager were done in and around this “mixing” array in November 2015. Here we present the first preliminary results from these surveys and the recovered line moorings.

Quantifying Initial and Wind Forcing Uncertainties in Forecasts of the Gulf of Mexico Circulation

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This study presents a methodology to quantify the impacts of uncertainties in initial conditions and wind forcing on HYCOM forecasts of the circulation in the Gulf of Mexico using Polynomial Chaos Expansions (PCE). The uncertain input variables are the amplitude of variability modes identified using an Empirical Orthogonal Function decomposition of the model variable and its wind forcing. HYCOM is used to propagate the input uncertainties to output uncertainties via an efficient sampling of the uncertainty space. This sampling ensemble is used to build PCE surrogates for both localized and global Quantities of Interest, namely sea surface height and mixed layer depth. These PCE surrogates are constructed using a basis pursuit denoising method to filter model noise; their performance is assessed through various statistical measures. A global sensitivity analysis is then performed to quantify the contributions due individual uncertainty sources, as well as those due to their interactions, to output uncertainties. The analysis indicates that whereas local quantities can exhibit complex behavior that necessitates a large number of realizations, the modal analysis of field sensitivities can be suitably achieved with a moderate size ensemble.

The Physiological Resiliency of Marine Fish and Invertebrates following Oil Exposure

OXPHOS Capacity in Mahi-Mahi (*Coryphaena hippurus*) and Sheepshead Minnows (*Cyprinodon variegatus variegatus*) after Crude Oil Exposure

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Polycyclic aromatic hydrocarbons (PAHs) are a toxic component of crude oil and previous studies indicate that there is potential for impaired cardiac function after oil exposure. One marker of impaired cardiac function is abnormal mitochondrial respiration or OXPHOS (oxidative phosphorylation) capacity, which will be measured on an OROBOROS Oxygraph-2k high-resolution respirometer (OROBOROS Instruments, Austria). Preliminary OXPHOS data has been collected from permeabilized cardiac fibers of 0h, 24h, and 48h (n = 1 respectively) crude oil-exposed (10% solution) sheepshead minnows (*Cyprinodon variegatus variegatus*). OXPHOS capacity in complexes II-IV was decreased 5-fold at 24 hours and 14-fold at 48 hours of oil exposure, suggesting impaired cardiac function. This technique will be expanded upon and utilized in other fish species to determine cardiac recovery potential after oil exposure. Study is supported by the GoMRI RECOVER Consortium to M.G, A. R., and D.C.

Evaluation of DWHOS Ecosystem Impacts using an Atlantis Biogeochemical Model

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We present a revised application of the Gulf of Mexico Atlantis model developed for the CIMAGE consortium to examine ecosystem-level impacts of the Deepwater Horizon oil spill. Model training uses a historical reconstruction from 1980 to 2010 driven by time series of catch and spatial-temporal fishing restrictions. Forecasts from 2010 to 2030 examine ecological and economic impacts of the oil spill. Oil location and density is provided by a coupled Lagrangian particle transport model, while toxicological studies inform the functional responses used to model growth and mortality impacts on fish. Recent improvements in methodology include use of an uptake-depuration model and an examination of larvae-oil interactions to represent recruitment effects based on SEAMAP Ichthyoplankton surveys and surface oil observations. We estimate recovery time and present evidence for trophic cascades and fisheries losses. A new Campeche Bay Atlantis model in development for CIMAGE II will examine the 1979 IXTOC oil spill as an analog to Deepwater Horizon.

Combined Effects of Deepwater Horizon Crude Oil Exposure, Temperature and Developmental Stage on Oxygen Consumption of Embryonic and Larval Mahi-mahi

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The timing and location of the 2010 Deepwater Horizon (DWH) incident within the Gulf of Mexico pelagic zone likely resulted in exposure of commercially and ecologically important fish species, such as mahi-mahi (*Coryphaena hippurus*) during the sensitive early life stages. Previous research has shown that oil exposure during the embryonic stage of large predatory pelagic fish reduces cardiac function - a particularly important trait for fast-swimming predators with high aerobic demands. However, it is

unclear whether reductions in cardiac function translate into impacts on oxygen consumption in these developing embryos and larvae. A 24-channel optical fluorescence oxygen sensing system for high through-put respiration measurements is employed to investigate the individual and combined effects of oil exposure, temperature and developmental stage on oxygen consumption rates in embryonic and larval mahi-mahi. Yolk sac larvae pre-exposed to 4-8% DWH oil for 24 hours post-fertilization exhibit significantly higher oxygen consumption rates than larvae raised in clean seawater, potentially indicating stress and faster yolk depletion. Larvae raised in 30 ^{o}C seawater develop and consume oxygen significantly faster than larvae raised in 26 ^{o}C pointing to synergistic effects of elevated temperature and oil exposure. Future directions include exploring such synergistic effects on oxygen consumption and nitrogenous waste excretion in developing embryos and larvae of mahi-mahi. Acknowledgements: We would like to acknowledge and thank our funding source, Gulf of Mexico Research Initiative (GOMRI).

Hemodynamics throughout Recovery from Polycyclic Aromatic Hydrocarbon Exposure in Juvenile Mahi-Mahi (*Coryphaena hippurus*)

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The polycyclic aromatic hydrocarbons (PAHs) contained in oil can have deleterious effect on animal biology and can lead to physiological disruptions but the potential for recovery is unknown. Prior studies have shown that embryonic and juvenile Mahi-Mahi (*Coryphaeus hippurus*) exposure to PAHs exhibit morphological abnormalities, altered cardiac development and reduced swimming performance. The goal of this project is to extend these investigations in the juvenile phase of life and evaluate the cardiovascular consequences of acute PAHs exposure in Mahi-Mahi. In this study we applied in-vivo techniques to measure cardiac output, stroke work, and electro-cardio gram (ECG). The parameters will be measured in control and oil exposed juvenile Mahi-Mahi during different conditions: at rest, during exercise and after a period of recovery from PAHs exposure. We hypothesize that oil exposed juvenile Mahi-Mahi will have decrease cardiac output and cardiac stroke work. To test this hypothesis we will unitize a conductance catheter (Scisense ADVantage) inserted directly into the ventricle of an anesthetized animal. To verify volume output of the heart absolute flow will also be quantified using a transit time blood flow system. Our preliminary data on cobia (*Rachycentron canadum*) indicate a positive correlation between fish mass and stroke volume. In addition using the conductance pressure volume catheter we determined there was a similar positive correlation between cardiac stroke work and fish mass. Our findings suggest the Scisense ADVantage can be used to produce novel data regarding the functional response of the fish cardiovascular system to PAHs exposure. Study is conducted with funding provided by the Gulf of Mexico Research Initiative.

Effects of 2- and 6-hydroxylated Chrysene on the Development of *Danio rerio* Embryos

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Oil spills are one of the primary sources of polycyclic aromatic hydrocarbons (PAHs) in marine environments. They are subject to biotic and abiotic weathering that can alter their physical and chemical characteristics. PAHs can undergo photochemical oxidation forming oxygenated photoproducts that can have severe effects on marine life and the environment. Among the PAHs found in crude oil, chrysene is one of the most persistent in the water column and can undergo photo-oxidation to produce oxygenated derivatives such as 2-hydroxychrysene and 6-hydroxychrysene. Both of

which have been shown to have estrogenic effects that can potentially disrupt estrogen-signaling pathways important during development. To evaluate this, *Danio rerio* embryos (2 hpf) were exposed to 2- and 6-hydroxychrysene separately for 74 hours under controlled laboratory conditions. Embryos were treated with several concentrations of 2-hydroxychrysene (0.1 µM, 0.5 µM, 1 µM, 2 µM, 5 µM) and 6 - hydroxychrysene (0.5 µM, 3 µM, 5 µM, 8 µM) to determine percent survival and the occurrence of deformities. Our data show no significant difference in mortality after exposure to 2-hydroxychrysene at 76hpf; however, there was a significant decrease in the survival of the larvae, 4 days after treatment. There was also a significant increase in the percentage of cardiac deformities observed, 34 ±20.1%, 62 ±29.2%, 92 ±14.1% and 97 ± 5.44%, after exposure to 0.5, 1, 2, and 5µM of 2-hydroxychrysene, respectively. When embryos were treated with 3 µM of 6-hydroxychrysene the percent survival was 65 ±3.9% at 76hpf. The occurrence of cardiac deformities was also significantly higher after treatment with 6-hydroxychrysene compared to the control group. After exposure to 3 µM, 5 µM and 8 µM of 6-hydroxychrysene, the percentages of cardiac deformities were 61 ±19.4%, 68 ±17.4% and 67 ±17.1% respectively. These studies show for the first time the regioselective impacts of hydroxylated PAHs on cardiac development and survival of fish embryos. Our findings raise the need to identify mechanisms that are involved in the toxicity of these compounds to assess the potential risks of oil spills on fish populations. This research was made possible in part by a grant from The Gulf of Mexico Research Initiative to the RECOVER Consortium, and in part by CAPES/INCT-TA and CNPq.

Molecular Characterization of Antioxidant Response in Mahi Mahi (*Coryphaena hippurus*) Embryos Co-exposed to Oil and Ultraviolet Radiation

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The Deepwater Horizon spill between April and July 2010 released millions of barrels of oil into the Gulf of Mexico at peak spawning periods of commercially important fishes, such as the mahi mahi (*Coryphaena hippurus*). Polycyclic aromatic hydrocarbons (PAHs) present in the oil have been shown to cause adverse health effects to fish and this toxicity may be enhanced by co-exposure to ultraviolet (UV) radiation. Photo-enhanced toxicity of PAHs results in increased production of reactive oxygen species. In this study, mahi mahi embryos were exposed to high energy water accommodated fractions (HEWAFs) of source oil A (SOA), source oil B (SOB), and Massachusetts source oil (MASS) for 48-h. Embryos were co-exposed to UV radiation at 7-hpf for 8-h, and 27-hpf for 8-h, with hatching success documented at 48-h. Expression of several genes involved in antioxidant response (glutathione peroxidase, glutathione s-transferase, catalase, superoxide dismutase) were measured using qPCR. The results of this study will help provide further information on the mechanisms by which photo-enhanced toxicity exerts effects on early lifestage fishes. Funding for this research was provided by GoMRI.

Foraging Behavior and Predator Prey Interactions of Mahi Mahi (*Coryphaena hippurus*) Exposed to Crude Oil from the Deep Water Horizon Event

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During the Deep Water Horizon event in 2010 approximately 4 million barrels of crude oil were spilled into the northern Gulf of Mexico overlapping with the spawning habitat of many ecologically and commercially important species of pelagic fishes, including Mahi Mahi (*Coryphaena hippurus*). Recent

research has shown that fish exposed to sub-lethal concentrations of crude oil during embryonic and larval stages develop cardiac arrhythmias, abnormal cardiac morphology, and reduced swimming efficiency. The effects of oil exposure on juvenile and adult stages, however, remain largely unexplored. We hypothesize that a reduction in swimming efficiency that occurs as a result of oil exposure will have downstream effects on the ability of juvenile Mahi Mahi to find, capture, and consume prey, however our early results have shown no difference in the number of prey consumed over a short time period between oil exposed and control Mahi Mahi. We are currently testing how exposure to crude oil affects the routine foraging behavior and response to prey and predator cues in juvenile Mahi Mahi by measuring the distance travelled, maximum speed, and directionality during foraging and in response to prey and predator cues. We expect that our results will show fine-scale differences between oil exposed and controls in the hunting and predator avoidance efficiency of Mahi Mahi that were not apparent in the gross comparison of prey consumed. This work is funded by the Gulf of Mexico Research Initiative.

An Evaluation of Mortality and Burrowing Behavior of Fiddler Crabs (*Uca* sp.) in Response to Exposure to Petroleum Hydrocarbons

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Oil spills such as those associated with the Deepwater Horizon incident often have an impact on intertidal zone communities. Organisms inhabiting these areas, such as fiddler crabs in the genus *Uca*, are good indicators of the ecological status of such ecosystems. Their burrowing and feeding activities may influence the distribution of oxygen and other nutrients making them bioavailable for other organisms. Furthermore, burrowing may have an effect on the fate of the spilled oil by moving contaminated sediment and by changing conditions for microbial biodegradation of the oil. Therefore, this study assesses the impact of petroleum hydrocarbons on mortality and bioturbation behavior of fiddler crabs. Toxicity and bioturbation experiments are conducted in greenhouse microcosms with oil deposited on the sediment surface. Crabs are placed in aquaria filled with sediment from their collection site and exposed to petroleum hydrocarbons for 14 to 21 days. Variables being analyzed include mortality (LC50) and changes in burrowing activity. The latter will be determined with the use of luminophores, which are initially placed on the sediment surface and their sediment depth distribution is determined at the end of the experiment. Results will provide information that can aid in onsite assessments of oil spill ecological impacts and of the success of remediation and restoration efforts for the intertidal zone.

Influence of Hypoxia on Biochemical and Cellular Responses of Sheepshead Minnow Larvae (*Cyprinodon variegatus*) Exposed to Oil Spill Contaminants

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Hypoxia represents a potential co-stressor to chemical exposures, yet comparatively little is known about the combined effects of oil and hypoxia. To address this we examined the influence of hypoxia on toxicity of physically or chemically dispersed oil. Sheepshead minnow (*Cyprinodon variegatus*) larvae were exposed to undispersed (WAF) and chemically dispersed (CEWAF) Southern Louisiana Crude oil, as well the dispersant Corexit 9500 under normoxic and hypoxic (~2mg/L O2) conditions. Early work demonstrated hypoxia more than doubled mortality observed under normoxic conditions in response to CEWAF and Corexit 9500 (Dasgupta *et al*. 2015, 10.1371/journal.pone.0128939). In this study we

assessed CYP1A expression, antioxidant parameters and genotoxicity in larvae. Under normoxic conditions, WAF and CEWAF significantly induced CYP1A expression, but the induction was ameliorated under hypoxia, indicating downregulation of this important defense system. CEWAF-mediated induction of antioxidant enzymes under both normoxic and hypoxic conditions indicates they are still able to handle some level of oxidative stress even under hypoxic conditions. Measurement of whole-larvae genotoxicity using the Comet Assay showed that hypoxia significantly enhanced DNA damage in both WAF and CEWAF treatments, indicating that DNA may be an important cellular target. Further work will attempt to examine other pathways associated with hypoxia enhanced oil toxicity and adaptation.

Effects of Acute Crude Oil Exposure on Growth and Survival of Two Life Stages of the Blue Crab, *Callinectes sapidus*

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Blue crabs, *Callinectes sapidus*, begin their larval (zoeal) phase offshore and circulate for approximately 30 days before settling near shore. As crabs transition to the juvenile stage, they move into estuary environments with lower salinity. In the northern Gulf of Mexico during the Deepwater Horizon spill, oil was released offshore with some reaching the coastline - thus both larvae and juveniles may have encountered oil. This study investigates the effects of acute oil exposure on growth and molting frequency at both life stages. Larvae showed resiliency under oil exposure with no change in survival or condition whereas juveniles showed greater mortality when exposed to oil as well as longer intermolt duration. The health and growth of the larvae and juveniles has implications for the next life history stage as well as for the population at large. This research relates directly to the economically important coastal blue crab fishery of Louisiana. In a dynamic coastal environment, the impact of pollutants and changing climate will be varied and hard to predict.

Exposure to Deepwater Horizon Oil in Sediment Inhibited Growth in Juvenile Red Drum and Pacific White Shrimp

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In support of the Deepwater Horizon (DWH) Natural Resource Damage Assessment, we exposed juvenile (21 days post-fertilization) red drum (*Sciaenops ocellatus*) and post-larval Pacific white shrimp (*Litopenaeus vannamei*) to sediment spiked with DWH oil. We initiated these tests simultaneously using identical sediment prepared with naturally weathered DWH oil and identical flow-through exposure systems. We exposed juvenile red drum for 13 days and Pacific white shrimp for 6 days. Exposure to DWH oil in sediment inhibited growth in both species. We will present the results of these bioassays and compare them to growth- inhibition effects we observed in similar bioassays that we conducted with amphipods (*Leptocheirus plumulosus*) and southern flounder (*Paralichthys lethostigma*) using sediment spiked with DWH oil.

Applications of Research in Oil Spill Transport, Fate and Effects Modeling for Decision Support and Ecosystem Services

Drop Dissolution and Stabilization in the Water Column
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The paper will describe the mass exchange processes between an oil drop and the surrounding ocean water. These processes are greatly enhanced by the rising of the drop and by the water turbulence. Characteristic time scales for the exchange of mass will be determined from a simple analytical model and supported by direct numerical simulations. Due to the gradual dissolution of the lighter oil components as the drops rise, their density slowly increases until it becomes equal to that of the surrounding water, at which point the rising motion stops and the drops remain trapped. From the rise velocity and the time scales for the mass exchange it is possible to estimate the depth at which the drops stabilize, which can be compared with experimental data.

Improving the Efficiency of Hazardous Spill Cleanup Efforts Using in situ Drifter Observations
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Contaminants on the ocean surface will be coalesced in some places and dispersed in others. Knowing the locations of higher material density can improve the efficiency of clean-up efforts, lowering both the environmental impact and the cost of remediation. This research focuses on using high numbers of in situ drifter observations to find convergent areas where material density is high. An observation system capability will be a function of the spacing between drifters as well as time. Once drifters are placed, the deformation of the array will degrade the capability to map convergent areas. Thus we must know the accuracy to which an array can measure the ocean as a function of time past deployment. Since the underlying ocean conditions may span a large range, sufficient statistical information on performance must be constructed over many deployments. To approach the problem, we turn to experiments using numerical ocean models. The time evolution of simulated drifter positions is determined using 3 years of velocity fields taken from a 1km NCOM model run over the Gulf of Mexico. Deployment grids of 16x16 drifters are placed in to the ocean currents and evolved over 10 days. This provides a set of over 400 deployments spanning many different ocean events to quantify the observation system capability. The primary deformation quantities obtained from the drifters are surface divergence (which relates to the coalescing of material), vorticity, stretch rate and shear rate, which are the four kinematic properties. To estimate these, at each point in time, drifters are clustered together according to their proximity to one another and these clusters are used to create first order estimates of velocity gradients at the cluster center point. The gradients are then converted to divergence, vorticity, shear and stretch. Current results show that the accuracy of these estimates degrades as drifter deployments are pulled apart. Very close initial spacing of drifters produces reasonable estimates for 4-5 days. This degrades rapidly as spacing increases. The results imply the time interval over which the observation system remains viable and after which additional drifters may need to be deployed.

Numerical Circulation Model Skill Assessment from Observed Deepwater Currents over 2 Years on the Continental Slope near the Macondo Spill Site

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The Gulf Integrated Spill Research (GISR) Consortia deployed an array of six deepwater moorings on the DeSoto Slope and Mississippi Canyon Region from July 2012 to July 2014. Each mooring consisted of an upward looking 75kHz ADCP in the upper 1000 meters, three deep current meters from 15m above the bottom and spaced ~200m apart, as well as numerous sensors for temperature and salinity. The purpose of the GISR mooring array was to characterize variability along the slope in support of both near field plume modeling and a deep tracer release experiment. We compare the observational estimates from the mooring array to those predicted from a coupled ocean-atmosphere numerical circulation model of the Gulf of Mexico for July 2012 through July 2013; this corresponds to the first 13 months the mooring array was deployed. The comparison will include both the relative accuracy of the model in time, as well as long term statistics and means for the region. We report variability and transport estimates for volume, mass, and nutrients (using hydrography); as well as the model's predictive capabilities within different portions of the water column in close proximity to the Macondo spill site. We place special focus on the model's abilities in the midwater depths where the methane plume observed during the oil spill.

The Influence of Spatial and Temporal Resolutions of Hydrodynamic Model on the Deepwater Oil Spill Model predictions: Case Study Using OSCAR

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Increased oil and gas activity raises the risk of marine oil spills, which is of significant concern because of the potentially devastating environmental effects. The recent Deepwater Horizon disaster has shown that spills in the deep-water environment present extremely difficult response logistics; hence, it is vital that a reliable oil spill model be available to predict the trajectory of oil and delineate the allocation of limited response resources. Although there are many models have been developed for this purpose and only very few of them are full three-dimensional models which can predict both the near field oil plumes and far field trajectory and oil weathering processes. To employ such as a model to predict the fate/behaviour and evaluate potential environmental impacts from deepwater oil spills, it is important to know the sensitivity of model to different model parameters and inputs. Although there are sensitivity studies of oil spill models to selected model parameters such as particle number, spreading coefficient etc., there lacks information on the effects of spatial and temporal resolutions of hydrodynamic models on the model predictions. In this study, a fully 3D deepwater oil spill model OSCAR was employed to predict the oil transport behaviours from a hypothetical spill on Scotia Slope at 1700m depth. The model was forced by three hydrodynamics models: 1) HYCOM 1/12o, Time Step= 24 hrs, 2) NEMO 1/12o, Time Step= 24 hrs, and 3) NEMO 1/12o, Time Step= 1hr, to study the effects of spatial and temporal resolutions on potential surface, water column, and shoreline oil contaminations. The results show that the spatial resolution has more significant effects on the prediction that temporal resolution. The effects are more significant for shoreline contamination than for water column and surface contamination. The model results also demonstrated that although particle numbers are less important for prediction of surface and water column contamination, it does have significant impacts on the overall shoreline contamination.

Sun Glint Requirement for the Remote Detection of Surface Oil Films

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Optical remote sensing images under sun glint have been shown to be capable of detecting oil slicks on the ocean surface, yet it has never been quantified what sun glint strength is required for such detections. Here, oil slicks from natural seeps in the western Gulf of Mexico (GoM) are used to determine the sun glint threshold required for oil film detections. The threshold is determined using the same-day image pairs collected by MODIS Terra (MODIST), MODIS Aqua (MODISA), and VIIRS over the same oil slick locations where at least one of the sensors captures the oil slicks. For each sensor, statistics of sun glint strengths, represented by the normalized glint reflectance (Lgn, sr-1), when oil slicks can and cannot be observed is generated. The Lgn threshold for oil film detections is determined to be 10-5-10-6 sr-1 for MODIST and MODISA, and 10-6-10-7 sr-1 for VIIRS. Below these thresholds, no oil films can be detected, while above these thresholds oil films can always be detected except near the critical-angle zone where oil slicks reverse their contrast against the background water.

Numerical Simulation of Oil Biodegradation and Bioremediation in a Tidally-influenced Sand Beach

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The aerobic biodegradation and bioremediation of oil in tidally influenced beaches were investigated numerically in this work using realistic beach and tide conditions from Gulf of Mexico. A numerical model BIOMARUN, coupling a multiple-Monod kinetic model BIOB to a density-dependent variably saturated groundwater flow model 2-D MARUN, was used to simulate the biodegradation of low-solubility hydrocarbon and transport processes of associated solute species (i.e., oxygen and nitrogen) in a tidally influenced beach environment. It was found that different limiting factors affect different portions of the beach. In the upper intertidal zone, where the inland incoming nutrient concentration was large (1.2 mg N/L), natural attenuation of oil occurred deeper in the beach (i.e., 0.3 m below the surface). In the midintertidal zone, a reversal was noted where the natural attenuation was fast at shallow locations (i.e., 0.1 m below the surface), and it was due to the decrease of oxygen with depth due to consumption, which made oxygen the limiting factor for biodegradation. Bioremediation was numerically conducted through the application of a solution containing nutrient at concentrations larger than the background, and oxygen concentration in equilibrium with the atmosphere to enhance the biodegradation of low solubility hydrocarbons. The application was assumed to occur onto the upper intertidal zone of the beach. It was found that, compared to natural attenuation, bioremediation increased the concentration of nutrient and oxygen in the oiled zone thereby promoting subsurface oil removal efficiency. While the increase in nutrient concentration is expected, the increase in oxygen concentration was found necessary for efficient oil biodegradation. This means that increasing the nutrient concentration in the applied solution might not enhance oil biodegradation as the oxygen might become the limiting compound. Biochemical retention time map (BRTM) showed that extending the solution application period would increase the residence time of high nutrient solution in the beach, and would increase the subsurface space occupied by the a high nutrient plume. Simulation results revealed a complex interaction between the applied solutions and the tidally driven seawater-groundwater dynamics within the beach.

The Effect of Pressure and Viscosity on Oil-in-Water Droplet Size Distributions

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The dispersion of hydrocarbon droplets in the water column has been identified as a critical parameter in predicting when and where crude oil will surface following a deepwater blowout. In recent years, several studies have identified the importance of oil density and viscosity in predicting the droplet size distribution. Under high confining pressures, natural gas components will preferentially solubilise in the liquid hydrocarbon phase, thereby decreasing the effective density of the phase. There are limited data in the literature to describe droplet size from ambient to high-pressure conditions up to 100 bar, which limit the validation potential of droplet size models. In this study, we present a comprehensive study of multiple crude oils, where droplet size distributions were captured at 4 °C and methane pressures of 1 to 100 bar; live oil density was estimated based on dissolved gas content, and live oil viscosity was measured directly on a controlled stress rheometer. For each system, oil-in-water droplet size distributions were measured visually using a high-pressure sapphire visual autoclave, where a turbulent shear field was generated using a magnetically-coupled, vane-and-baffle impeller. The results are compared to published models for oil-in-water mean droplet size, to compare the dependence of each model on the physical properties of the water and oil phases. The data provide a benchmarking capability for the development of future near-field plume models, to address the distributed range of pressure and viscosity conditions likely to be encountered in the field.

Numerical Methods to Estimate Near-Field Turbulence in Deepwater Blowout

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In the wake of the Deepwater Horizon incident, many laboratory apparatus have been constructed to investigate the dispersion of crude oil in the water column. These efforts have produced estimates of both oil density and droplet size distribution within the plume, which are thought to provide a representative laboratory estimate to describe field-scale systems. The scaling of droplet size results from laboratory to field requires an understanding of how turbulence operates on these two very unique length-scales, which is not well-behaved. To develop a stronger understanding of this turbulence scaling, simple axisymmetric models for the deepwater plume were constructed in Ansys Fluent 14, where a single pseudo-component hydrocarbon phase was ejected into a continuous phase of water under high-pressure conditions. Model parameters were varied to study the effect of hydrocarbon phase density and viscosity, ejection velocity, and ejection nozzle tip diameter. The results provide a context for evaluating a variety of turbulent scaling parameters, including dimensionless Reynolds and Weber numbers.

Volume and Area Time Series of DWH Surface Oil: Comparison of Modeling and Remote Sensing Results

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The magnitude and distribution of surface oil released during the DWH discharge was simulated with SINTEF's OSCAR model on the basis of published flow rates and release points, which changed at

different stages of the response effort. From the 22nd of April 2010 to the 3rd of June, when the riser was cut, we simulated the release of a total of 9000 m3/d of oil through two release sites: one from the broken riser end and the other representing kinks in the pipe above the blowout preventer. The number of 9000 m3/d represents an average between the estimated 63k barrels per day (PBD) at the beginning of the release and 53k BPD when the riser was cut. The 9000 m3 were divided between 2340 m3 from the kinks and 6660 m3 from the broken riser end, where the fractionation is obtained from estimates of the flow rates from these two sites by in situ measurements. After the broken riser was cut on June 3rd, a single release site was formed, and some oil started being collected at the source. Subsea dispersants had already been applied, but could now be focused to a single source. The oil spill was simulated until the 20th of August, after the well had been capped. The composition and weathering characteristics of the oil used in the simulation is based on weathering studies of the Macondo crude. Two separate simulations were completed: one with and one without subsea application of dispersant into the discharge plume; dispersant application amounts and injection points taken from the discharge documentation. The currents used in the simulation were from the HYCOM Gulf of Mexico 1/25° (GOMl0.04) model, obtained from hycom.org (https://hycom.org/dataserver/gom-analysis, experiment 31.0). The wind data was obtained with the COAMPS model. Results were compiled in an array of 5x5km gird cells covering the entire area where surface oil was observed. Comparing the distribution map revealed discrepancies in the composite footprints of the OSCAR simulation versus surface oil detected in satellite (SAR) images. However, the time-series of daily totals for surface oil volume, mass, and area in the with-dispersant simulation showed better general agreement with satellite results than did the without dispersant simulation. This underscores the respective effects of environmental factors and dispersant controlling the fate of surface oil.

Predicting (Natural and Chemical) Dispersion of Floating Oil

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The decision to apply chemical dispersants on surface oil slicks involves a trade-off between the effects of oil on the water surface and the effects of oil in the water column (dispersed). The effects of dispersed oil are still under investigation and under debate. A crucial variable to be considered is the NET effectiveness of the dispersants: *What volume of oil will disperse naturally? What volume of oil will additionally disperse due to application of dispersants?* This NET effectiveness will provide the basis to infer the NET (environmental) effects and whether this response can be considered beneficial.

In order to assess the NET effectiveness in an actual spill situation, there is a need for an improved surface oil dispersion algorithm. Such algorithm should predict both natural and chemical dispersion based on input parameters that are readily available to spill responders.

We propose to build this algorithm based on a fundamental understanding of the processes necessary for dispersion of surface oil. The effect of known key parameters for dispersion on these separate processes is investigated from literature data or from experiments.

Animal Oil/Dispersant Exposure Trials Post-Deepwater Horizon: Design, Analysis and Interpretation of Results

Mercury Found in MC252 & CWAF Depleted MC252 Can Be Transmitted through the American Alligator Eggshell to the Embryo

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The American alligator (*Alligator mississippiensis*) is an ideal bio-accumulating and bio-concentrating sentinel species. It is a long-lived top predator with high location fidelity, endemic to the coastal wetlands of Southeastern United States (North Carolina to Texas). Anthropogenic contaminants, including coastal oil spills present a threat to these sentinels and their ecosystem. This is especially the case for heavy metals such as mercury, which has known potent and deleterious impacts on human and wildlife development. Here, we measured the total mercury fraction of MC252 oil, COREXIT water accommodated MC252 oil (CWAF), CWAF-depleted MC252, and standard cell culture media (the aqueous 'water' portion of CWAF). We find that both MC252 and CWAF-depleted MC252 have concentrations of mercury above the limits of our detection (2.9 ± 2.1 ng/g, 6.8 ± 4.4 ng/g, respectively) and, within the range of concentrations that have previously been shown to elicit deleterious effects on developing organisms (5-10ng/g). We next asked whether transmission of mercury occurs through the alligator eggshell. We applied varying doses of methylmercury to the outside of the eggshell (5ng/g, 96ng/g, and 375ng/g (mercury solution/egg mass)) and determined that a greater proportion of lower doses of mercury transited through the chorioallantoic membrane into the embryo after 14 days, but the higher doses transited faster, and may more profoundly influence early stages of development. We will present data comparing mercury transmission of MC252 oil and CWAF-depleted MC252 oil and their impacts on alligator development as well as an eggshell pore density comparison used to determine the variability within and between nests. This study lends insight into to the potential added risk of mercury from oil spills impacting developing alligator and other wildlife embryos, and possibly impacting the human population of this important coastal wetland.

Design and Testing of a Novel System for Producing Weathered Oil

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Toxicology studies concerning the 2010 Deepwater Horizon (DWH) oil spill have largely relied either on oil collected from the wellhead or naturally weathered oil slicks collected from the Gulf of Mexico. Because the weathering process significantly alters the composition and concentration of toxic constituents in oil, such as polycyclic aromatic hydrocarbons (PAHs), researchers may prefer conducting tests with weathered oil. To increase the amount of available weathered DWH oil, we developed an artificial weathering process, using commercially available components, which mimicked the natural weathering process and which allowed researchers to quickly and easily produce weathered oil for a variety of uses. The weathering process was conducted outdoors to accurately capture the effects of cloud cover, wind, and natural sunlight, and used aquarium wave generators to mimic wave mechanics. Acrylic that was transparent to ultraviolet light was placed over the framework to prevent wildlife and rain water from disturbing the weathering process. This procedure was successful in producing oil samples with a range of weathering states similar to DWH samples taken from the Gulf in the summer of 2010. Time-series analyses showed that the total PAH depletion relative to hopane increased from 0% at test initiation to 79% by the end of the test, six weeks later. The primary loss was in the lower molecular

weight PAH components. The weathering process we developed allows researchers to produce a range of weathered oils that can be tailored to different research goals.

The Effects of the Deepwater Horizon Oil Spill on Blue Crab Embryos

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Blue crabs (*Callinectes sapidus*) are ubiquitous along the east coast; however, they play a particularly integral role in the Gulf of Mexico (GOM), where, not only are they a keystone species, but they are also socioeconomically important. The survival of embryos is necessary to insure adequate recruitment into the next generation. Because the Deepwater Horizon oil spill occurred during the peak of the blue crab spawning season, the incident likely impacted blue crab embryos. This study was conducted in order to assess the effect of oil on embryonic growth and development. The eggs from seven different female crabs were collected from the GOM throughout the spawning season and exposed to an oil concentration of 500ppm (the approximate concentration of oil at the site of the DWH). We found that, while the overall mortality rate and the proportion hatched was not significantly different between embryos that were exposed to oil and those not exposed to oil, the proportion of prezoea in the experimental group was significantly greater. Prezoea are known to occur in suboptimal conditions such as low salinities, or bacterial and fungal infection, and have been documented to have reduced survival. Our results support these findings and indicate that oil concentrations of 500 ppm negatively impact the development of blue crab embryos. This study sheds light on a critical, but poorly investigated, phase of an important species' life cycle in addition to providing further insight into the effects of the DWH spill.

Annual Variation in Phytoplankton Abundance due to Water Accommodated Petroleum Hydrocarbon Exposure in the Northern Gulf of Mexico

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System perturbation due to oil spills causes a large influx of organic matter to pelagic systems which can have variable effects on phytoplankton growth and productivity. Several studies have shown crude oil exposure to have detrimental effects on phytoplankton; such as reduced light and oxygen availability, decreased expression of photosynthetic-related genes and reduced function of photosystem II. However, there are also reports that demonstrate no such negative effects. This discrepancy highlights a lack of knowledge as to whether chemical or ecological effects are the most important indicators of phytoplankton response to oil spills. As there is a marked seasonality in the relative abundance of phytoplankton groups, extended temporal studies are integral to elucidating these indices. To understand these effects, we are conducting monthly experiments using water from the Alabama coast, in the northern Gulf of Mexico. This region is highly dynamic due to influx from the Mobile Bay fresh-water plume; which carries high concentrations of inorganic nutrients, suspended sediment and dissolved organic matter. Multi-day grow out experiments are conducted using treatments of water accommodated fraction of crude oil (WAF, MC252 Surrogate Crude Oil) and chemically enhanced WAF (CEWAF, Crude + Dasic International Slickgone NS®) relative to controls. We are examining changes in photophysiology, productivity, biomass accumulation and community composition. Preliminary results show significant photochemical quenching of chlorophyll fluorescence after one day of exposure to 10% WAF, relative to controls. In addition, significant divergences in chlorophyll concentrations were

observed among treatments. These results imply strong sublethal effects for the aggregate phytoplankton community. Ongoing time-series results will be presented to examine whether similar sublethal effects are observed throughout the year and whether the magnitude of this variation is affected by the encountered community composition and hydrographic conditions. Given that phytoplankton mediate the transfer of carbon to higher trophic levels, understanding the effect of perturbations on relative phytoplankton abundance has implications for ecosystem resilience as a whole.

Quantifying Hydrocarbon Toxicity to Shallow-water Corals: 1-methylnapthlene

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A significant data gap exists on the toxicity of petroleum hydrocarbons to corals, from the organismal to cellular level. To address this need, this study examined the toxicity of a single hydrocarbon, 1-methylnapthalene, to the shallow water coral *Porites divaricata* in a constant exposure, multi-concentration toxicity test utilizing a passive dosing system. Acute and sub-acute effects (physical changes, calcification, photosynthetic efficiency, and histological changes) were evaluated during pre-exposure (4 week), exposure (48 hour) and post-exposure recovery (4 week) periods. Coral condition scores at the end of the 48 hour exposure were used to determine an EC50 of 4,856 ug/L (95% C.L.s 4,472-5,157). Coral condition was significantly impacted by 4,000 ug/L within 4 hours of initial exposure. Coral mortality at the end of the 48 hour exposure was used to estimate an LC50 of 10,091 ug/L (95% C.L.s 8,967-11,355). The highest concentration used, 16,000 ug/L, resulted in 100% mortality after <48 hours of exposure. Photosynthetic efficiency (ΔF/Fm) was significantly reduced after 48 hours of exposure to 8,000 ug/L. The 4,000 ug/L and 8,000 ug/L exposed corals recovered by 4 and 12 days following the exposure period. The toxicity thresholds determined in this study provide essential data for modeling impacts of petroleum hydrocarbon exposure, especially useful in Net Environmental Benefit Analysis (NEBA) of predicted impacts and response methods in coral reef environments.

Toxic Effects of Deepwater Horizon Oil on Early Life-stage Red Drum and Speckled Seatrout

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In 2010, the Deepwater Horizon (DWH) blowout caused the release of millions of barrels of oil into the Gulf of Mexico, resulting in the contamination of coastal ecosystems. In support of the DWH Natural Resource Damage Assessment, we conducted a series of laboratory tests to investigate the toxicological impacts of DWH oil on early life-stage coastal fish. Embryos and larvae of red drum (*Scianops ocellatus*) and speckled seatrout (*Cynoscion nebulosus*), two ecologically and recreationally important fish species of the Gulf coast, were exposed to oil via water accommodated fractions (WAFs) for 24-72h. We used high-energy (HEWAF), low-energy (LEWAF), and chemically-enhanced (COREXIT 9500: CEWAF) preparations of WAFs with two types of DWH surface oil collected during the DWH response (Slick A and Slick B). Our analysis is ongoing, but DWH oil's lethal effects on both red drum and speckled seatrout demonstrate a similar dose-dependent relationship, with LC20 values for all time-points and WAF preparations ranging from 9.4 to 34.0 µg TPAH50/L for red drum and 6.2 to 49.2 µg TPAH50/L for

speckled seatrout (sum of 50 polycyclic aromatic hydrocarbons [TPAH50]). Both oils resulted in similar toxicity (when comparing TPAH50 concentrations), and the WAF preparation method slightly affected toxicity. Exposure duration and age of the animals also influenced toxicity. Our results demonstrate that DWH oil is toxic to the early life-stages of red drum and speckled seatrout.

Light External Exposure to Deepwater Horizon Oil Effects Avian Flight Behavior

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In support of the Deepwater Horizon Natural Resource Damage Assessment (NRDA), this study utilized the homing pigeon as a surrogate species for migratory birds to investigate the effects a single external oiling event has on the flight performance of birds. Homing pigeons were trained out to 50 miles from their lofts and baseline flight performance characteristics were recorded. Following baseline flights, oil was applied to half of the birds (treated) and water was applied to the other half (control). Thereafter, all birds resumed 50-mile flights, with GPS data loggers attached. Treated pigeons took significantly longer to return to their lofts and spent more time stopped than did the control pigeons. After only the single oil application, feather damage was apparent and increased over time with repeated flights. This suggests that migratory birds affected by the oil spill would have experienced long-term flight impairment and delayed arrival to breeding, wintering, or crucial stopover sites. Delays during avian migration are known to cause reductions in reproductive success and survival. This work was funded in part by the Deepwater Horizon NRDA Trustees and the Nevada Agricultural Experiment Station.

Large Marine Vertebrates as Indicators of Ecosystem Recovery, Resilience and Restoration Success

Oil Vapors from Deepwater Horizon Oil and Altered Development of Avian Embryos

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The effects of the Deepwater Horizon oil spill on avian health are poorly understood. This is surprising since landfall of oil coincided with the breeding season of many resident and migrant avian species. It follows that developing birds were exposed to toxicants in crude oil either by direct exposure to oil during landfall and transfer of oil to the nest by the parent, or indirectly by exposure to volatile organic compounds in air or water while in the egg. Studies of the effects of oil on developing avian species have largely been focused on direct exposures. Here, we have exposed the embryos of model avian species to airborne volatile organic compounds from oil from the spill. Exposure to these vapors caused a significant increase in multiple biological indices of exposure to oil-derived toxicants and morphological defects that were characteristic of exposure to oil. Experiments are presently developing new methodologies and equipment for real-time monitoring of airborne oil-derived toxicants using portable high-resolution detection devices to monitor volatile organic compounds, alongside the use of fine-scale indices of *in ovo* cardiac and metabolic function. We have characterized the effects of development in close proximity to oil on embryonic physiology, and the potential for long-lasting effects of early life stage exposure in avian model species. Using novel analytical methodologies, these results will provide benchmark data and methodologies for assessing avian species to determine extent of exposure and health effects during remediation of this and other spills.

LADC-GEMM: Towed Hydrophone Cetacean Survey Using Autonomous Surface Vehicles (ASVs)

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ASVs have a number of potential advantages as towing platforms for collecting passive acoustic data on marine mammals, compared to conventional survey vessels. ASV operation requires fewer personnel than that required to crew a conventional ship; ASVs are therefore cheaper to run and reduce exposure of personnel to HSE risk when working in remote locations. A relatively small and acoustically quiet ASV contributes less background noise than a ship and is therefore, less likely to disturb the behaviour of target species or mask their vocalisations from detection. During 2015 LADC-GEMM consortium Experimental Cruise 1 we deployed towed hydrophone arrays from two types of ASV. The ASVs were equipped with a wireless telemetry link to a support vessel, which enabled the hydrophone signals and processing software to be monitored in real-time. Here, we present the results of offline analysis of acoustic detections of marine mammals from continuous and wideband (20-160,000 Hz) sound recordings. The recordings were searched for sounds produced by Bryde's whale, delphinid species, sperm whale, beaked whales, and *Kogia* using automatic detectors for tonal sounds; mid-frequency and high frequency click detectors; and manual spectrogram review. We investigated the use of ASV-derived survey data for localising sperm whales using Target Motion Analysis and estimating their density and abundance by Distance Sampling. The LADC-GOMRI project aims to compare the suitability of various PAM platforms for marine mammal encounter and population surveys of the Gulf of Mexico to

understand impacts of short-term and long-term environmental stresses. [Research supported by GOMRI Consortium grant]

Manatee Habitat Use in the Northern Gulf of Mexico: A Project to Assist with Management of Coastal Resources

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In recent years, West Indian manatees (*Trichechus manatus*) have been infrequently documented in the northern Gulf of Mexico (NGOM) states. Over the last decade their use of this region has been increasing during warmer months, but their distribution, movements, and resource use in these areas have not been well documented. Response and damage assessment related to the Deepwater Horizon oil spill highlighted the data gap on manatee knowledge in this area. Since 2007, USGS researchers have been conducting studies on manatee movements and habitat use in the NGOM to document extent of migrations and determine patterns of habitat use. Our current study seeks to aid the Bureau of Ocean Energy Management and other agencies to better understand manatee interactions with energy industry shipping and operations in the region. This study is providing information on spatial and temporal manatee use of the NGOM, the health and disposition of individual manatees traversing the study area, and the extent and quality of the habitat they may use. Capturing and assessing manatees that use this region, documenting individuals through photo-id, interpreting their movements through satellite telemetry, and investigating use areas, are tools being used to create maps of functional habitat types, along with detailed assessments of the underlying habitat components (temperature, salinity, seagrass coverage and density, etc.) that contribute to manatee use within the region.

Shared Foraging Areas in the Gulf of Mexico for Two Imperiled Species: Kemp's Ridley and Loggerhead Sea Turtles

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The Gulf of Mexico (GoM) is an important life-history area for Kemp's ridleys and two of five subpopulations of loggerheads. It also presents a high level of anthropogenic threats. Foraging areas are an important part of an animal's home range and characterizing them is critical in conservation efforts, especially for species at risk. We use previously published and newly calculated kernel density estimates along with switching state space modeling to determine foraging locations for Kemp's ridley and loggerhead turtles in the GoM. Satellite tracking data spanned 15 years for Kemp's ridleys and 5 years for loggerheads. Using grids, we show where foraging areas for these two species overlap and we characterize these areas by depth, distance to shore, and other habitat features. From 1998 to 2013, we obtained foraging areas for 127 turtles (63 loggerheads and 64 Kemp's ridleys). We calculated 109 KDEs (58 for Kemp's ridleys and 51 for loggerheads) for 88 turtles (39 Kemp's ridleys and 49 loggerheads). Mean values for core-use areas were almost ten times larger for Kemp's ridleys than for loggerheads. The home ranges followed a similar pattern, with Kemp's ridley home ranges almost nine times larger than loggerhead home ranges. Home ranges for both species intersected in areas throughout the GoM.

These shared foraging areas can assist in future conservation habitat modeling, providing managers with key spatial information on areas with high conservation value.

Research and Monitoring Priorities for Gulf of Mexico Sea Turtles

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The Gulf of Mexico is essential habitat for five species of sea turtle. Sea turtles nest on Gulf beaches, they feed nearshore and offshore and all life stages migrate through these waters. The success of sea turtle conservation programs in the Gulf, wider Caribbean and greater Atlantic has resulted in notably more sea turtles inhabiting Gulf waters in the last two decades. Despite this increase however, research, monitoring and conservation of sea turtles in the Gulf has not advanced as far as it has in other regions, nor as quickly as it needs to. The Deepwater Horizon Oil Spill that occurred in the Gulf of Mexico in 2010, and calls to develop better science in its wake (Bjorndal *et al*., 2011), illustrates this point very clearly. We lack the capacity in the Gulf to assess sea turtle population status. Restoration funding available for the Gulf of Mexico presents an opportunity to further sea turtle research, monitoring and conservation in the Gulf of Mexico, fill some of the gaps in our knowledge about their life history, biology and ecology, and better understand threats to inform sea turtle management and Gulf of Mexico restoration. Furthermore, because sea turtles occupy high trophic levels, they can serve as an important indicator of Gulf of Mexico restoration success.

In this poster presentation, we present the results from a stakeholder-driven workshop held in October 2015 to:

1. Identify gaps in knowledge and prioritize key research and monitoring needs.
2. Identify and prioritize key conservation needs based on known threats.
3. Identify and prioritize opportunities for networking, collaboration and data sharing.
4. Develop a plan for Gulf of Mexico sea turtles.
5. Increase awareness of sea turtles throughout the Gulf of Mexico.

Tampa Bay Bottlenose Dolphins: Long Term Study to Explore Impacts of the Deepwater Horizon Oil Spill on a Relatively Distant and Protected Population

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Long term studies provide an opportunity to examine the effects of unusual events, including the Deepwater Horizon oil spill. The Eckerd College Dolphin Project has been conducting sighting surveys and photo identification of Tampa Bay bottlenose dolphins (*Tursiops truncatus*) since 1993. This long term database can be used to examine changes between the five years prior to the oil spill with the subsequent five years. Preliminary analysis indicates an increase in sightings of groups of dolphins after the oil spill when compared with sighting rates from 2004-2009. The total number of dolphins observed did not appear to change over this time, but instead, in the years 2011-2015 group size tended to be smaller, which lead to a higher sighting rate. Photo identification data indicates that although new dolphins continue to be identified throughout the study, the rate of new identifications declined after 2010. As animals enter the identifiable population through birth, mark change and emigration into the

area, this suggests changes in the population demography after the spill. The inshore waters of Tampa Bay are relatively protected and distant from the Deepwater Horizon oil spill, yet there are detectable differences in the population after the spill. Future work, examining differences between the sighting and identification rates inshore and offshore of the barrier islands of Tampa Bay may reveal additional subtle impacts on this population.

The Dynamics of Vertical Movement in the Oceanic Gulf of Mexico after Deepwater Horizon: Active Linkage of Large Vertebrates and Deep-Pelagic Nekton

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Toothed whales, smaller oceanic cetaceans, seabirds, and epipelagic gamefishes rely on deep-pelagic (meso- and bathypelagic) nekton as primary or secondary prey. This trophic interaction is mediated by downward and upward vertical movements (e.g., sperm whale diving and lanternfish diel migration, respectively). This interaction also links particle-feeding lower trophic levels with top predators in a manner that spans the gamut of depth domains. This is particularly important with respect to a whole-water column disturbance such as the Deepwater Horizon oil spill. Here we present highly resolved vertical distribution and migration data collected during a large-scale, NOAA-supported, deep-pelagic (0-1500 m) survey in 2011, along with data collected during ongoing GoMRI-supported DEEPEND consortium surveys. The deep-pelagic nekton community of the Gulf of Mexico is a complex mixture of migrating, non-migrating, and partially migrating assemblages that connect surface waters with depths in excess of 1000 m. Major patterns of vertical distribution for 400+ species of fishes, shrimps, and cephalopods, the primary prey of many important species of oceanic vertebrates living near-surface, will be summarized and quantified with the goal of highlighting potential vectors of anthropogenic contaminant transfer in the deep-pelagial, the Gulf's largest ecosystem.

Determination of the Oil Droplet Size Distribution and Its Impact on the Fate and Transport of Oil: Consequences on Public Health and Ecology

Evaluation of Sorbent and Solidifier Properties and their Impact on Oil Removal Efficiency
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Additional evaluation of sorbents and solidifiers is needed in order to increase confidence in their use for containment of oil spills. The primary focus of this project was to compare the oil removal efficiency of natural and polymeric sorbents as well as solidifiers under different environmental conditions. The physical/chemical characteristics of products were also studied and correlation of these properties with effectiveness enabled identification of characteristics that resulted in high oil uptake. Products with lower bulk powder density and large pores size had the highest oil removal efficiency. Natural sorbents, polymeric solidifiers, and polymeric sorbents had bulk densities of 0.14, 0.18-0.27, and 0.25-0.62 g cm-3, respectively. This resulted in removal efficiencies of 90, 87-65 and 40-12% for the corresponding products. Analysis of experimental data yielded empirical correlations involving certain operational variables such as application rate, product bulk density, and oil viscosity. The type of product used in a sorbent boom could greatly affect its performance. Since bulk density is a readily available measurement and can provide an approximation of product efficacy, these results could aid in evaluating and choosing high performance construction material for booms used in oil spill remediation.

Effects of Chemical Dispersants on Intrusion Dynamics of Oil Droplets from a Deep Ocean Blowout
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Chemical dispersants reduce interfacial tension between oil and water, producing smaller droplets. This is known directly from laboratory experiments, indirectly from surface observations during the Deepwater Horizon (DWH) spill, and theoretically from a variety of droplet size prediction models. To better understand the role of dispersants, we have been conducting laboratory experiments on the effects of droplet size on near-field oil transport. Earlier, we identified threshold diameters for droplets to detrain from the rising plume near the height of neutral buoyancy, and for them to enter an intrusion. We also provided estimates for oil transport within the intrusion for a range of conditions and droplet sizes encompassing those expected during the DWH, both with and without dispersants. The fate of oil droplets clearly depends on the depth and shape of the intrusion layer(s). While intrusion layers from multiphase plumes have been studied previously under stagnant conditions, their behavior in a current, especially a weak current, is less well understood. The common classification of plume behavior as either current-dominated or stratification- dominated, depending on the physical mechanism driving phase separation, does not consider the interplay between the two effects. To fill this gap, we are conducting additional laboratory experiments, to investigate the behavior of intrusion layers with both currents and stratification. Like our earlier experiments, we use an inverted frame of reference, using spherical glass beads with a range of diameters to simulate oil droplets and towing a carriage with the release mechanism in a salinity-stratified tank. Laser-induced fluorescence is used to measure dilution and geometrical characteristic of the intrusion. We find that a weak current creates enhanced ambient entrainment, which in turn leads to a shorter trapping height compared with the quiescent case. Complementing the experiments is a semi-empirical model that extends previous models to account for current effects, allowing more accurate prediction of average and maximum depths of the intrusion

layer. Field observations taken during the DWH are used to validate some of the analytical and experimental findings.

Advancing Technology to Extend the Limits of Particle Measurements in Subsea Blowouts

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Measurements of the size distribution of oil droplets, gas bubbles, or the mixture of both are of critical importance in understanding the dynamics of subsea blowouts. This is due to the well-confined relationship between the turbulent energy at the release point and the resulting droplet and bubble sizes. Accurate knowledge of the particle size distribution is therefore a key requirement for predictive oil spill models. Experiments to-date have often been restricted to a limited droplet size and concentration, governed by the available instrumentation. It has therefore been necessary to scale down laboratory simulations of subsea blowouts so that the resulting droplet size distribution and concentration falls within a measureable range. Potential scaling errors in these types of experiments have created a need for extending droplet measurements to larger sizes and higher concentrations so that more realistic experimental conditions can be simulated and documented accurately. Here we present a novel telecentric silhouette-based imaging system, specifically designed for measurements of large droplets in high concentrations. The system is configured to combat the challenges associated with conventional particle measurements, and provides both images and size distributions from within a wide depth-of-field, void of position-dependent magnification errors. The ability to select from a suite of multiple techniques (e.g. LISST-100 and LISST-Holo, together with this silhouette camera) now enables accurate in-situ particle size measurements than span diameters from 5-12000µm. We show how this new measurement capability has enabled more realistic-scale experiments to be performed, which include full-scale droplet sizes.

Human Functioning and Adaptation to Stress: Implications of Prolonged Exposure for Individuals and Communities

Does Environmental Concern Influence Women to Postpone Pregnancy? The Environmental Worry Scale and the Effect on Reproductive Decision Making

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Background: Previous studies indicate that environmental worry may lead to behavior change. We examined how women's environmental concerns were affected by Deepwater Horizon and if they were associated with postponing pregnancy. **Methods**: We interviewed 937 women of reproductive age from oil spill affected areas between 2012 and 2014. We used Hodapp *et al*'s environmental worry scale and grouped questions into personal and general environmental concerns. We asked women if they had changed behavior due to the oil spill, including postponing pregnancy. We calculated bivariate associations between environmental worry and demographic variables, then created logistic regression models for postponing pregnancy and environmental concern, adjusting for demographics. **Results**: There were 52 (6%) women who postponed pregnancy due to the oil spill. Environmental worry was higher among women who reported not postponing pregnancy. After adjusting for demographics, there was an association between reported postponed pregnancy and personal environmental worry (POR=1.11 [95%CI: 1.02, 1.21])) and general environmental worry (POR=1.11 [95% CI 1.00, 1.22]). **Conclusions**: Women with higher levels of environmental worry were more likely to report postponed pregnancy due to the oil spill compared to those with lower levels of environmental worry. This could indicate that environmental concern caused women to delay pregnancy. Our study indicates that environmental concern is a possible predictor for family planning.

Trauma, Resilience, and Opportunities among Neighborhoods in the Gulf: Design and Administration of the STRONG Survey

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The gulf coast is a source of both economic and recreational livelihood for the neighborhoods along it, and thus environmental insults like oil spills can affect those living in the area in ways that directly affect residents' physical and mental health. Local resources, social ties, trust in sources and communication, and personal factors are among the many factors that influence the effect of the oil spill on health outcomes among gulf coast residents. As one of its fundamental goals, the Consortium for Resilient Gulf Coast Communities (CRGCC) will administer a survey to a representative sample of residents in the Gulf Coast. During this presentation, consortium leads Dr. Matt Lee (LSU) and Dr. Rajeev Ramchand (RAND) will discuss: (1) the existing literature on the health effects of oil spills on community residents (versus, for example, cleanup workers); (2) the challenges, and opportunities, associated with administering a survey on a community 5 years after the spill; and (3) the procedures and methods underlying the CRGCC Survey on Trauma, Resilience, and Opportunity among Neighborhoods in the Gulf (STRONG) expected to be complete by Summer 2015. The discussion will conclude with anticipated analyses that will be priorities for the CRGCC, and plans for releasing a public use dataset that will provide opportunities for parties beyond the consortium to use the data contribute to the field.

Ecological Impacts of the Deepwater Horizon Oil Spill across Multiple Scales

Assessing Hydrocarbon Incorporation into the Planktonic Food Web at Cold Seeps

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Natural hydrocarbon seeps account for up to 47% of the oil and gas released into the oceans globally, In the Gulf of Mexico (GoM), over 20,000 cold seeps act as a constant source of hydrocarbons and gas to the water column. This baseline input may precondition the system to hydrocarbon exposure, and provides a natural system for assessing the impacts of accidental hydrocarbon releases in oceanic waters. While a large fraction of the oil and gas released by seeps is dissolved in the water column, accumulates at the surface, or is released to the atmosphere, a portion is incorporated directly into marine food webs. The impact of cold seeps on benthic communities is well studied, but less is known about how hydrocarbons influence pelagic food webs. The low δ13C values characteristic of oil and methane derived carbon (e.g., δ13C = -27‰ and -57‰, respectively, for Macondo oil) can be used to trace the movement of oil and gas into organisms. Here we explore the role of cold seeps in supporting pelagic food webs in the GoM by assessing the distribution of nitrogen and carbon stable isotopes in zooplankton collected at sites of different seepage magnitude over several years. We build on prior research documenting low δ13C values in suspended particles and zooplankton in the two years immediately following the Deepwater Horizon (DWH) spill in 2010. Our measurements provide a multiyear record of the contribution of oil and gas release to zooplankton biomass across a range of offshore habitats, a critical part of any baseline assessment of hydrocarbon impacts in the GoM. Such baseline studies are critical for future assessments of food web impacts of accidental spills in regions with prior oil exposure like the GoM.

Spatial and Temporal Variation in DeSoto Canyon Macrofaunal Community Structure

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Sediment-dwelling macrofauna (polychaetes, bivalves, and assorted crustaceans ≥ 300 µm) have long served as biological indicators of ecosystem stress. As part of evaluating the 2010 impact from the Deepwater Horizon blowout, we sampled 12 sites along and transverse to the DeSoto Canyon axis, Gulf of Mexico, as well as 2 control sites outside the Canyon. Sites ranged in depth from 479-2310 m. Three of the sites (PCB06, S36, and XC4) were sampled annually from 2012-2014. We provide an overview of the macrofauna community structure of canyon and non-canyon sites, as well as trends in community structure and diversity at the time-series sites. Compositionally, polychaetes dominated the communities, followed by tanaid crustaceans and bivalves. The total number of individuals was not significantly correlated with depth while the total number of taxa and species richness was. Rarefaction shows the deepest station, XC4 (2310 m) had the lowest diversity while NT800 (a non-canyon control at 800m) had the highest. Multivariate analysis shows the canyon assemblages fall into eight clusters with the non-canyon stations forming a separate ninth cluster, indicating a detectable difference in canyon and non-canyon communities. Time series stations show an increase in diversity from 2012-2014 with a strong overlap in community structure in 2013 and 2014 samples. Environmental analysis, via BEST, using data from 10 canyon sites and the controls, indicated depth in combination with latitude explain the most variation in macrofaunal community structure.

Health of the Mud Shrimp *Lepidophthalmus louisianensis* in Response to Crude Oil Exposure

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Different species of 'mud shrimp' are found all over the coast of the tropics and subtropics. They live in intertidal and sub tidal zones at densities of up to 300 indv/m2 and create burrows up to 3m in depth. In the process of burrow creation and ventilation, these organisms provide habitat for many microbial, benthic invertebrate, and vertebrate species, making them important to the overall functioning of the local ecosystem. A preliminary experiment investigated the toxicity of oil to the ghost shrimp *L. louisianensis*. The experiment involved 30 cores (10 cm diameter, 60 cm height). Cores were filled with 40 cm of sediment and 10 cm of seawater before 1 organism was added to each. Oil was added to the top of the cores at 6 different concentrations. Cores were examined at 24, 48, 72, and 96 hrs. The 96h-LC50 was 23.92 µl/cm2. There also appeared to be a positive relationship between the incidence of cuticular lesions on the shrimp and oil exposure level. Results for additional toxicity experiments and from more-detailed investigations of the cuticular lesions will be presented at the meeting.

Trophic Structure, Feeding Ecology and Hg Bioaccumulation of the Three Species of Hagfish Found in the Gulf of Mexico

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We investigated the trophic structure, feeding ecology and bioaccumulation of Hg in three species of hagfish from the Gulf of Mexico (GoM). Inter and intra specific variations as well as changes along important environmental gradients in trophic structure and feeding ecology of *Eptatretus springeri*, *Eptatretus minor*, *Myxine mcmillanae* were studied using nitrogen (δ15N), carbon (δ13C) and sulfur (δ34S) stable isotope analysis along with DNA analysis of stomach and fecal samples. Total Hg, Methyl-Mercury and Inorganic Hg concentrations in muscle tissues were measured via cold vapor fluorescent mass spectrometry and combined with stable isotope measurements to identify the influence of trophic structure in Hg accumulation and any potential effects of the DWH oil spill on diet composition and Hg concentrations. *E. springeri* had the lowest δ15N value (11.1‰), followed by *E. minor* (12.3‰) and *M. mcmillanae* (13.4‰). *E. springeri* also had the lowest δ34S value (20.3‰) followed by *E. minor* (21.8‰) and *M. mcmillanae* (21.9‰). The only significant changes with depth were observed for *E. springeri* with an enrichment in δ15N and a depletion of δ34S suggesting a diet shift with increased depth. Despite having the largest mean body length (518.6 mm) and body mass (262.6 g) *E. springeri* had the lowest mean THg concentrations (1.1 µg g-1), while *M. mcmillanae* had the smallest mean body length (74.2 mm) and the highest THg concentration (11.2 µg g-1). Only *M.mcmillanae* had a significant increase in Hg concentrations with depth. Preliminary results indicate variations in trophic structure and diet composition and Hg concentrations in GoM hagfishes.

Otolith δ13C and Δ14C Document Food Web Impacts of the Deepwater Horizon Oil Spill

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Results from previous reef fish diet and muscle stable isotope analyses revealed food web impacts of the Deepwater Horizon Oil Spill (DWH) in the northern Gulf of Mexico (GOM). However, neither stomach contents nor muscle stable isotopes constitute a permanent natural marker to examine historical effects of the spill. Therefore, we explored whether otoliths might serve as natural biogeochemical markers of DWH food web impacts given their chronometric properties, as well as their well-established characteristic of recording the biogeochemical environment to which fish are exposed. Age-0 red snapper were sampled from 2009-2013 in the north central GOM, as well as in a control area in the western GOM off Texas. Otoliths from fish sampled in the north central GOM were depleted in 14C following the DWH, but Δ14C values recovered to expected values by year three post-spill. In the same region, otoliths were unexpectedly enriched in 13C following the spill, which likely resulted from slower growth thus dissolved inorganic C contributing a greater proportion (relative to metabolic sources) of C in otolith CaCO3. These results demonstrate otoliths to be effective recorders of DWH food web impacts; physiological mechanisms are currently being examined. Results from analyses of other reef fishes that also demonstrate the utility of otoliths to serve as natural biogeochemical markers of DWH food web impacts will also be presented.

Polycyclic Aromatic Hydrocarbons in Red Snapper, *Lutjanus campechanus*, and Sediment Samples Following the Deepwater Horizon Oil Spill

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The Deepwater Horizon oil spill occurred on 20 April 2010, releasing an estimated 3.19 million barrels of oil into the Northern Gulf of Mexico. Red snapper, *Lutjanus campechanus*, were potentially exposed to polycyclic aromatic hydrocarbons (PAHs) from this oil spill. To assess this potential exposure, red snapper tissue samples were collected from 2010 to 2014, and analyzed for several PAHs. All red snapper tissue samples showed mean total PAH concentrations < 10 ppb. Significant differences were observed in total (± SD) PAH by year. Sediment samples were also analyzed for PAHs, these showed no evidence of contamination above background levels. Condition indices were used to determine if any physiological changes occurred in red snapper condition, gonadal tissue, or liver tissue following the oil spill. Significant differences were observed in gonadosomatic index and Fulton's K (condition factor); these were likely attributable to normal yearly variations due to temperature and nutrition status. Lesions were observed in 10 of 3,934 (0.25%) red snapper collected during this study. These levels of lesions were at similar levels to non-oil exposed fishes. Based on low levels of PAH in red snapper and sediment samples, and low rate of external lesions, it is unlikely that adult red snapper in the study area on the Alabama-Mississippi continental shelf were affected by the Deepwater Horizon oil spill.

Increased Growth in the Estuarine-Dependent Spotted Seatrout following the Deepwater Horizon Oil Spill in the Gulf of Mexico

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One of the most immediate fisheries concerns following the Deepwater Horizon (DWH) oil spill in the Gulf of Mexico in April 2010 was to what extent the productivity of recreational and commercial fisheries would be an impacted. Spotted Seatrout was one estuarine-dependent species of fisheries concern in Louisiana. Changes in age-specific and estuary-specific growth of Spotted Seatrout was measured prior to (2005-2009) and after (2010-2014) the DWH oil spill using growth increments in their

otoliths. Female Spotted Seatrout (n=4,964) had significantly greater growth in their second, third and fourth year increments in the post- versus the pre-spill period. Growth was also consistently greater post- versus pre-spill in female Spotted Seatrout collected from the major estuaries of Terrebonne, Barataria and Lake Pontchartrain in Louisiana. Slower growing male Spotted Seatrout (n=1,369) also showed greater growth increments in the post- versus pre-spill period for the third year of growth in their otoliths, but not in their second and fourth years of growth. Greater growth in Spotted Seatrout in the post-spill period is hypothesized to be due to a density-dependent response.

Using Image-Based Long-Term Monitoring to Estimate the Recovery of Deep-Sea Corals after the Deepwater Horizon Oil Spill

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Deep-water corals form one of the most complex biological habitats on continental shelves, and house a high diversity of associated fauna. Yet, they are very vulnerable to anthropogenic impact due to their lack of mobility, exposed tissue, and very low growth rates. In this study we are assessing the long-term impact of the Deepwater Horizon oil spill on coral communities in the deep Gulf of Mexico. Coral colonies were imaged every year between 2011 and 2015 at four different sites, and the images digitized to quantify impact, identify hydroid overgrowth, and track recovery patterns. Observed recovery between consecutive years was negatively correlated with the level of impact apparent on coral colonies in 2011. Similarly, healthy branches were less likely to remain healthy when the level of visible impact was high in 2011. Significant branch loss was observed throughout the study period; breakage most often occurred in impacted areas of the colony but sometimes resulted in the loss of apparently healthy portions of colonies. Commensal ophiuroids appear to have mitigated the effects of the initial impact, and to have contributed to recovery of the colonies hosting them. Although more than five years have passed since the oil spill, the ultimate fate of corals impacted in 2010 is still uncertain. However, long-term monitoring is leading to a better understanding of the resilience of these vulnerable ecosystems and the value of octocorals as sentinel species.

The Effects of Planting and Fertilization on Native Soil Microbial Community in Louisiana Coastal Marshes Affected by the Deep Water Horizon Oil Spill

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This study is part of a larger project that evaluates the longer-term impacts of the Deep Water Horizon (DWH) event on the plant-microbial-benthic marsh system and the effectiveness of remediation treatments on accelerating recovery rates. Remediation test sites were established and maintained to study the effectiveness of vegetation plantings and fertilization on recovery, resilience, and long-term sustainability of the DWH oil-impacted coastal marshes in northern Barataria Bay. Responses of indigenous soil microbial community structure and composition to the planting of *Juncus roemerianus* or *Spartina alterniflora*, with or without application of the control-released N, P and K fertilizer, were determined through Illumina 16S metagenomic sequencing. The microbial data will be correlated with soil and plant variables that were collected simultaneously within the same experimental designs to produce a comprehensive interpretation of remediation-assisted recovery on microbial dynamics DWH oil-impacted marshes.

Vertical Distribution Patterns of the Cephalopod Fauna of the Gulf of Mexico

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The Deepwater Horizon Oil Spill (DWHOS) necessitated a whole-water-column approach for assessment that included the epipelagic (0-200m), mesopelagic (200-1000m) and bathypelagic (>1000m) domains. The latter two domains collectively form the largest integrated habitat in the Gulf of Mexico (GoM). This habitat received the initial oil/methane discharge, plus millions of liters of dispersant, and contained persistent deep (~1100m) plumes of oil, methane, and dispersant, demonstrating that DWHOS had an extensive deep-pelagic component. As part of the Natural Resource Damage Assessment process, the NOAA-supported Offshore Nekton Sampling and Analysis Program (ONSAP) was developed to evaluate impacts from the spill and enhance the basic knowledge of the biodiversity, abundance, and distribution of deep-pelagic GoM fauna. Here we provide the initial results of a field campaign in 2011 that included two cruise series with different midwater trawl types (large dual-warp and 10-m2 MOCNESS) in which the pelagic fauna was sampled from 0-1500 m. During this campaign, over 10,000 cephalopods were collected. At least 67 cephalopod species were collected by ONSAP, and ongoing analyses through the Deep Pelagic Nekton Dynamics Program (DEEPEND) will certainly increase this number, as cryptic taxa are resolved. Cephalopod vertical MOC-10 sampling from both ONSAP and preliminary DEEPEND data will be highlighted.

A Time-series Assessment of Polycyclic Aromatic Hydrocarbons in Fish Communities before and after the DWH Event

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A time-series assessment of polycyclic aromatic hydrocarbons (PAHs) content in fish communities was conducted in the northern Gulf of Mexico (GoM). Two fish communities (shallow- and deep-water) were examined to determine levels of exposure in contrasting environments and ecologies, to establish baseline levels, and to infer trends in chemical composition before and years after the Deepwater Horizon oil spill (DWHOS). Deep-water mesopelagic fishes (from 25 to 1250 m depth) collected in 2007 contain a baseline level of muscle PAH concentrations of 0.3-1.3 µg/g dry wt, which increased in 2010 and 2011 by up to 10-fold. Similarly, shallow-water reef fishes (from 15 to 80 m depth) collected in summer 2010 have liver PAH concentrations of ~0.3 µg/g dry wt, which increased in fall 2010 and in 2011 by up to 20-fold. Differences in PAH concentrations among feeding behaviors were also observed. For both communities, average concentrations were higher than the established threshold PAH level for adverse biological effects (4.0 µg/g dry wt). After 2012, a decline in the concentration of PAHs was observed reaching values close to baseline levels. Temporal variability of PAH concentrations and composition up to 2015, and its relationships to species composition in both reef and mesopelagic environments will be discussed.

The Interplay of Geomorphic and Ecological Factors and Ultimate Survival of Tidal Wetlands

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Concepts of how marshes function have largely been developed in macro-tidal and meso-tidal regimes, those with >2 m tidal ranges. Most intertidal wetlands, however, are exposed to lower tidal ranges. In large well developed ecosystems like the Louisiana Delta and Chesapeake Bay, mean tidal ranges often less than 1 m. What does this mean for marsh function and survival? Low tidal energy limits their ability to import sediment (and nutrients), and vertical accretion relies primarily on organic accumulation. The export of toxic metabolites (e.g. hydrogen sulfide) is also often hampered. In these wetlands tidal energies are often ebb-dominated, promoting sediment export, not retention. Further, a weak astronomical tidal pulse means that wind-driven tides often dominate, making the tidal regime highly irregular. With strong onshore winds, marshes can be inundated for several days, potentially damaging to plants when overlying waters have low or no oxygen. In contrast, strong offshore winds may suppress flood tides (and tidal flushing) for days such that when droughts occur, brackish marshes become vulnerable to sudden die-off. A growing awareness that sea-level rise complicates the classic picture of tidal marshes as robust sites of sedimentation which are sustainable in a period of increasing human intervention. Despite having higher species diversity than more saline marshes, micro-tidal wetlands appear to be very fragile when stressed. This has implications when a wide range of wetlands are exposed to catastrophic events.

Association of Oil-related Trace Metals with Lesioned Fish Collected after the Deepwater Horizon Oil Disaster

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The incidence of external lesions on Gulf of Mexico fishes is suspected of increasing after the Deepwater Horizon (DWH) oil disaster. The objective of the present study was to compare the otolith element histories of lesioned and non-lesioned fish before and after the spill. We analyzed otoliths from the following species collected from 2011 to 2013: Red Snapper *Lutjanus campechanus*, Red Grouper *Epinephelus morio*, Yellowedge Grouper *Epinephelus flavolimbatus*, Southern Hake *Urophycis floridana*, and Tilefish *Lopholatilus chamaeleonticeps*. Otoliths were analyzed using laser-ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) for a suite of 9 trace metals that are known to be associated with DWH crude oil: 24Mg, 51V, 53Cr, 57Fe, 59Co, 60Ni, 63Cu, 64Zn, and 208Pb. We ablated otoliths along a transect that extended from the center (primordium) to the outer edge of the otolith, which allowed us to establish baseline otolith microchemistry measurements for fish prior to the spill. Lesioned fish of 3 of the 5 species (Red Grouper, Southern Hake, and Tilefish) had distinctive trace-metal compositions in their otoliths, with 60Ni and 64Zn being the primary elements responsible for distinguishing lesioned from non-lesioned fish groups. Lesioned fish often had elevated otolith 60Ni and 64Zn both before and after the DWH oil disaster.

Increasing Blood PAH Concentrations in Wintering Common Loons off the Louisiana Coast Negatively Affect Body Mass and Hematocrit Levels

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Oil exposure to birds has clear short-term negative effects; however long-term effects have not been as well-studied. To evaluate the exposure levels and effects from oil leaked during the Deepwater Horizon Event in April 2010, we monitored wintering Common Loons (*Gavia immer*) from 2011-15 in Barataria Bay and associated watercourses off the Louisiana coast--an area that received moderate to heavy amounts of oiling. We captured 93 individuals and obtained blood samples to measure concentrations of pyrogenic (all years) and petrogenic (two years) polycyclic aromatic hydrocarbon (PAH) levels. Total PAH levels increased over the five years of study, though annual variability was strong as the lowest levels were found in 2014. The PAH profile changed from all lightweight PAHs in 2011-12, to all heavyweight PAHs in 2013; and back to lightweight in 2015. Increasing concentrations of total PAHs had a significant negative correlation on Common Loon body mass and a borderline significant correlation with hematocrit levels. Adult blood PAHs were also positively correlated with total serum protein levels. Wintering loons from this area are long-distant migrants and it is possible that negative phenotypic effects loons experience from increasing PAH concentrations may impact their breeding success as well as their winter survival.

Temporal Variability of Deep-sea Coral-associated Macrofauna in Gulf of Mexico sediment after the Deepwater Horizon Oil Spill

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Deep-sea octocorals occur throughout the northern Gulf of Mexico, creating complex three-dimensional habitats that support significant levels of biodiversity and provide important ecosystem functions. Several deep-sea coral habitats were impacted by the 2010 Deepwater Horizon oil spill, and recovery of impacted benthic communities may take decades or longer due to their typically slow growth rates and limited mobility. However, the natural temporal variability of coral-associated benthos is unknown and represents an important factor to include in post-spill community assessments. From 2010 to 2014, we examined deep-sea coral-associated sediment macrofauna (>300 µm) at multiple impacted and reference sites to quantify post-spill temporal changes in macrofaunal density, diversity, community composition, grain size, and organic content. Temporal changes in benthic community structure were site specific, where impacted sites had variable changes in density and overall lower diversity than reference sites. The relative composition of opportunistic and tolerant taxa varied among years as did key sediment parameters. These multi-year data provide an unprecedented post-spill baseline for assessing the recovery of coral-associated benthic communities in natural and exposed habitats. Analysis of these data will help inform and potentially enhance future monitoring and restoration activities.

Towed Camera Applications for Monitoring Mesophotic Marine Resources

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Continued monitoring and assessment of marine communities is necessary to protect species and habitats that contribute to the health of ecosystems and fisheries. With advancements in instrumentation, reconciliation of at-depth image quality, and synthesis of survey resources, camera systems can provide an effective and efficient method for short- and long-term marine resource monitoring. The towed Camera-Based Assessment Survey System (C-BASS) collects environmental data at depth while six cameras continuously feed live video shipboard. This study examines the habitat composition of still images sampled in constant intervals from C-BASS transects within the Florida Middle Grounds from 2013 to 2015. Images were processed for contrast and color reconciliation resulting from light attenuation at depth. Environmental data was summarized for the area covered. Percent benthic cover was measured using the Coastal and Marine Ecosystem Standard (CMECS). A benthic species guide for the west Florida shelf is presented and discussed in terms of utility within CMECS surveys. Economically-important fish species and habitat autocorrelation is considered using fish abundance data from the same video surveys. Application of the C-BASS, including development of automated identification systems, is discussed for long-term ecosystem health and dynamics monitoring and short- to long-term damage assessments, as well as the continued synthesis of marine geographic information for the Gulf of Mexico.

Shipwrecks of Opportunity: Monitoring Oil Spill Impacts on Deep Reef Ecosystems in the Gulf of Mexico

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There are more than 2,000 documented shipwrecks in the Gulf of Mexico spanning the last 500 years of human history, and more are discovered each year as oil and gas exploration expands into deeper waters. While the cultural, historical, and archaeological value of shipwrecks is established, their function and value as ecosystem monitoring platforms after a major environmental disaster is beginning to emerge. Shipwrecks serve as artificial reefs and hotspots of biodiversity; these features provide the basis for monitoring whole ecosystems, especially in the deep Gulf where natural hard-bottom is rare. After the 2010 Deepwater Horizon oil spill, the Bureau of Ocean Energy Management and partners initiated a multidisciplinary study to examine spill effects on shipwrecks across micro to macro scales. This is the only study directly addressing the spill's impact on the ecological function and preservation of historic shipwrecks. The team collected microbiological, geochemical, and archaeological data at wooden- and steel-hulled shipwrecks within and outside of the spill-impacted area. The diversity and biogeochemical function of resident bacteria and their sensitivity to environmental disturbances was monitored in situ, and evaluated in laboratory experiments. The potential feedbacks between oil/dispersant contamination, microbial gene function, and hull degradation were also evaluated using molecular biology and surface chemistry at the microscale and 3D laser and 3D sonar surveys at the macroscale. The latter provides a quantitative basis to monitor site formation processes at impacted sites over time. Results of this study have identified multiple, and cross-disciplinary, lines of evidence that sites were impacted by exposure to spill-related contaminants. Multidisciplinary studies of this type provide a holistic approach for evaluating trophic consequences of the spill on the seafloor, and have potential to inform on ecosystem recovery over time.

Age Frequency, Growth and PAH Levels of Roughtongue Bass, *Pronotogrammus martinicensis*, Following the Deepwater Horizon Oil Spill

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The roughtongue bass, *Pronotogrammus martinicensis*, is an ecologically important mesophotic reef fish species in the northern Gulf of Mexico. The 2010 Deepwater Horizon (DWH) oil spill may have exposed this small reef fish to hydrocarbons on deep reef areas close to the spill site. However, there has been limited study of the potential effects of oil on roughtongue bass. The present study examined age frequency, growth and polycyclic aromatic hydrocarbon (PAH) levels of roughtongue bass collected within approximately a 50mile radius of the DWH spill site. Seasonal samples of roughtongue bass were collected in Sep-Oct 2014 (n=190), December 2014 (n=249), March 2015 (n=310) and June-July 2015 (n=360). Standard length ranged from 54 to 122 mm (n=1109). Based on otolith increment counts, age frequencies showed that roughtongue captured in the fall surveys (n=437) were dominated by the 2010 and 2011-year classes. Growth rates were estimated with von Bertalanffy growth relation and showed K = 0.27 and Linf = 124. Results of PAH analysis to date has detected no PAH presence. Based on age frequencies, growth rates, and PAH levels analyzed from samples taken to date for roughtongue bass, we failed to detect any significant effects of the Deepwater Horizon spill on these mesophotic reef species.

Persistence of Mutagenicity in Sediments Three Years post DWH Spill

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This project reports results of research cruises monitoring the Northeastern Gulf of Mexico (NEGOM) in the vicinity of the spill and the West Florida Shelf (WFS) as a part of C-IMAGE I. Biologically-based testing was performed on water column and sediment pore water samples through August, 2013. Microtox acute toxicity testing showed only scattered low levels of toxicity. DNA-damaging potential was measured using the E. coli / lambda Microscreen Assay. In February 2013 most samples from the NEGOM were negative, yet two of the water column samples still showed high mutagenic response. Samples from both the WFS and the NEGOM Spring 2012 through early 2013 were primarily negative with scattered low positive (10%) results for mutagenic response. Resurgence in mutagenic potential was observed in Spring 2013 for several water column samples from the WFS. This indicated the possibility of introduction of residual contamination, most likely from contaminated sediments. The water samples from the Summer 2013 to the WFS and NEGOM were generally negative for mutagenic response, suggesting overall system recovery. However, three of four of the sediment samples tested from the NEGOM and one from the WFS demonstrated significant mutagenicity, indicating potential re-suspension of contaminants as well as long-term exposure of benthic organisms to DNA damage. A mutagenicity assay similar in concept to the Microscreen Assay but with a marine phage-host system is currently under development.

Comparative Toxicity of Two Oil Spill Dispersants in Estuarine Organisms; Laboratory and Mesocosm Exposures

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Chemical dispersants can be useful tools to mitigate oil spills, but the potential risks to sensitive estuarine species should be carefully considered. This study determined the toxicity of two oil dispersants (Corexit® 9500 and Finasol® OSR 52) individually and in chemically-enhanced water-accommodated fractions (CEWAFs) of Louisiana Sweet Crude (LSC) oil. Acute toxicity thresholds and sublethal responses were determined in seven estuarine species (sheepshead minnow, grass shrimp, mysid, amphipod, polychaete, hard clam, mud snail). Dispersants were also assessed using a pathogenic bacterium, *Vibrio vulnificus*. A chronic (45d) saltmarsh mesocosm exposure was used to assess fate and effects of each dispersant applied to weathered LSC under ambient conditions. Comparing median lethal values for dispersants alone, Finasol was generally more toxic than Corexit and had greater sublethal toxicity. Larval life stages were typically more sensitive than adult life stages. Comparing toxicity of the dispersed oil treatments, Corexit-CEWAF was more toxic than Finasol-CEWAF, most likely due to greater hydrocarbon concentrations measured in Corexit-CEWAF than in equivalent Finasol-CEWAF preparations. In the mesocosms, both dispersed oil treatments caused hypoxia, altered microbial community structure, and reduced growth and survival of marsh grass, grass shrimp, clams, and polychaetes. These findings demonstrate the need to consider complex dispersant-oil interactions when making oil spill response decisions.

Taxonomic Stability and Ecosystem Assessment: Twelve Years of Changes to the Known Cephalopod Fauna of the Western Central Atlantic Ocean

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Determination of changes to ecosystem structure assumes adequate knowledge of the species comprising the ecosystem. In 2003, I authored a guide, published by the United Nations Food and Agriculture Organization, to the cephalopods of the western central Atlantic Ocean. That publication listed approximately 121 species in 72 genera (32 families). During the dozen years since publication, numerous trawling and submersible cruises, as well as some monographic revisions, have added substantially to our knowledge of that fauna. In addition to numerous name changes, the known fauna has increased by two families, seven (possibly eight) genera, and 14 species. The species increase includes three new descriptions, three undescribed species, and eight range extensions (some of very great distances). Overall, the increase in the known fauna is approximately 10% in 12 years.

Effects of Salinity Alterations on Soil Greenhouse Gas Production and Denitrification along a Wetland Salinity Gradient in Barataria Bay, Louisiana

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Coastal wetlands provide several important ecosystem services including being important sites for carbon sequestration and nutrient retention and transformations. However, wetlands experience numerous stressors including changes in salinity regime; increases from salt water intrusion and

decreases from river diversions. The Barataria Bay (LA) estuarine system provides an ideal laboratory to examine the influence of current (Davis Pond; constructed in 2002) and future (2012 Coastal Master Plan calls for 2 large sediment diversions in the system) river diversions in a system that has well-documented increases in salinity. In this study, we examined greenhouse gas production (GHG; CO2, CH4, N2O) and denitrification enzyme activity (DEA) rates from 5 wetland sites along a salinity gradient in Barataria Bay: freshwater, intermediate, brackish, and salt marsh sites and a *Avicennia germinans* dominated site in August 2015. Soil cores were collected from 3 replicate plots at each site and transported back to the lab where they were subsampled for soil properties and incubated at 3 different salinities (ambient pore water salinity, +5ppt and -5ppt) in separate incubations for GHG production and DEA. GHG production and DEA rates will also be evaluated in relationship to soil properties to better understand the drivers in the observed spatial patterns. The results provide needed information on how future salinity alterations along the salinity gradient impact carbon balance and the cycling, retention, and removal of nutrients in coastal wetland ecosystems.

Sediment Bioturbation Affects the Fate of Pyrene in Laboratory Mesocosms

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Oil spills such as the one from the Deepwater Horizon incident cause oil deposition on the sediment in the intertidal and subtidal zones. These habitats are also home to a variety of benthic organisms that are active bioturbators. The bioturbation is likely to result in vertical movement of contaminated sediment, but it can also have an influence on sediment and water quality variables that may in turn affect the microbial community and its capacity for hydrocarbon biodegradation. The present study assessed the effect of bioturbators in pyrene-dosed laboratory mesocosms with beach sediment, seawater, and two bioturbators (razor clams or ghost shrimp). Both species had a variety of effects on sediment and water characteristics such as D.O., redox, turbidity, and the temperature differential between sediment and water column. The animals, and especially the ghost shrimp, increased the exchange between sediment and water column, supplying more oxygen to the sediment. The presence of both species also resulted in lower levels of pyrene at the end of the 10-15 day experiment duration, both in the water column and in the sediment. These results show that the bioturbator presence results in an increased disappearance of pyrene from the system. This is consistent with our earlier finding of an increased PAH-biodegradation capacity of the sediment microbial community in the presence of the bioturbators.

CONCORDE: Measurement of Fine- to Sub-Mesoscale Processes Driving Autumn Plankton Distributions and Transport in the Highly Dynamic Coastal Shelf System of the Northern Gulf of Mexico

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The CONsortium for oil exposure pathways in COastal River-Dominated Ecosystems (CONCORDE) is focused on identifying the processes influencing the exposure of marine organisms to contaminants in a river-dominated coast. The shelf waters within the northern GOM are characterized by complex three-dimensional flows impacted by pulsed river outflow, internal waves, tides, and winds. The aggregate impact of these physical features on stratification and plankton distributions is further influenced by biological responses, including overall plankton abundance and ontogenetic and diel vertical

movements. We used two ships for fine-scale to sub-mesoscale sampling in the vicinity of a mooring array capturing the 3-D advective flow and mixing. A broad suite of environmental (e.g., T, S, O2, PAR, pH) and fluorescence (Chl-a, CDOM) variables were measured. Fine-scale vertical profiles of fluorometry and Holocam were interspersed with spatially aligned, vertically undulated towed plankton imaging system (ISIIS) and multibeam acoustic watercolumn backscatter. Three days of sampling allowed assessment of diel, tidal, wind, and internal wave influence on plankton distributions. Ultimately, these empirical results will be used to assess the relative importance of individual and coupled processes driving plankton distributions and their respective potential for exposure to contaminants within this system.

Toxicity Responses of Killifish Embryos Exposed to Saturate, Aromatic, and Polar Fractions of Louisiana Sweet Crude Oil

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Current models for estimating the ecological risks of oil mixtures assume additive toxicities of polycyclic aromatic hydrocarbons, but recent studies suggest mixture effects depend on different combinations of different fractions of oils. Some of these fractions persist in the environment for decades, but their contribution to toxicity is not well understood. The purpose of this study is to analyze the developmental and transcriptomic responses of Atlantic killifish (*Fundulus heteroclitus*) embryos exposed to whole and fractionated Louisiana sweet crude (LSC) to discover the fractions of LSC oil that are responsible for toxicity. High-energy water-accommodated fractions (HEWAFs) and chemically enhanced HEWAFs (HE-CEWAFs) were prepared for animal exposures using whole LSC and 3 LSC fractions: saturate, aromatic, and polar. Embryos were exposed for 6 days post-fertilization (post-organogenesis) and assessed for heart rate, developmental abnormalities (scored as sublethal phenotypic endpoints), time to hatch, growth, and survival. Early-to-mid-development embryos were also archived for RNA-Seq gene expression profiling. HEWAFs and HE-CEWAFs produced dose-responsive sublethal effects on heart rate and development. Ongoing transcriptomic analyses may reveal mechanistic differences between oil fractions and will further our understanding of oil's potential for long-term ecological effects.

Benthic Indicators of a Deep-Sea Blowout

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Many studies have been performed in the past five years examining the resource injuries caused by the Deepwater Horizon (DWH) blowout, which released roughly five million barrels of oil into the deep Gulf of Mexico (GOM) in 2010. Injuries in the water column were observed during and immediately after the incident while long-term effects on coastal and deep-sea habitats have also been documented. However, due to the unique nature of the DWH blowout, and general lack of information on the deep-sea, there is still much to be learned about how deep-sea communities have responded to the blowout. This work examined infaunal macrobenthic communities collected from soft-bottom habitats in the fall of 2010 at various distances away from the DWH wellhead. Two areas or zones were defined: 1) as heavily or moderately impacted, and 2) as background or reference conditions. Community structure was confirmed to differ between reference and impact zones. Individual taxa were then examined to

determine how they responded to the blowout. These data were used to identify taxa whose presence or absence may be indicative of oil pollution, based on sensitivity. Defining benthic bioindicator taxa will be useful for assessing the effects of future pollution events in deep-sea habitats. The removal or addition of benthic taxa may also effect trophic transfer of contaminants in the sediments to the water column, organic recycling in the seafloor, and biodegradation of hydrocarbons.

The Evolution of the Deepwater Horizon Oil Spill: Updates on Fate and Transport of the Oil

Effect of Photooxidation on the Biodegradability of Macondo Oil Sand Patties Deposited on Gulf Shore Beaches

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The Macondo spill resulted in the deposition of sand patties in the swash zone along northern Gulf of Mexico (GoM) beaches. The susceptibility of sand patties to further weathering is unknown, but their exposure to sunlight and seawater suggests that photooxidation and biodegradation processes might be important. Initial experiments using a 35SO4 tracer revealed that seawater readily penetrated sand patties. Field collected sand patties were subjected to simulated sunlight in the presence of filter-sterilized seawater for up to 84 h. The seawater was replaced and stored at -20° C every 12 h, to represent 3 d of sunlight exposure in the illuminated samples while dark samples served as controls. Greater UV absorption (240 nm) was evident in seawater from illuminated samples relative to dark controls at all times, but maximum differences were observed upon initial collection. The sand patty/seawater extracts contained a wide variety of photooxidation products as determined by negative electrospray high resolution mass spectrometry. When the extracts were used as organic amendments in 24 d aerobic biodegradation experiments, the irradiated sand patty extracts stimulated total oxygen consumption (796 µM) well over endogenous (288 µM) or dark controls (420 µM). These findings suggest that photooxidation leads to the gradual dissolution of water-soluble polar organic compounds from sand patties and that some portion of these compounds is amenable to aerobic biodegradation.

Intact Ribosomal RNA in Mercury-poisoned Sediment Trap Samples: Preservation or Growth?

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Sediment trap sample preservation is critical for characterizing export to the deep ocean. Mercuric chloride ($HgCl_2$) is a common preservative. Ribosomal RNA (rRNA) is considered an indicator of currently active microbes, because it is susceptible to chemical and enzymatic degradation. Surprisingly, high rRNA concentrations were found in $HgCl_2$-preserved samples collected over a one-year trap deployment near the Deepwater Horizon wellhead. We are investigating the effects of $HgCl_2$ on pure-culture and particle-associated microbes. With *Escherichia coli* in artificial seawater plus $HgCl_2$, high rRNA concentrations could be recovered after 80 days at 4°C (but not room temperature), although no colony-forming bacteria were detected, suggesting they have entered a viable but non-culturable (VBNC) state. Marine aggregates were then prepared from estuarine water with or without weathered Macondo oil and incubated for one month with and without $HgCl_2$, at 4°C or room temperature. rRNA concentration decreased rapidly in all $HgCl_2$ treatments, but remained detectable in cold-room samples. Protease activity declined rapidly within the first week in all treatments, but then remained nearly constant. POC concentrations were relatively constant except in the $HgCl_2$ plus oil treatments (the most relevant to spills), where they decreased. Mercuric chloride's effectiveness may therefore depend on sample type and temperature, and intact rRNA may not always reflect the currently active population.

Distribution of Estimated Oil Equivalence (EOE) and Polycyclic Aromatic Hydrocarbon (PAH) in Water Samples after the Deepwater Horizon Incident

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Total scanning fluorescence (TSF) is an effective screening tool to detect the presence of aromatic compounds derived from petroleum in environmental samples. TSF analyses was performed to determine the estimated oil equivalence (EOE) of 562 water samples collected at various depths throughout the water column near the Deepwater Horizon wellhead between July 2012 and June 2014 as part of the GISR consortium. The EOE were calculated from TSF response of Deepwater Horizon Oil (DWHO) standards of varying concentrations. EOE ranged from <0.07 to 28 ug/L (median 0.33 ug/L mean 0.82 ug/L) when one surface sample collected with a bucket in an observed surface slick (EOE concentration of 3800 ug/L) is not included. A total of 51 samples with elevated EOE concentrations (range 0.4 to 28 ug/L) were analyzed for polycyclic aromatic hydrocarbons (PAH). The total PAH concentrations ranged from 0.61 to 621 ng/L (median 24.1 ng/L and mean 89.8 ng/L). PAH and EOE concentration had a linear correlation coefficient (R2) of only 0.74. This is due to the use of DWHO as a standard when there are likely multiple sources of oil in these sample, it is unlikely that DWHO is one of them, the PAH indicate oil at varying degrees of weathering (e.g. low C3-naphthalene/ C-3phenanthrene ratios) and in some samples presence of combustion sourced PAH.. On average, total PAHs measured represent 2.0% of EOE content present in these water samples. Only 12 of the samples had PAH concentrations above 100 ng/L and all of those were collected from depths of 0 to 40 meters and most were close to shore. These detection of EOE and PAH in these samples confirm the presence of background petroleum hydrocarbons in Gulf of Mexico in the absence of a major oil spill. The spatial and depth distribution of these backgrounds water concentrations will be discussed.

Analysis of Hydrocarbons in WAF and CWAF by Fluorescence. Results of an Intercalibration Exercise

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The water accommodated fraction (WAF) and chemically enhanced water accommodated fraction (CWAF) of petroleum has been widely used in toxicity tests, mesocosm experiments, and other experiments. In order to replicate what happened during the Macondo spill of 2010, we used the dispersant Corexit 9500A and surrogate Macondo oil to prepare WAF and CWAF. Analysis of aromatic hydrocarbons by fluorescence is a widely used technique, particularly for the analysis of hydrocarbons in WAF and CWAF, because it is a fast and inexpensive technique, which allows for near real-time measurements. An intercalibration exercise was conducted for the participants of the Aggregation and Degradation of Dispersants and Oil by Microbial Exopolymers (ADDOMEX) Consortium using three instruments, one of which was a filter fluorometer and its wavelengths could not be changed. A set of seven samples of WAF and CWAF at different concentrations was measured directly in seawater. Spearman correlation coefficients were between 0.81 (P=0.02) and 0.98 (P=0.01), but the graphs showed large scatter. The experiment was repeated using extracts of the WAF and CWAF solutions in CH2Cl2, and in this case correlation coefficients were between 0.96 (P=0.0009) and 1 (P=0.0001) with much less scatter. Based on these results, it is recommended that measurements of hydrocarbons in WAF and CWAF be in CH2Cl2 extracts.

Chemical Evidence for Exposure of Red Crabs (*Chaceon quinquedens*) to Macondo Oil after the Deep Water Horizon Oil Spill

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The Deepwater Horizon (DWH) oil spill is unique because unlike most oil spills, a substantial fraction of the released oil was deposited on deep benthic sediments in the form of particulate, dispersed and floc related oil. From 2010 to 2014 benthic macrofauna (e.g., red crabs) were collected from the deep seafloor to determine if there was forensic evidence to indicate exposure to the spilled Macondo oil. Polycyclic aromatic hydrocarbons (PAH) and biomarkers (triterpane and steranes) were measured in whole body and dissected tissue samples from red crabs, in order to identify the chemical fingerprint of any oil present within the tissue. Results show that red crabs were exposed to Macondo oil from the DWH oil spill. Specific results include:
(1)The red crab hepatopancreas samples provided the most sensitive and diagnostic chemical fingerprints by which to assess exposure of these animals.
(2) The highest exposures of red crabs to Macondo oil occurred closest to the well although exposures up to 14 km southwest of the well were recognized.
(3)The absolute total concentrations of PAH (TPAH) measured in red crab hepatopancreas samples decreased by almost two orders of magnitude between 2010/2011 and 2014, which is consistent with benthic exposures to Macondo oil-derived PAHs that have declined since the DWH oil spill - and are inconsistent with on-going exposure to oil from natural seeps in the area.

Hydrocarbon Composition and Bacterial Community Associated with Tarballs following the Texas City "Y" Oil Spill

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The Texas City "Y" incident, which occurred in Galveston Bay near Texas City, Texas on March 22, 2014 resulted in an oil spill of approximately 168,000 gallons. Strong northeasterly winds carried the oil out of the bay, but onshore winds brought back the oil ashore. A few days later, tarballs were found scattered over a large section on beaches as far as Mustang and Padre Islands, >200 miles southwest of the incident site. To determine the hydrocarbon and bacterial community composition of tarballs, we collected 44 samples from Galveston and Mustang Islands. Tarballs were collected 6 d, 11 d, 3 mo, 11 mo, and 13 mo after the spill. Tarballs were fingerprinted using conservative biomarkers hopanes and steranes. Confirmed samples from the Texas City Y Spill were analyzed for aliphatic hydrocarbons, polycyclic aromatic hydrocarbons (PAHs) and alkylated PAHs by GC-MS. Microbial community was determined by high throughput tag sequencing. Samples from Galveston 6 d after the spill were depleted of light alkanes and light PAHs and dominated by *Alcanivorax*, an alkane-degrading bacteria, and *Psychrobacter*. Samples from Mustang obtained 11 d after the spill were more depleted of mid-chain alkanes and heavier PAHs and comprised mainly of *Pseudoalteromonas*, a known PAH degrader, and *Psychrobacter*. This study relates oil transport and succession of bacterial communities to changes in oil chemistry, which is crucial in understanding the fate of oil in the marine environment.

Cuticle Accumulation of Petrogenic PAHs on *Spartina*: a Novel Exposure Pathway for Marsh Biota

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Deposition of 3-ring petrogenic PAHs (alkylated phenanthrenes and dibenzothiophenes) on the exterior of *Spartina* leaves has been demonstrated in field and laboratory measurements over the past 3 years in marshes impacted by the Macondo spill. Concentrations of PAHs exceeding 80 mg/kg have been detected in extracts from the cuticle of *Spartina* in plants with no other obvious indication of oiling. These measurements have led to the hypothesis that volatilization of PAHs from oiled sediments is followed by partitioning to the *Spartina* cuticle. This presentation will critically review the field and laboratory evidence for this route of exposure contrasting it with other explanations. These include leaf sorption of aqueous PAHs during tidal inundation or uptake through the plant tissues via the transpiration stream. Data to be presented include direct measurements from various fractions of *Spartina* tissue in oil-impacted marshes in Port Fourchon and upper Barataria Bay; laboratory chamber studies exploring PAH:cuticle partitioning under controlled conditions, and mass transfer models of relevant processes. These data will be presented in the context of completed routes of exposure to *Littoraria irrorata* (marsh periwinkle snails) who spend a significant portion of their life cycle on *Spartina* cuticle surfaces. Data from recently initiated studies on imaging of contaminated *Spartina* cuticles using two-photon confocal scanning laser microscopy will also be presented. The significance of this research is that this route of exposure has the potential to continue as the long-term recovery of marshes proceeds. Cuticle PAH measurements may serve as an effective measure of long-term recovery of oil-impacted marshes.

Characterization of Sedimentary Biomarker Species from the Northeastern Gulf of Mexico Using Ultra-High Resolution FTICR-MS

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Marine surface sediments provide a unique, spatially and temporally integrated record of the changes and impacts to which a given regional sea was subjected. Hence, various analytical methods have been developed in order to investigate recalcitrant organic molecules in sediments, and use them as proxies for the reconstructions of past marine conditions (e.g. sea surface temperature), processes (e.g. methanotrophy), communities (e.g. phytoplankton); or the forensics of anthropogenic pollutants (e.g. oil spills). Yet, most of these commonly used strategies focus on a limited set of species, due to the lack of comprehensive analytical methods and instrumentation able to deal with the complex composition of sediments. We present an FTICR-MS based method which can overcome these limitations, and enable rapid, non-target screening of known and novel sedimentary biomarkers, after simplified sample preparation. Overview of the simultaneously detected suites of species, such as Archaeal ether lipids (e.g. glycerol dialkyl glycerol tetraethers - GDGTs), or pigments (e.g. porphyrins, carotenoids), among others, will demonstrate the potential of this methodology. We discuss the distributions of biomarker species along the selected sediment cores from the NE Gulf of Mexico (DeSoto Canyon), where elevated hydrocarbon deposition was detected in the aftermath of the DWH blowout; and investigate their potential use as proxies of oil pollution and/or records of marine geochemical background.

Oxygen Biostimulation of Buried MC252 Oil in Coastal Beach Sands

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Following the Deepwater Horizon spill, MC252 oil accumulated and was subsequently buried in front of a hard structure constructed at a breach on Fourchon Beach, Louisiana. Despite mechanical efforts made to remove the buried oil, contamination currently remains beneath the anoxic groundwater table. Groundwater characteristics suggest nutrient conditions are favorable for biodegradation in the subsurface. However, the persistence of 3-ring PAHs (alkylated phenanthrenes, dibenzothiophenes) and chrysenes demonstrates inefficient biodegradation rates under sulfate reducing conditions. Injection of oxygen into anaerobic sulfidic groundwater could improve the biogeochemical conditions and allow for PAH degraders to emerge. Two microcosm studies were conducted to determine if suboptimal additions of oxygen can create sufficient conditions for PAH degraders to be stimulated. Oiled sand, sampled in 2013 and 2015, and groundwater from the study site were treated over 80 days by adding varying volumes of pure oxygen (O2). Treatments included: (i) anaerobic (no O2 added), (ii) killed control (no O2 added + biocide), (iii) 2.5 mg O2/L, (iv) 4.5 mg O2/L, and (v) 6.5 mg O2/L. Oxygen was dosed in batch every 2 days. Initial PAH analysis was generated from time zero samples, and analyzed forward every 27 days. After 80 days, the samples treated with 4.5 mg O2/L showed the highest decrease in total PAHs for both the 2013 and 2015 material at 88% and 30%, respectively. Weathering ratios comparing alkylated phenanthrenes and dibenzothiophenes with poorly biodegradable alkylated chrysenes decreased by half for the 2013 material. Extension of these studies are in progress, as well as a metagenomics analysis of the microbial populations involved and additional oxygen demand tests.

Compositional Changes in Oil Exposed to Sunlight

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Solar irradiation of oil results in the formation of highly oxygenated photoproducts. We have utilized high resolution mass spectrometry to determine molecular formulas of water soluble organic photoproducts as well as photoproducts in the oil phase. A range of oil materials were studied, including oil from the MC252 well (source of Deepwater Horizon spill), residual fuel oil (NIST 2717a), and sand patties collected from the swash zone on Gulf of Mexico beaches. Oxygenation occurred across a broad range of oil compounds, including saturated alkanes and aromatic species, and across a wide range of carbon number. Furthermore, both nitrogen containing and non-nitrogen containing molecules were susceptible to oxygenation. Photoproducts with up to ten oxygen atoms per molecule have been observed in studies with extended exposure to simulated sunlight. Although all samples showed solar initiated oxygenation, resulting photoproducts from irradiated sand patties did not inhibit microbial respiratory activity. We also measured reactive transients formed from solar irradiation of oil. Singlet oxygen and hydroxyl radical were detected when oil on water was irradiated. In addition, excited triplet states were observed with excited state energies near 280-300 kJ/mol, which is higher than values previously observed for natural organic matter derived triplets (~250 kJ/mol). Individual PAHs in tetradecane films on water produced singlet oxygen and hydroxyl radical when exposed to simulated sunlight, suggesting that these molecules are the source of the reactive transients in solar irradiated oil. This project was supported by the US National Science Foundation and The Gulf of Mexico Research Initiative.

Water Accommodated Fraction (WAF) and Chemical Enhanced Water Accommodated Fraction (CWAF) Production using BP surrogate oil and COREXIT 9500A for Dosing of ADDOMEX Mesocosms: Experiment 1

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The 2010 Deep Water Horizon (DWH) oil spill is reported to have deposited flocculent materials. An objective of the ADDOMEX consortium is to employ mesocosms to understand the role of phytoplankton and bacteria in the production of neutrally and positively buoyant particles when petroleum and dispersants are present. As part of these studies, a water accommodated oil fraction (WAF), Corexit plus WAF (CWAF), a diluted CWAF (to match oil concentration in the WAF tank) and control mesocosms were tested. . Each tank was filled with 79L sea water and 2L concentrated plankton collected from the Gulf of Mexico. Total Scanning Fluorescence (TSF) analysis was performed to estimate the petroleum concentration at the beginning, during and at the end of the experiment. No additional oil was added to the tanks during the incubations. Additional controls included WAF diluted CWAF and CWAF in the same seawater but with no added plankton populations. A calibration curve was generated using a BP surrogate standard oil at five different concentrations. These standards were analyzed on a Horiba Aqualog® fluorometer. The excitation/emission wavelengths for the maximum fluorescence intensity was determined and then used for calculating the sample concentration. Detailed chemical analyses will be presented on the amount and changes in the composition of the WAF and CWAF with time.

Monitoring the Aerosol Composition Changes in Oil Evaporation and Oxidation Experiments

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Primary Organic Aerosol (POA) is emitted directly by anthropogenic or natural sources, whereas Secondary Organic Aerosol (SOA) is formed in the atmosphere through chemical reactions that result from conversion of more volatile species into lower volatility oxidized products and their subsequent condensation to the particulate phase. We studied SOA formation from evaporation of Macondo crude oil (MC 252) using a wind tunnel coupled to a flow tube oxidation reactor. Ozone, UV lights, and water vapor were used to make OH radicals. Organic compounds in the gas phase, both those evaporated from the wind tunnel and those formed in the flow tube oxidation experiments, were monitored using proton-transfer-reaction mass spectrometry (PTR-qMS and PTR-TOF-MS). We observed approximately 400 different species. Compounds with less than C10 were mostly evaporated in the first 5 hours when maximum SOA formation was also obtained. Hydrocarbons with carbon number (11-14) were still present in the oil after 12 h of continuous evaporation at wind speed of 2 m s-1. We will show the implications of these results for the production of SOA related to the range of evaporated chemical size and reactivity.

Potential to Accurately Characterize Alkyl-PAHs in Weathered Oils in Environmental Matrices Using Gas Chromatography-Triple Quadrupole Mass Spectrometry (GC/MS/MS)

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The accurate identification and quantification of alkylated derivatives of polycyclic aromatic hydrocarbons (alkyl-PAHs) in complex weathered environmental matrices is always challenging, primarily due to the interferences in the samples which are co-extracted and co-eluted along with the target compounds. Alkyl-PAHs are the most abundant form of PAHs in crude oils, often tend to be more persistent and equally or more toxic than the parent PAHs, and may be the main constituents responsible for chronic toxicity. Thus, it is essential to efficiently separate, and accurately quantify their concentrations in high background samples. This study aims at development and utilization of a fingerprinting method in gas chromatography coupled with a triple quadrupole mass spectrometry (GC/MS/MS) in Multiple Reaction Monitoring (MRM) mode for the analysis of alkyl-PAHs in weathered oil matrices. The higher selectivity and signal to noise ratios of the MRM method provides a precise identification and quantification of target compounds at lower detection limits. The MRM method was optimized and used to analyze sediment samples collected in between 2010-2015 from the Louisiana coasts, heavily impacted by the Deepwater Horizon oil spill. The results were then compared with commonly used Selective Ion Monitoring (SIM) GC/MS method. The preliminary results indicate that the MRM method removes interfering ions from impurities and can be a powerful analytical strategy for a reliable quantitative determination of trace levels of alkyl-PAHs in complex matrices.

Sedimentological Signature of the 2010 DWH Event: Will It Be Preserved?

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Following the 2010 DWH event, a depositional pulse was documented in bottom sediments in the NE Gulf of Mexico (GoM). This sedimentation event resulted in a ~1 cm thick surface layer deposited within ~5 months, recorded by elevated excess 234Th inventories and mass accumulation rates (MAR), as compared to the following ~4 years. The sedimentological signature of the depositional event was recorded differently in two sedimentologic regimes. On the western, siliciclastic sediment-dominated side of the Desoto Canyon the event was manifested as increases in calcium carbonate content and silt-sized sediments. The eastern, carbonate sediment-dominated side of DeSoto Canyon exhibited no systematic change in carbonate content, but sediments were fining upward through the pulse layer. This sediment distribution pattern is consistent with a massive sediment influx from surface waters in both sedimentological regimes, but is inconsistent with increased siliciclastic sediment input by the Mississippi River. Time series data exhibit reproducibility in the years following initial sampling, and indicate that the sedimentological signature of the event has thus far been preserved. Continuation with the time series will provide insight into the long-term preservation potential of the sedimentological signature of this event, and can help to identify other, similar depositional events, whether natural or anthropogenic, that may be preserved in the sedimentary record.

Elucidation of Biodegradation Products and Rates of Surfactants from Corexit® 9500 Dispersant in Seawater under Aerobic Conditions

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The application of Corexit® series dispersants during the Deepwater Horizon emergency response facilitated the dispersion and dissolution of oil into the water column. However, the fate and overall biotransformation kinetics and products of Corexit® 9500 in seawater remain comparatively unknown. Corexit® 9500 is a mixture of hydrocarbon solvents, the anionic surfactant DOSS and nonionic SPAN 80 and TWEEN 80 and 85 surfactants. Biotransformation experiments with Corexit® and the individual dispersant components (total concentration of 10 mg/L) were conducted in aerobic batch reaction flasks using coastal seawater over a period of 30 days. Samples were analyzed by LC-HRMS and tandem MS/MS to characterize and identify the components and transformation products using high mass accuracy and fragmentation analysis. A charged aerosol detector was also used to quantify the components and transformation products over the course of the experiment. We observed complete ester hydrolysis of sorbitan and isosorbide polyethoxylate (PEO) monoesters during the first 24 hours of the experiment, and ester hydrolysis of the sorbitan and isosorbide PEO di- and tri-esters after 7 days. The DOSS component remained stable over the initial 7 days of the experiment and then decreased by 25% over the final 20 days. Results from parallel killed (50 mg/L HgCl2) control samples indicated abiotic hydrolysis of the monoester polyethoxylates, albeit at slower rates than under biotic conditions. Identification of transformation products of Corexit® 9500 surfactants and the measurement of associated transformation rates will lead to a better understanding of the fate, transport, and persistence of dispersants in marine environments, ultimately informing use of these materials in mitigation of future oil spills.

The Influence of Mixing Energy on the Concentration, Composition, Toxicity, and Relevance of Laboratory Toxicity Tests

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Water accommodated fractions (WAFs) are standard laboratory preparations used to simulate oil exposure in aquatic toxicity testing. Standard protocols for preparing WAFs use low- or medium-energy mixing. Recently, a new high-energy mixing technique (HEWAF) has been used to test the toxicity of oil. In this presentation, WAF preparations are compared to 2010 field-collected water chemistry using laboratory chemistry data from toxicity tests and laboratory measurements of the mixing energies (turbulent dissipation rates) of different WAF preparations. Concentrations of total polycyclic aromatic hydrocarbon (TPAH) and tricyclic PAH in unfiltered HEWAFs were 1-2 orders of magnitude higher than WAFs prepared using established methods. Unfiltered HEWAFs also had a larger percentage of high molecular weight PAHs and alkylated PAHs. Compared to field-collected samples, HEWAFs have considerably different chemical compositions and concentrations of important tri-cyclic PAHs and, hence, do not provide a realistic environmental analog. In related experiments, the turbulent dissipation rates of HEWAF preparations were measured and determined to be greater than 60,000 times that which have been recorded and published for breaking waves. Even the mixing energy of standard WAF preparations was over 7 times stronger than a breaking wave. These characteristics bear on the relevance of HEWAF toxicity studies to field conditions.

The Effect of Oil Spills on Marine Microbes: the Importance of Where, When, and How

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While much recent attention has been paid to the Deepwater Horizon oil spill in the Gulf of Mexico and biodegradation by microbial communities, it is important to remember that numerous factors may determine the types of environmental effects that may result from oil spills. Not all oil spills (e.g., crude, refined, weathered, fuels, use of dispersants) are created equal, and it is likely that the characteristics of different environments will affect ecosystem response to oil. Temperature, salinity, and solar radiation are three potentially important factors related to location and seasonality. The effects of some of these environmental factors on the formation of Water Accommodated Fractions (WAFs) developed from Deepwater Horizon oils and the subsequent effects on microbial growth are being investigated. WAFs were generated under varying solar but controlled temperature conditions, various temperatures and salinities, as well as from burned and weathered oil. After all WAFs were collected, each was added to a coastal seawater sample and their effects on bacterial production or phytoplankton photosynthesis determined. Results from both assays demonstrated that WAFs produced in the dark had minimal effects on growth while inhibition was proportional to the amount of solar exposure. Burning oil prior to formation of WAFs increased inhibition of production independent of subsequent solar treatment. Preliminary data suggests that temperature plays a minimal role. The results imply that the ecological effects caused by oil spills are very light dependent and thus could vary by season, location, and may occur to significant depths in the ocean.

Hydrostatic Modeling of Buoyant Plumes

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The Deepwater Horizon (DwH) oil spill in the Gulf of Mexico has led to increased interest in understanding point source convection dynamics in deep water. Most existing oil plume models use a Lagrangian based approach, which computes integral measures such as plume centerline trajectory and plume radius. However, by construction Lagrangian models neglect internal plume dynamics, as well as feedbacks of the buoyant plume on the ambient environment. We hypothesize that DwH-like plumes are dynamically active, and we use an Eulerian based convection model to test this hypothesis. We perform a series of hydrostatic numerical simulations to examine the dynamics of buoyant plumes in the presence of stratification, planetary rotation, and background cross flow. Initial results show that planetary rotation strongly affects the spreading buoyant plume and results in a modification of the plume trajectory relative to the background environment. In a quiescent environment, the buoyant plume becomes baroclinically unstable, resulting in anticyclonic vortex formation at the neutral buoyancy layer. After approximately 35 days, this vortex begins to propagate away from the buoyancy source. In the presence of a background cross flow, dynamically active bands of anticyclonic vorticity moving relative to the background flow appear at the neutral buoyancy layer. We also observe cyclonic vortex formation and propagation at several depths in the vicinity of the wellhead in a both a quiescent environment and an environment with a weak background cross flow. In addition, initial results show that by increasing planetary rotation in a quiescent environment, vortex formation and propagation occurs at a faster rate at all levels.

Characterization of Oil and Water Accommodated Fractions used to Conduct Toxicity Testing for the Deepwater Horizon Natural Resource Damage Assessment

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The April 2010 blowout of the Deepwater Horizon (DWH) released millions of barrels of crude oil 80 kilometers off the coast of Louisiana. As part of the subsequent Natural Resource Damage Assessment (NRDA), we implemented a laboratory testing program to evaluate the toxicity of DWH oil and oil/dispersant mixtures to aquatic organisms of the Gulf of Mexico. Due to the variety of exposures that likely occurred during and after the spill, the testing program included four DWH oils, which encompassed a range of oil weathering states, and three different oil-in-water mixing methods, for a total of 12 different water-accommodated fractions (WAFs). To better understand exposure chemistry across the toxicity testing program, we examined the effect of various WAF preparation parameters - including mixing energy, starting oil composition, and oil-to-water mixing ratios - on the chemical profiles and the final concentrations of these 12 WAFs. Our results showed that both the degree of oil weathering and the mixing energy played a role in determining polycyclic aromatic hydrocarbon (PAH) composition and concentration in each WAF. In addition, we describe the dissolved and particulate phases and the associated droplet sizes for each WAF preparation/oil type combination, including assessing how these parameters change over time. Ultimately, the detailed chemical characterization presented can aid in the analysis and interpretation of several hundred aquatic toxicity tests performed as part of the DWH NRDA toxicity testing program.

A Field Trial of In Situ Bioremediation as a Response Option for Oil-Contaminated Beaches

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Expanding the range of options for oil spill response along the Gulf Coast is an important outcome of Macondo spill research. This paper will present an updated case study of a beach segment on Fourchon Beach, Louisiana where hard structures used to protect adjacent marsh and mangroves created conditions for burial of oil beneath the beach groundwater table. Response option are particularly sparse for this oiling condition even through established technologies can be readily ported from risk-based corrective action program for contaminant clean-up from other spills. At this location, a field trial of in situ aerobic bioremediation of buried oil remaining in this segment has been underway since July 2015. At a location on the supratidal portion of the beach, oxygen is being added using controlled addition to the subsurface using Waterloo emitters which deliver O2 through diffusion via pressurized tubing placed below the water table in fixed wells. The addition of O2 stimulates the growth of aerobic crude oil degrading microorganisms in this anaerobic groundwater environment. A range of chemical and microbiological lines of evidence are being collected during the demonstration including: stable isotopic and 14C analysis of dissolved CO2 in groundwater; O2 and other alternate electron acceptor concentrations, in situ nutrient concentrations, and weathering ratios constructed by comparing 3-ring PAHs (alkylated phenanthrenes and dibenzothiophenes) with poorly biodegradable C30-hopanes and alkylated chrysenes. Microbial characterization using next-generation sequencing is also being conducted on DNA extracted from oiled sands before and after O2 addition. Characterization of groundwater flow, direction and salinity will be presented from field-deployed dataloggers at the site. The study design uses a weight of evidence approach to judge success of in situ bioremediation in sands of various oiling conditions. The study is deploying phased O2 dosing using sequential additions of breathing air, pure oxygen and oxygen supplemented by solid oxidants. The significance of this study is it

represents one of only field scale demonstrations of alternate approaches to reaching clean-up endpoints for MC252 crude oil in Gulf Coast coastal beach habitats.

The Chemistry of Oil Evolution and Exopolymeric Substances and their Interaction with Microbes in Oil Spills

CONCORDE: Preliminary Distribution of Plankton along Three Sampling Corridors in the Northern Gulf of Mexico

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The CONsortium for oil spill exposure pathways in COastal River-Dominated Ecosystems (CONCORDE) is integrating biological and physical observations to understand potential transport pathways for oil and oil-dispersant complexes in dynamic, nearshore areas of the Northern Gulf of Mexico. Three regions of interest were identified, each with different biophysical characteristics (e.g., freshwater discharge, turbidity, nutrient loading), which vary seasonally (e.g., high flow vs. low flow) and are expected to influence the distribution and composition of planktonic assemblages. The three cross-shelf sampling "corridors" extend from the 15-m to the 50-m isobaths and are located: 1) south of the Alabama-Florida border; 2) south of Mobile Bay; and 3) south of Horn Island along the eastern edge of the Chandeleur Islands. To characterize the planktonic community in relation to local hydrography, each of these corridors will be sampled during low flow (Fall 2015) and high flow (Spring 2016) periods. We present preliminary findings from the Fall 2015 sampling cruise, which included high-resolution vertical and horizontal sampling with a vertically undulated towed plankton imaging system (ISIIS), multi-beam acoustic backscatter, FlowCAM®, and depth-discrete plankton net samplers. By examining the distribution of plankton relative to biophysical parameters, we will gain a better understanding of the sub-surface transport of oil into nearshore, river-dominated ecosystems as well as the planktonic organisms most vulnerable to exposure, which support valuable fisheries in the region.

Fate of Oil Droplets and Dispersants on Zooplankton and its Effect on the Ecosystem

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Little attention has been paid to the ability of abundant marine animals to alter the fate of oil. Planktonic invertebrates are numerically dominant in the ocean and many species process huge quantities of water, and directly interact with particles in the size range of oil droplets. We observed the interactions between oil droplets and several zooplankton: copepods, *Daphnia*, and *Artemia*. We found no effect of oil droplets on the swimming behavior of copepods. In contrast, oil droplets suspended in water stick to *Daphnia* and restrict their swimming ability. Specifically, the *Daphnia* get stuck at the air-water interface. Although the swimming behavior of *Artemia* was not affected, animals consume the oil droplets and dispersants which produce abnormally long fecal pellets (~ three times body length). These fecal pellets remain attached to the body of *Artemia*. We hypothesize that *Daphnia* stuck at the water surface and *Artemia* carrying long fecal pellets may experience higher predation risk by fish due to greater visibility. It could result in fish consuming higher concentration of oil droplets and dispersants.

Interaction of a Natural Protist Community with Crude Oil Results in Dominance by a Dinoflagellate
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Despite their abundance, diversity and ecological importance, the interaction of protist communities with crude oil has received comparatively little attention. We investigated the response of a protist community to an oil spill that occurred in Galveston Bay, Texas and followed up with detailed laboratory experiments using natural communities from the Northern-western Gulf of Mexico. Results from field data showed no significant change in diatom abundance but significant increases dinoflagellates in areas impacted by oil. Increases in dinoflagelates within oil impacted sites were primarily the result of a single species (*Prorocentrum sp*.). This genus has been previously implicated in shellfish closures and is known to cause 'mahogany' tides. Oil concentrations were determined and results show that the highest concentrations of this dinoflagellate occurred at the highest oil concentrations. Laboratory experiments with natural communities resulted in significant increases of *Prorocentrum sp*. after exposure to crude oil and dispersants, relative to controls. However this pattern was not observed with *Prorocentrum sp*. as a monospecific culture. Heterotrophic ciliates exhibited an inverse relationship to *Prorocentrum sp*. in the natural community experiments and suggest that a higher tolerance to crude oil of *Prorocentrum sp*. may result in a release of grazing pressure from ciliates and result in population blooms after oil spills.

Capturing Floating Oils with Floating Granular Materials: Sorptive Carpets
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For small oil spills near the shorelines and such areas, as mangroves, an effective and quick capture method is needed. We developed an effective oil entrapment method for floating oils utilizing pulverized rubber (obtained from used tires) which can be subsequently recovered as floating carpet. Our objective was to estimate effective rubber to oil ratio and compare with powdered activated carbon (one of commonly used materials used in adsorption studies). A series of experiments utilized pulverized rubber and activated carbon with mesh size 50-200 and South Louisiana crude. The effective ratios of granular material to oil (w/w) were 0.85 for rubber and 1.56 for carbon. Efficiencies of these ratios and smaller ratios (around 70% of the initial) were very similar for both materials. Pulverized rubber can be an efficient and cheap method for the coastal areas to capture floating fresh oil spills. The floating layer can easily be removed from the surface as it forms a stable floating aggregate.

Impact of Marine Snow on Fate and Effects of Oil in Multispecies Experiments: You're Invited to Join!
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It is believed that the massive production of marine snow during the DwH oil spill resulted in the development of a layer of oil contaminated marine snow on the seafloor with adverse impact on the benthic community. Even years after the spill, recovery of the benthic community seems poor. This suggests that the presence of the marine snow enhances the (duration of the) impact of the oil. Within the C-IMAGE consortium, we studied the impact of oil polluted marine snow on oil degradation, on selected invertebrate species and on bioturbation. A selection of the results from these tests will be presented. In 2016 we will conduct multispecies studies in model ecosystems, containing a water column and benthic compartment housing a stable community of phytoplankton and micro- and

macroinvertebrates (including annelids, crustaceans, echinoderms, molluscs). Of course we will analyse many parameters such as fate of the oil over time (chemically and via bioanalysis), toxicity, bioturbation and core physical/chemical water quality parameters. In addition we invite fellow researchers to participate in these studies, for instance by applying their techniques to gain more insight in the functioning of the microbial community, or to demonstrate the practical value of new tools for field assessments. Science and scientists all profit if we share our effort and output!

Hyperbranched Polymers as Oil Dispersants: Influence of Salinity, pH, and Concentration on Dispersion Effectiveness

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In the quest for biocompatible dispersants, this research utilizes the oil-encapsulation and surfactant-like properties of hyperbranched polymers. Various molecular sizes of hyperbranched polyethyleneimine (HPEI) polymers were tested against Corexit 9500. Multiple dispersant-to-oil ratios (DORs) were evaluated while varying salinity and pH in order to determine how these parameters influence a dispersants' effectiveness. The effectiveness was measured using a batch bottle-mixing method followed by division into four layers with a separatory funnel. Dichloromethane extraction and total petroleum hydrocarbon measurements were used to quantify dispersed oil. The data show that HPEI polymers with low molecular weights (1.2 and 1.8 kilo-Daltons [kDa]) were not efficient as dispersants, but 10 kDa and 70 kDa can be comparable to Corexit. Larger polymers (750 kDa) are fairly effective, but inter-polymer interactions can cause enhanced aggregation and drop coalescence; this aggregation is magnified as the DOR increases. Atomistic discrete molecular dynamics simulations also show a strong cooperativity in the binding of dendritic polymers with model hydrocarbons. The polymers' effectiveness decreased as salinity increased due to double layer compression encouraging additional and more rapid drop coalescence. This knowledge is being used to design hyperbranched polymers with reduced toxicity and increased biocompatibility, capable of dispersion in a variety of marine, estuary, and fresh-water environments.

Fusion of Bio-physical Data and Predictive Modeling to Understand Gulf of Mexico Marine Species Resilience to Environmental Stresses and Disasters

Defining Surface Land Cover Features Using High Resolution Imagery from Unmanned Aerial Systems

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This project utilizes Unmanned Aerial Systems (UASs) imagery from a series of UAS missions flown over southern Louisiana to develop a method for identification and classification of land cover and surface water features. The system is being flown every two months providing a seasonal record that is important for identifying both the temporal and spatial changes in vegetation and stream networks. Using high resolution UAS imagery, change detection analyses quantify these temporal and spatial changes providing important information towards understanding the impacts of oil spills, hurricanes, and upstream pollutants. Similarly, this high precision stream network delineation within the estuary can help improve accuracy of future oil spill damage assessments by increasing our understanding of waterways and potential movement of oil. UAS imagery will prove to be instrumental in pre and post storm analyses because it is less resource intensive than satellite, field surveys, or manned aerial systems reconnaissance. Therefore, it would be possible to collect high resolution UAS imagery before and after an impending storm to identify damage and storm induced changes to the landscape. Furthermore, it is also possible to collect information about harmful algal blooms, suspended sediments, and colored dissolved organic matter from UAS data which can provide valuable information about the health of aquatic ecosystems.

Numerical Simulation of Diel Vertical Migrations of Zooplankton in Oil Emulsions and Freshwater Lenses

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Diel vertical migration (DVM) of zooplankton may have an impact on ocean mixing, though details are not completely clear. Zooplankton that undergo DVM can have an impact on oil transport through the water column and oil can have a negative effect on the ability to vertically migrate due to the highly viscous nature of oil emulsions. DVM patterns may also be altered by freshwater inflow, due to convective rains or river runoff, which produces strong anomalies of stratification associated with lenses of freshened water in the near surface layer of the ocean. A computational fluid dynamics model was used to simulate the turbulence signature of DVM in the upper ocean in the presence of oil emulsions and freshwater lenses. The model was initialized with typical vertical density and velocity profiles in the De Soto Canyon (CARTHE GLAD experimental range) located in the northeastern Gulf of Mexico. The effect of oil emulsions on DVM was included by altering the molecular viscosity of water in the upper layer of the ocean. The freshwater lenses were simulated as localized (in space) salinity and temperature anomalies, propagating as gravity currents, eventually mixing with the environment and increasing the vertical stratification. The model results suggest that propulsion speed of some organisms may somewhat change because of buoyancy effects due to varying salinity stratification in the upper layer of the ocean; the presence of oil emulsions, however, can have a more dramatic effect on the DVM of zooplankton (with dire consequences for the marine ecosystem).

CONCORDE: Environmental Observations and Planktonic Processes

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The CONsortium for oil spill exposure pathways in COastal River-Dominated Ecosystems (CONCORDE) focuses on the nearshore environment (within the 50-m isobath) of the northern Gulf of Mexico. The goal of CONCORDE is to integrate biological and physical data and construct high resolution ocean models that will help predict the movement of oil in nearshore environments and how exposure to oil is mitigated by biological and oceanographic processes. Research cruises will be conducted during "low flow" (Fall) and "high flow" (Spring) periods to examine the influence of river discharge and other seasonably variable parameters on the planktonic community. A towed plankton imaging system (ISIIS), traditional net samplers, acoustic backscatter, Flow Cytometry and Microscopy (FlowCAM), and high resolution profilers equipped with physical, optical, and chemical instruments will be used to characterize the three-dimensional, bio-physical environment in the study region (Chandeleur Islands to just east of Mobile Bay). By examining how plankton aggregate in response to environmental and physical parameters, we will have a better understanding of how the sub-surface oil and dispersant complex distributes in nearshore river-dominated ecosystems and elucidate exposure pathways for organisms through trophic interactions of the planktonic community.

Impact of the 2010 Deepwater Horizon Oil Spill on Southeastern Louisiana Marshes Evaluated with Landsat Data from 1984 - 2015

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The effects of the 20 April 2010 Deepwater Horizon oil spill on Terrebonne Bay, Barataria Bay, and Breton Sound coastal marshes within 90 m of the Gulf of Mexico were investigated using satellite data collected between 1984 and 2011 by Landsat Thematic Mapper (TM) and between 2013 and 2015 by Landsat Operational Land Imager (OLI). Landsat data were unavailable between the 2011 failure of Landsat TM sensor and the launch of Landsat OLI sensor in April of 2013. The Landsat data sets collected before April 2010 provide context to interpret changes in land area detected after the oil spill. A comparison of the erosion rates of heavily oiled and un-oiled marshes, as identified by Shoreline Cleanup and Assessment Technique (SCAT) surveys (Michel *et al*. 2013), formed the basis of this research. Sixty- and 180-meter buffers of the SCAT lines were used to estimate variation in the percentage of marshland over time before and after the oil spill. Results suggest that changes in shoreline marsh area varied spatially and temporally in the three basins between 1984 and 2015. At the 30 x 30 m scale examined, the variation in marsh area in the three bays suggests that the marsh erosion reflects marsh location within the bays and the geometry of the marsh area with respect to the wave and current direction and energy of Gulf of Mexico waters as it does the effects of the oiling. The decrease in marsh area since 1984 is attributed primarily to sea level rise and, to a lesser extent, wave erosion and marsh subsidence. The results suggest a slight, statistically insignificant increase in erosion rates of some heavily oiled marshes compared to unoiled marshes consistent with ground observations, but the 30 x 30 m spatial resolution of Landsat prevents a determination of exactly how far oil may have penetrated into the marshes. Field measurements suggest that the erosion rate of heavily oiled marshes increased after October 2011, simultaneous with a decrease in erosion rates of low oil sites, and lateral

accretion after May 2012 (McChenachan *et al*. 2013). McChenachan *et al*. (2013) hypothesize that heavy oiling weakens the soil, undercutting the upper 50 cm of the marsh edge, increasing marsh erosion.

CONCORDE: Modeling and Synthesis

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The CONCORDE consortium seeks to illuminate the pathways of oil/dispersant transport to the northern Gulf of Mexico's coastal zone, and the mechanisms that affect its fate and potential toxic exposure of planktonic populations. The Mississippi Bight region features: 1) surface and sub-surface advective exchanges across the shelf break; 2) sensitive planktonic constituents at risk of exposure to toxins with concomitant ecosystem function degradation; and 3) physical and/or geochemical mechanisms that may shield the lagoonal waters of Mississippi Sound from toxicological exposure. CONCORDE's synthetic model is being developed to: 1) explore and assess these toxicological, hydrodynamic and geochemical influences; and 2) evaluate strategies for mitigating oil spill exposure for Mississippi's coastal marine ecosystems, fisheries and recreational areas. Two principal components of the CONCORDE synthesis effort are being integrated into a coupled ROMS-based biogeochemical/upper trophic level model. These components are a 1 km resolution Gulf of Mexico forecast model and a 1 km atmospheric reanalysis product that provide outer and surface boundary conditions, respectively. The details of these two supporting components, and the development of the coupled model will be described. Knowledge drawn from analysis of data from the first set of CONCORDE cruises that reveal key biophysical mechanisms and variability that further the synthetic model development effort will be highlighted.

Automated Detection and Classification Algorithm for Beaked Whales in the Northern Gulf of Mexico

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This research focuses on developing a multi-stage detector for fully automated beaked whale detection and classification from passive acoustic monitoring data collected in the northern Gulf of Mexico before and after the 2010 oil spill. Current classification methods are strongly dependent on operator skills and require extensive manual quality control of initial detection events. This approach becomes impractical as the volume of collected data increases and cross-disciplinary data sharing broadens. Detection and classification of beaked whales in the northern Gulf of Mexico encounter additional challenges due to lack of sufficient data from tagged animals to create a species library, the presence of Risso's dolphin clicks in the same frequency band, and difficulties in estimating inter-click intervals because of the high directionality of beaked whale clicks. In this work, an advanced method of detection and classification is proposed. The first-stage detector compares representative spectral energy of the time series to a baseline detection threshold in the given frequency band and identifies potential detection events. The second stage detector performs a multi-attribute analysis on the first-stage detection events. Peak frequency, centroid frequency, call bandwidth, click duration, and interclick interval are measured using the time and spectral characteristics of the raw signals to distinguish beaked whales among first-stage detection events. The third stage detector separates identified beaked whales into separate species groups. The performance of a Hidden Markov Model is discussed for the third stage grouping. The proposed automatic multi-stage detector considerably reduces the rate of false positive detections to

20% and does not rely on the skills or time-involvement of individual operators after a representative regional library of species calls is assembled. The increased quality of detections will provide better accuracy of abundance estimates and trends based on acoustic input. It will also estimate individual species present in the region versus bulk estimates of the family ziphiidae encounters.

Mapping of Phragmites Australis in Gulf of Mexico Wetlands Using Small UAS

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The wetland species, *Phragmites australis*, also refereed as Common Reed, is an invasive plant present on every continent except Antarctica. In the North America its presence is marked by native and non-native subspecies with the non-natives quickly displacing native plants. Along the Gulf Coast, *Phragmites* grows in impenetrable stands at heights of 15 feet and is usually the tallest grass species in wetland, estuary, and marsh ecosystems. *Phragmites* invasion has been shown to have adverse impacts on the local ecosystem, most notably through decreased biodiversity. Furthermore, it presents a navigation hazard to smaller boats by impairing visibility along shorelines of canals and rivers. Management efforts targeting non-native *Phragmites* rely heavily on accurately mapping invaded areas. Historically, mapping has been done by walking the perimeter of a stand with a GPS unit, using satellite imagery, or through aerial photography from manned aircraft. These methods are time consuming, expensive, can have inadequate resolution, and are prone to human error. To overcome these drawbacks, we employed an Unmanned Aerial System (UAS) capable of collecting geo-referenced high spatial resolution imagery. This system negates the low resolution and long update times of satellite imagery, the cost issues and pilot error associated with manned aircraft, and the hazards of on-the-ground fieldwork. We have collected over 20 square miles of imagery using an Altavian NOVA UAS platform. The images were collected at an altitude of 700 feet with ground resolution of approximately 2 inches. Images are then mosaicked to form an orthomosaic. Initial pilot experiments with texture based mapping analysis shows over 90% agreement with manual analysis.

Assessment of the 2010 Oil Spill Impact on Deep Diving Marine Mammals: Beaked Whales

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To assess the impact of the Deepwater Horizon oil spill on marine mammals, we utilize acoustic data collected by the Littoral Acoustic Demonstration Center (LADC) from two locations (9 miles and 25 miles away from the oil spill site) during 2007 and 2010. We use passive acoustic data to estimate and compare the abundance of beaked whales in Northern Gulf of Mexico in 2007 and 2010 to understand a beaked whale population trend. Based on the method developed by Buckland *et al*. (2001) and Marques et al. (2009), we propose a statistical methodology which provides point and interval estimations of population abundance. A bootstrap method is introduced to account for limited data size and localization information. An increase by a factor of 3 has been observed from 2007 to 2010 at both sites. These results match a general trend from the recently released NOAA estimation based on the 2009 visual survey. In June 2015, the newly GOMRII-funded LADC-GEMM consortium conducted follow-up PAM monitoring experiments to study long-term impact. Data collected during the experiment and other acoustic surveys in the area will assist in better understanding how the spill affected different species. [Research supported by GOMRI, SPAWAR, ONR, NSF, and Greenpeace.]

Baseline High-Resolution Multi-Sensor Remote Mapping of Wetlands in the Barataria Bay Estuarine System

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The National Center for Airborne Laser Mapping (NCALM) conducted a multi-sensor aerial survey in mid August, 2015 of several marsh monitoring sites located within the larger Barataria Bay estuarine system. The airborne survey was performed with a novel multispectral mapping LiDAR and a passive hyperspectral camera. With four flights and a total of 19 flying hours the team collected airborne data of more than 500 km² of marsh and open water areas. Mapping LiDAR returns were collected at the 532, 1064, and 1550 nm wavelengths with a combined density of 12-15 shots/m². The hyperspectral dataset was collected at a spatial resolution of 1.2-1.5 m and at a spectral resolution of 14 nm in the visible and near-infrared range (380-1050 nm). Concurrently with the airborne data collection, a field crew conducted in-situ spectral and biological sampling at selected areas. The in-situ spectral samples were collected with an ASD FieldSpec 4 HiRes spectrophotometer. This dataset constitutes a baseline for monitoring the evolution of the geomorphology and health of the different elements that constitute the Barataria estuarine system as it responds to natural and anthropogenic forcings. In this presentation we will discuss the coverage, the format and specifications of the remotely sensed data, some of its potential applications, and how to access the data when they become available.

General Poster Session I

Impacts of Deepwater Horizon Oil Pollution on Wetlands Resiliency
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Biodiversity can influence marine ecosystem services such as productivity and resource utilization, and these effects may be strongest in the presence of disturbance. Thus, wetland plant diversity may be critical for ecosystem responses in the aftermath of oiling from the Deepwater Horizon incident. We predicted that the positive effects of increased diversity on ecosystem processes would be more prominent in oiled than non-oiled systems. We conducted an 8-week experiment in 3,785 L outdoor flow-through mesocosms and examined the interactive effects of emulsified weathered oil exposure, plant genetic diversity, and plant species diversity on key ecosystem processes. Experimental tubs within the mesocosms (N=24-25 per) were assigned to a no plant control or one of five plant diversity treatments: *Spartina alterniflora* genotypic monoculture, *S. alterniflora* genotypic polyculture, *S. alterniflora* genotypic monoculture + *Avicennia germinans*, *S. alterniflora* genotypic polyculture + *A. germinans*, or *A. germinans* only. In the two oil-exposed mesocosms, we used a 5-day repetitive dosage procedure, with each experimental tub receiving an initial 1 L m-2 of a 1:1 oil-water mixture. In the two non-oiled mesocosms, seawater was added using the same procedure. We quantified plant growth, morphology, and productivity in response to plant diversity and oiling. To better understand impacts on nitrogen cycling, we quantified PAH tissue concentrations and used quantitative PCR (qPCR) to quantify denitrification gene copies from sediments. Temporal determination of denitrifier gene copies coupled with rate measurements provides insights into microbial responses, particularly with regard to N cycling. The poster will summarize these results and the implications for wetlands exposed to oiling.

Early Life Sensitivity of Red Drum, Sciaenops ocellatus, to Source and Naturally Weathered Oil
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The Deepwater Horizon oil spill released more than 636 million liters of crude oil during the spawning season of many commercially and ecologically important fish species in the Gulf of Mexico (GOM). Polycyclic aromatic hydrocarbons (PAHs) are a class of chemicals found in oil that are known to induce cardiotoxicity and other morphological deformities in the larvae of pelagic gulf species. However, little is known about the impact of crude oil toxicity on the larvae of coastal species such as the red drum. Our objective therefore aimed to assess the impacts of oil exposure on cardiac function and survival in developing red drum. Toxicity tests were performed using high energy water accommodated fractions (HEWAF) of either naturally weathered oil (OFS) or non-weathered source oil (MASS). Embryos (≤ 12-15 hpf) were exposed to varying doses of HEWAF and assessed for cardiotoxicity and survival after 48 h and 72 h, respectively. Initial results show that survival endpoints were similar to those previously found for pelagic larvae from the GOM. Interestingly, survival was similar in embryos exposed at the 2-4 hpf stage and those exposed at 12-15 hpf. As expected, dose-dependent cardiotoxicity was observed in both naturally weathered and source oil preparations, which may subsequently impact eco-physiological, behavioral and performance indices. Funding for this work was provided by the Gulf of Mexico Research Initiative through the RECOVER consortium.

Surface VOC Emissions from Subsurface Oil Releases with and without Dispersant Application: Flume Tank Tests

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The use of chemical dispersants during the response to a well blowout is often promoted as a means of protecting onsite workers from exposure to Volatile Organic Compounds (VOCs), yet very little information is available to demonstrate the effect that subsurface dispersant use has on surface VOC emissions. To evaluate this hypothesis, a series of experiments were conducted in a 32 m long flume tank located at the Bedford Institute of Oceanography. Four different hydrocarbon products (ANS, SLC, IFO-120, gas condensate) were tested to represent a range of different physical and chemical properties. Two dispersant products were used in four dispersant-to-oil ratio (DOR) treatments. The tank was equipped with a subsurface oil injection system used to release oil or oil/dispersant premix through a small diameter (2.4 mm) nozzle under high pressure, forming a plume of oil droplets, which was transported horizontally by water currents. Different droplet size distributions were formed, depending on the treatment, which affected the transport of the oil in the tank. Increased DOR resulted in decreased surface VOC concentrations for all four products. Compared to the non-treated oils, a DOR of 1:20 resulted in a 5 to 25 fold decrease, depending on the oil type, in surface VOC concentrations. This study demonstrated that the use of chemical dispersants on a subsurface oil release reduces surface VOC emissions.

Detection of PAHs via Energy Transfer using Mixed Cyclodextrins Solutions

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Small-molecule pollutants, such as polycyclic aromatic hydrocarbons (PAHs), are leaked into the environment via anthropogenic and naturogenic events. The rapid detection of toxicants is vital for first responders to monitor their response in real time. Array-based detection can address this detection need by utilizing the energy transfer that occurs between toxicants and a high quantum yield fluorophore. In the presence of cyclodextrin, proximity-induced toxicant-to-fluorophore energy transfer is promoted, resulting in a new fluorophore emission signal in the presence of the toxicant. Previous work by our group has shown that γ-cyclodextrin promotes efficient energy transfer, methyl-β-cyclodextrin promotes strong fluorophore binding, and 2-hydroxypropyl-β-cyclodextrin promotes strong analyte binding. In this work, we report that by introducing multiple cyclodextrin derivatives simultaneously, we can increase dramatically the extraction of PAHs and fluorophores, as well as promote energy transfer. Development of array-based detection of small-molecule pollutants based on such energy transfer provides the accelerated detection techniques required for environmental first responders.

Aggregation and Submergence Behavior of Floating Hydrophobic Liquids by Fine Quartz Sand

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Floating oils can be densified, captured and settled by surface application of dry fine particles of such material as quartz sand. As a hydrophobic liquid (HL) we studied the aggregation behavior of South

Louisiana crude, alkanes (decane, tetradecane, and hexadecane), aromatics (BTEX group: benzene, toluene, ethylbenzene, and m-xylene), and 2-chlorotoluene. Floating layer of HLs transformed instantaneously to globular aggregates that are encapsulated by the granular material (sand) when applied to the floating slick. Our objective was to investigate the dependence of the aggregates volume of HLs (captured by fine quartz sand) on the wetting characteristics and other properties of HLs (i.e., density, viscosity, surface and interfacial tensions). A series of experiments were conducted utilizing fine quartz sand (passing sieve No. 40 with openings 0.425 mm), salt water (34 g/L) which was applied to the floating layer of the selected HLs. Contact angle measurements were conducted by submerging a large quartz crystal with the HL drop on its surface into salt water. Our results showed that there is a positive correlation between the aggregated HL volume and the wetting angle of HL, density and surface tension. A model was developed to estimate the aggregation number (AN) to predict the amount of HL aggregated with fine quartz sand using a standardized procedure (0.5 mL HL and 1.0 g sand; floating HL layer thickness to particle diameter ratio > 4:1).

Analysis of Marsh Loss and Erosion within Northern Barataria Bay Louisiana: the Effects of the Deepwater Horizon Oil Spill

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The Deepwater Horizon oil spill caused varying degrees of oiling in the marshes of Louisiana, USA. In general, oil spills can cause widespread impacts to the structure, function, resilience and sustainability of coastal wetlands depending upon oil type, volume, degree of weathering, mode of contact and other environmental and biotic factors. Impacts of the oil release on the shoreline salt marshes along northern Barataria Bay, Louisiana were investigated. Our sampling sites span Barataria Bay from Wilkinson Bay to Bay Jimmy and represent areas of marsh shoreline classified as reference (no observed oil impact), moderately-oiled (some oiling observed), and heavily-oiled (significant oiling observed). Available aerial images of the region were obtained over a time series to examine time periods representing a period prior to Hurricane Katrina, during Katrina, after Katrina and before the oil spill, and after the oil spill. The availability of aerial images was inconsistent prior to the oil spill, but consistently available bi-annually after the spill. Lack of sediment delivery into the marshes and sea level rise/climate change effects cause a background erosion rate of approximately 1 m yr1 found in other studies and at reference stations and pre-Katrina period in this study. Wind-related (fetch), wave-driven exposure and erosion caused an increase of the background rate at the heavily-oiled stations during Hurricane Katrina. A higher erosion rate continued through the period after Katrina and prior to the spill. The oil spill destabilized the shoreline through above- and below-ground plant loss decreasing the soil shear strength. This effect resulted in a higher shoreline loss at the heavily-oiled stations after the spill.

The Relative Potency of Methylated Chrysenes in Aryl Hydrocarbon Receptor (AhR) Activation

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This study was designed to identify differences in the ability of monomethyl-substituted chrysenes to activate human aryl hydrocarbon receptor signaling, a key pathway that leads to toxicity. We identified 2-, 3-, and 6-methylchrysene as being similar to the unsubstituted chrysene, and 1-, and 5-methylchrysenes as having greater activity. 4-methylchrysene was the most potent activator, having approximately ten-fold more activity than the parent chrysene.

Analysis of Long-term Datasets Indicates Heterogeneous Impacts Resulting from the DwH Accident on Nekton in the Northcentral Gulf of Mexico

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Among the greatest of the challenges scientists face is determining the relative effects of natural and anthropogenic disturbances on ecosystem structure even more so because of the paucity of long-term monitoring efforts that span the occurrences of both forms of disturbance. Here, we report on the results of such an effort to separate the relative impacts of the Deepwater Horizon (DwH) accident, and earlier natural disturbances, on nekton in the northcentral Gulf of Mexico. Specifically, we used two state and federal databases (1999-2014), and our intensive sampling efforts (2010-2012), to assess the impacts of the DwH accident on these consumers in the region's inshore and offshore waters. Results from these analyses detected significant changes in the relative abundances and biomasses of most of these organisms beginning in 2010 offshore, where oiling was heaviest, which persisted through 2014. The exception to these results was offshore sharks whose abundance receded to background levels quickly. Importantly, no such shifts were detected in the region's inshore waters where oiling was intermittent. We found no evidence of lasting impacts from natural disturbances (i.e., freshets or hurricanes) on nekton in the region. These results provide evidence that longer-term impacts of the DwH accident on nektonic consumers were limited to offshore waters of the northcentral Gulf of Mexico.

Immediate and Prolonged Changes to Swim Performance of Red Drum (*Sciaenops ocellatus*) following Acute Exposure to Naturally Weathered Crude Oil

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The Deepwater Horizon incident released more than 4.9 million barrels of crude oil into the Gulf of Mexico. Acute exposure to crude oil can negatively affect cardiac function, which has been linked to reduced swim performance in pelagic larval and juvenile fish. However, little is known about the effects of oil exposure on swim performance in coastal predatory species. Red drum is a commercially important apex predator on the eastern and southern seaboard of the continental USA. Importantly, this species is tolerant to a wide array of environmental perturbations, which raises questions about whether this may also extend to environmental contaminants. Here we examine the sub-lethal sensitivity of red drum to naturally weathered oil water accommodated fractions, with a particular emphasis on swimming performance, aerobic scope, and the capacity to repay oxygen debt following exhaustive exercise. These eco-physiological endpoints are critical for performance and success of all life stages of fishes. Swimming performance and aerobic scope determine the capacity to hunt prey and evade predators, while repayment of oxygen debt determines the capacity to repeat these activities (e.g. following an unsuccessful chase or a successful escape). All performance measures were examined immediately after a 24 h critical exposure, and the capacity for recovery for acute exposure was assessed at multiple time points post-exposure. Funding for this work was provided by the Gulf of Mexico Research Initiative through the RECOVER consortium.

Experiments to Test Whether Toxicity is Different at Hydrostatic Pressure

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Most research on toxicity of oil on living entities are conducted in laboratories at atmospheric pressure. We constructed equipment allowing us to conduct experiments at hydrostatic pressures of up to 40 MPa. Animals as well as fish eggs were tested with and without contact with oil droplets. To date, the results are not yet conclusive. However, the trend shows differences with laboratory results.

Evaluating the Relationship between Integrated Hydrocarbon Exposure and Coral Occurrence

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As part of a larger multi-component study examining the tolerance of corals to natural seepage, we are examining the relationship between coral occurrence and C isotope signatures of sediment, as an indicator hydrocarbon exposure. Our goal is to test the hypothesis that stable and radiocarbon isotopes in sediments can be used as a proxy for time-integrated hydrocarbon exposure to corals at seep sites and that different coral types will have different degrees of tolerance. We tested this hypothesis by analyzing the C isotopic signatures of sediment collected in 2014 and 2015 in the vicinity of various coral colonies such as *Callogorgia*, *Paramuricea*, and *Lophelia*, among others and near bacterial mats. The 2014 data have been analyzed to date. Bacterial mats were found to be the most depleted averaging δ13C = -29.1±2.5‰ followed by *Paramuricea*, *Callogorgia* and *Lophelia* averaging -24.4±2.3‰, -22.9±0.6‰ and -21.4±0.9‰ for δ13C, respectively. Bacterial mats, *Callogorgia*, *Paramuricea* and *Lophelia* averaged -400±94‰, -398±140‰, -351±77‰, and -311±122‰ for Δ14C signatures. Using a three equation mixing model to estimate the contribution of carbon from modern, methane, and oil sources, we found that organic carbon in the sediment was composed of up to 63% oil and up to 30% methane. From the 2014 data, we have found preliminary differences between coral type and associated sediment δ13C and Δ14C; consistent with our hypothesis. However we are performing the analysis of the 2015 samples to determine statistical significance.

Development of a Biophysical Model to Predict the Presence of Two Scyphozoan Jellyfish in the Gulf of Mexico

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The study and quantification of jellyfish (cnidarian medusae and ctenophores) is difficult due to their fragile body plan and a composition similar to their environment. The development of a predictive biophysical model would be the first of its kind for the Gulf of Mexico and could provide assistance in ecological research and human interactions. In this study, the collection data of two scyphozoan medusae, *Chrysaora quinquecirrha* and *Aurelia spp*., were extracted from SEAMAP surveys and were used to determine biophysical predictors for the presence of large jellyfish medusae in the Gulf of Mexico. Both in situ and remote sensing measurements from 2003 to 2013 were obtained. Logistic regressions were then applied to 27 biophysical parameters derived from these data to explore for and determine significant predictors for the presence of medusae. Significant predictors identified by this

analysis included water temperature, chlorophyll a, turbidity, distance from shore, and salinity. Future applications of this model include foraging assessment of gelatinous predators as well as possible near real time monitoring of the distribution and movement of these medusae in the Gulf of Mexico.

Storm-induced Sediment Resuspension in the Mississippi Canyon Affects Deepwater Particle Fluxes and Heterotrophic Bacterial Activities

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We measured bacterial abundance, bacterial protein production, and activities of hydrolytic enzymes within and above bottom nepheloid layers (BNLs) that formed in the deep Mississippi Canyon shortly after Hurricane Isaac had passed over the study area in late August 2012. The BNLs were detected via beam attenuation in CTD casts over an area of at least 3.5 km2, extending up to 200 m above the seafloor at a water depth of ~1500 m. A large fraction of the suspended matter in the BNLs consisted of resuspended sediments, as indicated by high levels of lithogenic material collected in near-bottom sediment traps shortly before the start of our sampling campaign. Observations of suspended particle abundance and sizes throughout the water column, using a combined camera-CTD system (marine snow camera, MSC), revealed the presences of macroaggregates (> 1 mm in diameter) within the BNL, indicating resuspension of canyon sediments. A distinct bacterial response to enhanced particle concentrations within the BNL was evident from the observation that the highest enzymatic activities (peptidase, β-glucosidase) and protein production (3H-leucine incorporation) were found within the most particle rich sections of the BNL. Our data suggest that event-driven formation of BNLs stimulate bacterial cycling of organic matter in the deep Gulf of Mexico. At the time of our sampling, resuspended sediments may have contained particulate material from the oil-fallout of the Deepwater Horizon spill in 2010. Potentially, sediment resuspension events like the one we observed may periodically transport oil-carbon deposits into the overlying water where it can re-enter deep water microbial food webs.

Understanding the Role Oil and Surfactants Play in Controlling Gas Hydrate Stability

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The high pressure and low temperature conditions surrounding the Macondo oil well blowout site were sufficient to stabilize gas hydrates, where small gas molecules are trapped in an ice-like crystalline solid. During the blowout, gas hydrates were observed to form in the Cofferdam, which failed in part due to the build-up of hydrate particles in the water column. Despite the prominence of gas hydrate during both release and remediation stages of the blowout, insufficient data has been collected to determine how long hydrate may have persisted in the water column. The dynamic conditions of the spill require the pairing of fundamental measurements of hydrate formation and dissolution rates, which may then be up-scaled in the laboratory to larger flow fields. Furthermore, the dispersants deployed at the Macondo wellhead may also have strongly influenced hydrate-specific transport phenomena, which has not been studied to date. This poster will address this question: How do dispersant or crude oil-coated gas bubbles dissolve in hydrate-forming conditions? We will present results from preliminary experiments carried out in the laboratory that directly assess gas hydrate dissolution rates in contact with oil.

Application of High-Resolution Multibeam Sonar Backscatter to Estimate Benthic Sediment Type Distributions in the Mississippi Bight

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Multibeam acoustic backscatter intensity data can provide a proxy for the composition and distribution of surficial seabed sediments. The acoustic response of the seabed across a variety of grazing angles provides an indication of seabed scattering and, therefore, an estimate of general grain-size distributions. These characteristics, along with multibeam bathymetry, can be used to derive a spatial overview of benthic habitats and aid in informing numerical models. As part of the GoMRI Consortium for oil spill exposure pathways in Coastal River-Dominated Ecosystems (CONCORDE), a high-resolution biogeochemical/lower trophic level model will be developed for further investigation of the river-dominated, coastal environment of the Mississippi Bight. One of the necessary model inputs is distribution of bottom sediment type that factors into local sediment resuspension. Sediment type estimates will be obtained from multibeam backscatter data along the CONCORDE observational corridors. In order to constrain this data and produce acoustically-derived sediment distribution maps, physical grab sampling and grain-size analysis of sediments at select locations along the project corridors will be performed. The sediment distribution corridor maps developed as part of this project will guide additional sampling and further our understanding of the benthic and demersal ecosystems within the Mississippi Bight. Future CONCORDE cruises will build on this dataset to enable analysis of the sediment dynamics in the region on biannual timescales.

The Significance of Coherent Material Eddies in the Ocean

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Ocean flows are routinely inferred from low-resolution satellite altimetry measurements of sea surface height assuming a geostrophic balance. Application of recent techniques from nonlinear dynamical systems theory has revealed that altimetry-inferred flows can support long-lived coherent material eddies. We investigate the significance of such elliptic Lagrangian coherent structures by analyzing the output from a high-resolution ocean circulation model that is expected to provide a more realistic (ageostrophic) flow representation than that inferred from altimetry.

Examining Internal Waves on the Northern Gulf of Mexico Continental Shelf with Navy Coastal Ocean Model, NCOM

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The stratification of the water column in the northern Gulf of Mexico (nGoM) may provide favorable conditions for the formation and propagation of internal waves. Internal waves have been shown to enhance mixing in the upper ocean, transport nutrients and plankton, and could transport pollutants (e.g., oil spill in coastal waters). It is important to be able to simulate and predict these internal waves in

the coastal ocean to understand their impact on the dynamics of a river-dominated environment. The results of a regional high-resolution (1km) application of the Navy Coastal Ocean Model (NCOM) are used in this study to investigate the internal waves in the northern Gulf of Mexico. In particular, we analyze three dimensional salinity, temperature, and current fields of NCOM model output over the Gulf of Mexico. We aim to identify and study the time periods of internal wave appearances in the model output to understand their spatial scales and propagation patterns on the continental shelf in the nGoM. We also investigate if internal wave signatures are visible in ocean color imagery (e.g., Chlorophyll-a) from the Visible Infrared Imaging Radiometer Suite (VIIRS) at those time periods. We investigate the interaction and relationship of internal wave patterns with possible forcing mechanisms, such as atmospheric wind conditions, tides, ocean bottom topography, circulation, and with the freshwater discharge from the Mississippi river plume in the northern Gulf of Mexico. The findings of this study help us understand the internal wave dynamics in the region and plan process-based observational studies of the CONsortium for oil spill exposure pathways in COastal River- Dominated Ecosystems (CONCORDE) cruises accordingly to observe such internal waves and their impact on the marine ecosystem.

Cyclodextrin-Based Systems for Environmental Remediation Applications

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Our research group has been focused for several years on the use of cyclodextrins and cyclodextrin-derivatives as supramolecular scaffolds for the binding of highly toxic polycyclic aromatic hydrocarbons (PAHs) and PAH metabolites, and for the detection of these small molecules via cyclodextrin-promoted energy transfer. Recent advances in the development of practical cyclodextrin-based systems for environmental remediation will be discussed, including array-based detection of PAHs, solid-state detection of PAHs, and highly sensitive and selective PAH detection at sub-micro molar levels.

High Frequency Multibeam Sonar Water Column Backscatter: A 3D View of Water Column Acoustic Anomalies to Facilitate Ecosystem Science

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The traditional use of hydrographic multibeam sonar has been to provide a three dimensional view of the seabed bathymetry. Water column acoustic scattering information obtained above the seabed bottom detection is often removed and considered noise. Advances in computational processing capacity, along with the reduction in data storage costs, have allowed for multibeam water column data to be retained and analyzed. As part of the GoMRI CONCORDE project, a 200/400 kHz Reson Seabat 7125 multibeam sonar will be utilized to discover water column anomalies along corridors in the Mississippi Bight. Biomass and density contrasts within the water column will scatter the multibeam acoustic signal depending on the size and acoustic impedance. The multibeam system will be operated simultaneously with a profiling towed In Situ Ichthyoplankton Imaging System (ISIIS), which measures zooplankton abundance, salinity, temperature, dissolved oxygen, fluorescence and PAR. The multibeam system is not calibrated for source level; therefore, relative strengths of water column scattering from each of the 512 beams will be examined and compared with observational data from a the ISIIS. The focus of this poster will be the technical challenges associated with processing the multibeam water column imagery and delivering a useful product to researchers for integration of the three dimensional

acoustic response data with the ISIIS images. The high spatial and temporal resolution water column acoustic data provides an important baseline to improve linkages between physical sampling and offers a technique to remotely sense water column impedance anomalies and scattering features.

Laboratory Measurements of Near-Surface Wind-Wave-Current Interaction

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In the study of oceanic material transport, it is essential to properly characterize the physical processes which occur at the air-sea interface. Exchanges of momentum and heat can dramatically affect the atmospheric and oceanographic states, altering the ways in which surface-following objects behave. Furthermore, satellite remote sensing relies fundamentally on the short-scale (O(0.1)m and smaller) structure of the ocean surface in its determination of physical parameters. Here we present a multi-instrument approach towards investigating near-boundary wind, wave, and current interactions in a laboratory tank setup. High frequency anemometry and coherent Doppler current techniques are used alongside sub-millimeter water wavelength-resolving optical polarimetry. Connections are made to possible applications in the areas of research and operational response, especially with respect to satellite remote sensing and drifting instrument development.

Microbial Communities and Bioturbation Work Together to Accelerate Degradation of Oil Components in Coastal Sediments

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A significant portion of oil from the Deepwater Horizon incident made it to coastal sediments. Bioturbators, such as ghost shrimp and bivalves, are widely distributed in the intertidal to subtidal zones of the Gulf of Mexico, and, therefore, may affect the fate of the oil through stimulation of the microbial community. Their burrowing ability could modify physical and chemical properties of the sediment through sediment mixing and oxygenation. A series of greenhouse microcosm experiments was set up with ghost shrimp or razor clams. Microbial community changes were followed by 16S rRNA gene sequencing and the microbially-mediated rates of polycyclic aromatic hydrocarbon degradation were determined using incubations of sediment spiked with 14C-labeled naphthalene. The data suggest that the microbial communities of oil-contaminated sediment had significantly higher oil degradation rates than those from oil-free sediments. Bioturbation further enhanced oil degradation in the sediment. This effect was prominent for ghost shrimp, but not for razor clams. Bioturbation alone (without oil activation of the microbial community) did not show any significant effect on microbial degradation. Although it appears that bioturbation has a limited effect on the composition of the microbial community, ghost shrimp-mediated bioturbation does increase the rate at which petroleum hydrocarbons are broken down - possibly by stimulating the indigenous bacterial populations.

Deepwater Horizon Oil Spill in Early Life Stages Impairs Cardiac Development of Three Gulf of Mexico Fishes (Gulf Killifish, Redfish and Mahi-mahi)

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The Deepwater Horizon oil spill resulted in crude oil contamination that likely affected Gulf of Mexico fish during the breeding season of many species. As such, it is particularly important to characterize the effects of exposure on sensitive early life stages, to predict the effects on current and future generations. This work investigated the long-term physiological effects of sublethal exposure to oil during early life stages. Gulf killifish (*Fundulus grandis*), redfish (*Sciaenops ocellatus*) and mahi-mahi (*Coryphaena hippurus*) embryos were exposed to varying concentrations of oil-contaminated water (water-accommodated fractions) during different stages of embryogenesis. Larvae were hatched under control conditions and evaluated for a complimentary suite of cardiac phenotypes that are indicative of cardiac fitness. These experiments demonstrate evidence of varied cardiovascular impairment from sublethal exposure during embryogenesis that culminates in a disruption of cardiac output, potential leading to a reduced ability to perform in later life stages. These experiments also identified critical developmental stages (critical windows) where early oil exposure is particularly damaging to future cardiovascular health. Such modifications of cardiovascular phenotype interfere with metabolic, respiratory and/or neuronal functions, reducing the ability of the fish to respond to environmental stressors, potentially affecting future population recruitment of these species.

Toxicity Studies of *Sciaenops ocellatus* and *Menidia beryllina* Exposed to Deepwater Horizon Oil and Corexit 9500

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A Natural Resource Damage Assessment (NRDA) was initiated in 2010 to evaluate impacts of the Deepwater Horizon (DWH) oil spill. In support of this NRDA process, toxicity tests were carried out to determine the LC50s of larval stage red drum (*Sciaenops ocellatus*), larval and juvenile stages of inland silversides (*Menidia beryllina*) and the hatch success/deformity (EC50) of red drum embryos exposed to WAFS of oil and oil/dispersant mixtures, and through dietary exposure. Test organisms were exposed to HEWAFs and CEWAFs of weathered DWH source and Slick A (surface slick collected) oils, alone, and in combination with Corexit 9500. LC50s were reported as ΣPAHs of the exposure solutions while Corexit 9500 LC50 was reported in DOSS concentrations. Slick A CEWAF LC50s for red drum and silverside larvae were low. Weathered source oil HEWAF was more toxic to red drum larvae than embryos but the opposite was observed with Slick A HEWAF exposures. Here, the LC50 was greater in red drum embryos than larvae. The mean LC50 of Corexit 9500 on red drum embryo and larvae was less than those seen in the oil exposures. No mortality was seen with silversides exposed to Slick A HEWAF (larvae and juvenile) or Slick A CEWAF (juvenile). Red drum that were fed *Artemia* coated with Slick A CEWAF showed no significant mortality. High percentages of deformities occurred in embryos in both Slick A CEWAF and HEWAF exposures and low hatch success was observed in Slick A CEWAF.

In vivo Exposure and Stem Cell Transcriptomics to Determine If Dioctyl Sodium Sulfosuccinate (DOSS) Is a Bona Fide Obesogen

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The percentage of obese children and adults has increased at an alarming rate over the last three decades. While diet, exercise and genetics are central to obesity development, environmental exposures to 'obesogens' may also contribute. Obesogens are chemicals that drive fat cell differentiation and alter lipid homeostasis, metabolism and appetite. Identification of obesogens will aid our understanding of the etiology of obesity. Previously we evaluated MC252 oil and Corexit 9500 dispersant mixtures for obesogens and identified DOSS as a putative obesogen. Our current focus is on validating DOSS as an obesogen in vivo. After exposures in mice, body, fat pad and liver masses were monitored over time. Histomorphology was used to measure adipocyte size in fat pads and lipid accumulation in liver. Comparisons were also made of the transcriptional responses to DOSS using mouse-derived mesenchymal stem cells (MSCs), the progenitors of fat cells, and human induced pluripotent stem cells (iPSCs) via next generation RNA-sequencing. Initial results indicate that in vivo exposure to DOSS increases body mass and adipose tissue mass and alters PPARγ, a key player in fat cell differentiation, gene expression in liver and adipose tissues. Similarly, MSCs isolated from exposed mice display increased adipocyte differentiation and gene expression analysis indicates an upregulation of adipogenic genes in these cells. In addition, iPSCs exposed to DOSS display a unique transcriptomic profile compared to iPSCs exposed to the PPARγ agonist rosiglitazone. Upregulated pathways include those involved in lipid homeostasis and steroid biosynthesis. MSCs exposed to DOSS display similar gene expression profiles. Together these data can help predict and assess health risks associated with DOSS exposure in terrestrial and marine organisms.

Establishing Relative Baselines of Reef Fish Populations and Habitat on the West Florida Shelf using Multibeam and Towed Camera Systems

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A moratorium on oil production remains in effect for the West Florida Shelf (WFS) which prohibits drilling within ~125 miles of the Florida Coast. Recent political and economic developments indicate it is prudent to consider that this may not always remain in place. Environmental impacts will therefore be of considerable concern if any drilling was eventually to take place. When the Deepwater Horizon spill occurred, one of the more notable criticisms was the lack of baseline data. At the University of South Florida's College of Marine Science, ongoing benthic habitat mapping and fish population surveys seek to remedy this. A camera system known as C-BASS was designed to visually survey sea turtles, larger reef fishes and habitat on the WFS while being towed three meters above the bottom. Environmental data (temperature, salinity, chlorophyll, etc.) are also continuously collected during operation and C-BASS can be outfitted with other sensors such as small sonars and acoustic receivers. The system is part of a larger project called the Continental Shelf Characterization, Assessment and Mapping Project (C-SCAMP); over the next three years, new areas of the WFS will be mapped using a Teledyne RESON Seabat 7125 multibeam system and subsequently filmed using C-BASS. Preliminary work indicates this camera system can provide valuable data to supplement multibeam maps and aid in extensively documenting the current state of reef fish habitat and populations on the WFS.

Initial Analysis of Microbial Community Response to Oil and Corexit in Coastal Water Mesocosms

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Microbially produced exopolymeric substances (EPS) are believed to play a critical role in the weathering and degradation of oil in marine environments. However, the mechanisms by which EPS promotes the aggregation and/or dispersion of oil and dispersants are not well understood. Furthermore, current understanding of microbial community dynamics, especially between bacteria, archaea and eukaryotes, after exposure to oil and/or Corexit is poorly resolved. We prepared four 79L mesocosms to investigate the responses of natural microbial communities to the water accommodated fraction of oil with and without Corexit (CWAF/WAF, respectively). Prior to experiment initiation, phytoplankton were collected from coastal Galveston, TX waters and added to each tank to stimulate interactions between phytoplankton, oil, and Corexit. We present here data from 16S rRNA sequencing to monitor the composition and structure of the mesocosms' microbial communities over the course of the experiment. This molecular biology analysis is combined with simultaneous chemical (total petroleum hydrocarbons) and biochemical (protein/carbohydrate ratio) measurements of the water and marine snow aggregates within the mesocosms. Together, these data reveal interactions between microbial trophic levels and how these relationships affect the aggregation, dispersion, and degradation of oil by microbial exopolymers.

Use of Semi-permeable Membrane Devices to Assess Petroleum Hydrocarbon Contamination in the Waters of Coastal Florida and a Mesophotic Reef in the Northern Gulf of Mexico

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Semi-permeable membrane devices (SPMDs) were deployed in waters of coastal Florida in May and June of 2010, and of a mesophotic reef of the northern Gulf of Mexico in July to August of 2010 to assess petroleum hydrocarbon contamination. Two successive, approximately month-long deployments occurred in waters off the coast of west-central Florida and the Dry Tortugas, and in Biscayne and Florida Bays beginning in May. In addition, a single approximately month-long deployment was conducted on the Alabama Alps (AA), a mesophotic reef ecosystem in the northern Gulf of Mexico. Petroleum hydrocarbon profiles suggest the presence of both petrogenically (e.g., dibenzothiophenes) and pyrogenically (e.g., chrysenes) derived hydrocarbons in the water near the AA. Comparison of the profiles for the SPMDs deployed at the AA with the same for SPMDs deployed in Florida indicate elevated petroleum hydrocarbon presence in waters around the AA relative to other marine and estuarine environments.

Eicosanomics: Novel Approaches to Investigate the Effect of Oil/Dispersant Exposure on Eicosanoid Biosynthesis in Sentinel Species

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Eicosanoids are chemical messengers commonly associated with inflammation and the immune response. These metabolites have a vast array of functions, which vary from the resolution of inflammation to the promotion of angiogenesis. Due to their diverse nature, lipidomic platforms (termed eicosanomics) are used in clinical investigations to comprehensively study their roles in inflammatory processes (cancer, etc.). The application of this new approach for evaluating the effect of environmental exposure presents a novel direction. There exists little data to examine how 'obesogens' (Endocrine disrupting chemicals that perturb lipid homeostasis) preferentially alter the eicosanoid pathway. Further, there are few studies investigating the effect of an 'obesogen' on lipid homeostasis within the placenta. We propose that the chorioallanotic membrane (CAM) of chickens serves as an ideal model of placental development and function in oviparous species, as it is a relatively 'closed' system with no exogenous chemicals circulating in maternal blood flow. Our investigation explores the effect of Dioctyl Sodium Sulfosuccinate (DOSS) exposure on eicosanoid biosynthesis in the CAM of chickens. Eicosanoids are measured simultaneously and in a species-independent manner through Liquid Chromatography/Tandem Mass spectrometry. Preliminary data has identified 32 eicosanoids in the CAM tissue and significant developmental increases ($p=0.001$) in Prostaglandin E2 (PGE2). The 'baseline' of eicosanoid changes during development in the chicken has been established through comparative studies with the American alligator. We have also identified changes in eicosanoid secretion by pluripotent stem cells (iPSCs) exposed to DOSS; a surrogate for human developmental exposure and cross-species comparisons. Future work will investigate how DOSS exposure in the chicken alters eicosanoid synthesis during embryonic development and the use of eicosanomics as a tool to monitor human and ecosystem health.

Oil Droplets Transport due to Irregular Waves: Development of Large-scale Spreading Coefficients

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The movement of oil droplets due to waves and buoyancy was investigated by assuming an irregular sea state following a JONSWAP spectrum and four buoyancy values. A technique known as Wheeler stretching was used to model the movement of particles under the moving water surface. In each simulation, 500 particles were released and were tracked for a real time of 4.0 hours. A Monte Carlo approach was used to obtain ensemble properties. It was found that small eddy diffusivities that decrease rapidly with depth generated the largest horizontal spreading of the plume. It was also found that large eddy diffusivities that decrease slowly with depth generated the smallest horizontal spreading coefficient of the plume. The increase in buoyancy resulted in a decrease in the horizontal spreading coefficient, which suggests that two-dimensional (horizontal) models that predict the transport of surface oil could be overestimating the spreading of oil.

Peak-interpolation Method for Differentiating Deepwater Horizon Crude Oil from other Gulf of Mexico Crude Oils

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Due to their high abundance and resistance to biological and chemical degradation, biomarker compounds in crude oil are considered to be the most important group of chemicals used for fingerprinting or identifying different types of crude oils. In this study, we have analyzed five different Gulf of Mexico (GOM) sweet crude oil samples including two samples recovered from the Deepwater Horizon (DWH) well and three other sweet crudes collected from various GOM oil reservoirs. Chemical fingerprints of n-alkanes, hopanes, steranes, PAHs and their alkylated homologs were developed using a GC-MS method for differentiating these crude oil samples. Customarily, the numerical values of selected set of diagnostic ratios are compared to differentiate oils. Here, these diagnostic ratios are presented using a more intuitive set of radar plots. A novel peak-interpolation method is also introduced to better differentiate the crude oils by visual examination of the curve plots after normalizing the values to the largest peak value. Based on these diagnostic ratios and peak-interpolation plots, we conclude that the two DWH oils collected at different times have almost identical chemical signatures indicating that the chemical characteristics of crude extracted from the DWH reservoir was unique. The other GOM crude oils can be clearly differentiated from the DWH oil using the radar plots of diagnostic ratios and peak-interpolation plots. The relative abundance of C8-alkane and pritane/phytane ratio in alkanes, Ts/Tm ratio in hopanes, C27αββ(R+S)/C27(αββ(R+S)+ααα(S+R)) ratio in steranes and distribution of Naphthalenes in alkylated homologs in the three other three GOM crude oil samples are significantly different from the two DWH crude oil samples.

Biodegradation of Finasol OSR 52 and Dispersed Alaska North Slope Crude Oil at 5 °C and 25 °C

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A study was conducted with Finasol OSR 52 dispersant and Alaska North Slope (ANS) crude oil in sterile GP2 artificial seawater to investigate the biodegradability of the dispersant as well as the dispersed ANS. Two oil degrading cultures, isolated from the surface (meso) and deep sea (cryo) of the Gulf of Mexico, were enriched on ANS crude oil at 25 °C (meso) and 5 °C (cryo) and used as inocula. Time series concentrations for the oil components (alkanes and aromatics) and an anionic surfactant in Finasol were determined. Results indicated that almost all the surfactant was biodegraded by the meso culture at 25 °C, but the surfactant was stable in the presence of the meso culture at 5 °C and cryo cultures at 25 °C and 5 °C. Over 90% of the total alkane fraction was biodegraded for the oil with and without dispersant at both temperatures. For the aromatic fraction, the cryo culture metabolized 76% of the aromatics in ANS alone and 64% in ANS dispersed with Finasol, whereas aromatics persisted in both oil alone and dispersed oil samples at 25 °C. The results shed light on the effect of dispersant on the fate of spilled oil and rates of oil and dispersant biodegradation, which will be essential for dispersant usage.

How Was the Deep Scattering layers (DSLs) Influenced by the Deepwater Horizon Spill? -- Evidences from 10-year NTL Oil/Gas ADCP Backscattering Data Collected at the Spill Site

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There are suspicions that the 2010 DWH oil spill might have affected the biomass in the deep scattering layers (DSLs), at least during the period in which the spill was active and oil dispersants were used. The acoustic backscattering intensity (ABI) data from acoustic Doppler current profilers (ADCPs) have been shown to detect and monitor the spatial and temporal evolution of DSLs in many oceans. Since 2005 with the issue of a Notice of Lessees and Operators (NTL), namely, NTL No. 2005-G5, large amounts of continuous ADCP data have been collected by oil/gas companies in the Northern Gulf at more than 100 stations and made publically available via the National Data Buoyancy Center (NDBC) website. NTL ADCPs data have also been collected prior to, during and after the DWH spill at the spill site. The ADCP with station # 42872 was mounted on the DWH rig and collected ABI data from 2005 until the rig sank in April 2010. ADCPs with station # 42916 and 42868 were then moved into the spill region and collected ABI data during and after the spill. The deep scattering layers were well resolved by those 38 kHz with vertical range of 1000m. The SSL provides key food for many large sea-animals, including whales, dolphins, billfishes and giant tunas and therefore have important roles in the ecosystem of the deep Gulf. By carefully applying calibrations and corrections, the ABI data can be converted to biologically meaningful mean volume backscattering strength (MVBS) and areal backscattering strength (ABS). This is an effective and powerful way to study the pelagic communality dynamics in the deep scattering layers and to investigate greater details that were previously inaccessible. Utilizing the NTL data collected during the past 10 years around the DWH site, we investigate the spill influence on deep scattering layers by comparing the biomass pre- and post BP spill and comparing biomass variations in areas with and without oil contamination. Preliminary results have shown that there is a clear decrease trend of relative biomass in the deep scattering layer in 2010 after the spill. We also find extremely dense scattering patches at the depth of DSLs, which appear only during the spill and are likely formed by spill materials. Statistical analysis on the layer depth, intensity, and thickness and their variations over time are also investigated.

Transcriptional Upregulation of CYP1A1 and CYP1B1 by Alkylated Polycyclic Aromatic Hydrocarbons Found in Crude Oil in the Human RPTEC/TERT1 Cell Line

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Polycyclic aromatic hydrocarbons (PAHs) are chemicals that are abundant in the environment, can be generated through the process of incomplete combustion, and are relatively common hydrocarbons in crude oil. Some PAHs are known to be hazardous to human health due to their environmental persistence and carcinogenic properties. Although there are many types of PAHs, individual PAHs may produce different biochemical and toxicological responses in biological systems depending on their chemical structures. Many regulatory assessments are based on a few, unsubstituted PAHs that have been widely used for toxicity testing, but there has been comparatively little research on substituted PAHs such as those with one or more alkyl side groups. In order to determine if alkylated PAHs elicited different transcriptional responses compared to their unsubstituted parent compounds, we exposed a metabolically competent human renal cell line (RPTEC/TERT1) to specific PAHs found in MC252 oil. We found that 4- and 6-methylchrysene as well as 6,12-dimethylchrysene induce CYP1A1 and CYP1B1 gene expression significantly more than unsubstituted chrysene. We also found that 10-

methylbenzo[a]pyrene induces CYP1A1 and CYP1B1 more strongly than benzo[a]pyrene. These results indicate that future studies and regulatory testing should include substituted PAHs and mixtures of PAHs in toxicity assessments.

Jellyfish, Forage Fish and the Gulf of Mexico Menhaden Fishery

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Increases in the frequency and size of recurrent jellyfish blooms in a number of coastal areas worldwide have intensified concerns these ecosystems are shifting from fish to jellyfish. These gelatinous animals are voracious plankton consumers that not only compete with forage fish for food, but also feed on their larval stages. Ecosystems supporting major forage fish fisheries, like the Gulf of Mexico's menhaden (*Brevoortia spp*.) fishery, are believed to be particularly vulnerable given the considerable harvest pressure exerted on this species. Although forage fish - jellyfish replacement cycles have been detected in recent decades in the Gulf of Mexico, jellyfish are often not included as main components of ecosystem-based fisheries management production (EBFM) models. Here we examined the relationship between forage fish and jellyfish and assessed the potential ecological consequences of a shift from forage fish to jellyfish in the Gulf of Mexico using ECOPATH models. Changes in the productivity of functional groups in a jellyfish-dominated versus a forage fish-dominated food web were modeled using ECOTRAN techniques. These modeling efforts will improve EBFM of forage fish and their predators by increasing our understanding of trophic interactions between forage fish and large jellyfish, an important, but overlooked component in most ecosystem models to date.

General Poster Session II

Microzooplankton Grazing within Planktonic Thin Layers in the Northern Gulf of Mexico
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Plankton thin layers (PTLs) are important ecological features in marine environments, and are likely to have significant impacts upon regional aquatic food webs and ecosystem structure and function. While much of the physical and biological dynamics associated with PTL formation, persistence, and dissipation have been examined, quantified rates of phytoplankton growth and microzooplankton grazing tend to be underrepresented in these features. Thus, our overarching research objectives were to describe the trophic interactions between primary producers and primary consumers within coastal, river-dominated PTLs, using the Mississippi Bight (MB) as a model study site, as well as to highlight the biophysical mechanisms responsible for the formation, maintenance, and dissipation of PTLs within this environment. The specific objectives were to quantify the rates of phytoplankton growth and microzooplankton grazing using a common dilution technique and to evaluate plankton species and particle composition using Flow Cytometry and Microscopy (FlowCAM®) imaging technology. It is critical to understand these trophic interactions because microzooplankton grazing accounts for a significant fraction of phytoplankton mortality, consuming over 50% of the water column primary production. Thus, it is important to quantify the rates of phytoplankton growth and microzooplankton grazing to begin to understand how higher trophic organisms feed and utilize PTLs. Moreover, these trophic hot spots may serve also as a conduit for transferring hydrocarbons and pollutants throughout marine food webs. The research presented here will be critical for modelling those potential impacts, as well as providing information that is key to our visualization of energy flows within marine ecosystems. Our research provides novel information pertinent to the understanding of PTL ecosystem dynamics and presents the first study of its kind in this region.

Homogeneity of Microbial Communities in Marsh Soils since the Deepwater Horizon Oil Spill
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Coastal salt marshes in Louisiana are dynamic land-ocean interfaces where large quantities of C accumulate and are stored in predominately anoxic soils. Understanding microbial processes that affect short- and long-term C cycling in marshes is critical to explaining ecosystem resilience and recovery trajectories following different types of disturbances, such as sea-level rise or oil spills. However, knowledge about microbial community diversity and function from marsh soils is limited. Seasonal and annual changes in marsh soil bacterial communities from 2011 to 2014 were investigated from 18 distinct marsh systems that were moderately to heavily impacted by the 2010 Deepwater Horizon oil spill. From 1,880,940 16S rRNA classified amplicons (screened from over 2,600,000 raw amplicons) retrieved from predominately inland soil samples, bacterial communities from each of the sampling years were compared to each other using the similarity percentage (SIMPER) analysis. Communities from 2011 to 2012 were 50% similar, but 2012 to 2013 communities were 80% similar, and 2013 to 2014 communities were 82% similar. Communities from subtidal sediments collected in 2011 were compositionally similar to inland soil at depth in later sampling years. The greatest compositional differences were between 2011 and 2014, whereby dominance by Chloroflexi within the soils was replaced by Proteobacteria. Key community members included Proteobacteria, Chloroflexi,

Planctomycetes, Bacteroidetes, and Firmicutes. Over time, bacterial communities appear to have converged on a stable, common microbiome, regardless of geographic location or oiling history.

Sorption of DOSS to Marine Sediments: Its Fate in the Field and Laboratory

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The sorption of anionic surfactants to suspended sediments is high enough that it affects their fate in particle-rich coastal and estuarine sites. Following the 2010 Deepwater Horizon oil spill, the Corexit ingredient bis(2-ethylhexyl) sulfosuccinate, or DOSS, was observed to be persistent in the deep water plume and in underlying sediments, leading to questions about the factors that affect DOSS sorption to sediments, and the rate and extent of desorption from particles settling to, or after reaching, the sediment bed. The best data for anionic surfactant sorption data is for widely used linear alkylbenzene sulfonates (LAS). We have found that there are several similarities with respect to the sorption of LAS and DOSS, as well as some profound differences. Sediment sorption isotherms are near linear over environmentally relevant concentration ranges. In contrast, there are abrupt differences in the loss of DOSS from seawater to centrifuge tube that occur over a narrow concentration range of 10 - 50 ppb, with no analog in the case of LAS. Sorption increases with sediment organic matter content (explaining most of the variability in sorption energies for seen for 12 sediments in the case of DOSS and for ten sediments in studies by Rico-Rico and coworkers for LAS. Sorption is favored at higher salinity, and this is primarily due to increases in divalent calcium and magnesium cations. The rate of approach to sorption equilibrium has now been seen to be fast for both compounds. In recent work we have seen that desorption (after 48 hr of adsorption) is also fast and almost reversible - this result has implications for mechanisms responsible for the delivery and persistence of DOSS in some Gulf of Mexico sediments. However, while DOSS and C12-LAS have very similar hydrophobicity (solubilities in pure water) the sorption coefficients for LAS are more than 20 times higher than they are for DOSS. Possible explanations for these discrepancies will be presented.

Spatial Dynamics of Microbial Community across the Northwestern Gulf of Mexico

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The Gulf of Mexico (GOM) is a dynamic ecosystem influenced multiple processes that can greatly alter water conditions. This ecosystem is effected by GOM Loop current dynamics that can bring together multiple factors that can influence microbial communities; warm nutrient poor water from the Caribbean, freshwater input by the Mississippi river, natural seeps and leaks of hydrocarbons from the ocean floor, and more recently, anthropogenic influences of the Deepwater horizon oil spill and eutrophication due to agriculture along the Mississippi river basin. Microbial communities form the base of complex food webs in the GOM, but we know little about how these communities vary in response to these naturally occurring fluctuations in environmental conditions, as well as in response to anthropogenic disturbances. The current study will investigate spatial variation in microbial community at different depths across a stratified sampling grid in the northwestern GOM. This study will help establish an important baseline regarding natural fluctuations in microbial communities across these different environmental influences. Microbial community dynamics will be compared to a wealth of other data such as water quality, chlorophyll concentration, temperature, abundance of megafauna surveyed by the DEEPEND team, and more. Additionally, these data will be compared to current

dynamics during time of collection, to better understand variation due to influences such as the Loop current and the Mississippi river. Lastly, microbial community dynamics will be correlated with proximity to the location of the Deepwater Horizon oil spill site to investigate any potential effects on microbial community diversity and composition.

Dissolved Inorganic Carbon and Methane Interactions in the Deep Gulf of Mexico

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There is a dearth of data describing the inorganic carbon system in the deep Gulf of Mexico (GoM). The Gulf Integrated Spill Research (GISR) Consortium conducted a series of nine cruises after the Deepwater Horizon incident to examine watermass transport and mixing in the deep northern and western GoM. The first cruise began in July of 2012 and the last cruise was in April of 2015. During five of these cruises, approximately 1000 samples were collected and analyzed for dissolved inorganic carbon (DIC) content and also for total alkalinity (TA). Both DIC and TA were determined through titration techniques and were used to calculate pH (on the total pH scale), pCO2, aragonite saturation state (Ωaragonite), and calcite saturation state (Ωcalcite). During three of the cruises where inorganic carbon samples were collected, methane samples were also collected. The inorganic carbon data are used to assess the carbonate buffer system in the deep northern and western GoM. The methane data are used to examine a relationship between the deep water inorganic carbon cycle and the presence of methane in the water column.

Physical and Geochemical Drivers of CDOM Variability near a Natural Seep Site

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Colored dissolved organic matter (CDOM) on the continental shelf and slope can serve as a marker for fresh water influence, indicate the presence of hydrocarbons, and provide important clues about nutrient content and organic matter cycling. Autonomous underwater vehicles such as gliders allow for subsurface measurement of CDOM fluorescence for weeks to months; these time series may be especially valuable in the northern Gulf of Mexico, where CDOM inputs of both terrestrial and oil and gas sources can be significant. Data from a recent glider deployment near a natural seep site (GC600) on the continental slope suggest simultaneous influence of fresh water and hydrocarbon inputs in the upper 200m, with variability in fluorescence at a range of vertical and temporal scales. We will explore patterns in spatial and temporal variability of glider-measured hydrography, dissolved oxygen, and bio-optical data (CDOM, chlorophyll-a, backscatter), and use their combination to infer a terrigenous and/or fossil fuel source(s). Taking advantage of a combination of satellite sea surface temperature, ocean color, wind, and data from moored and mobile platforms, we will examine physical controls such as transport and vertical mixing; data from moored and mobile platforms will be used to consider potential physical and biogeochemical causes for CDOM fluorescence variability in the upper 200m.

Assessment of the Environmental Stress Factor for Four years Post BP Oil Spill in the Gulf of Mexico and its Potential Impact on Public Health

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The Gulf of Mexico experienced the largest maritime oil spill in U.S. history after the Deep Water Horizon (DWH) spill in 2010. An Oil spill of this magnitude resulted in a vast accumulation of genotoxic substances in the air, soil, and water. The contaminated environment has the potential to place significant impact for years to come on the populations that thrive on the gulf, such as employment, human and animal health, and food supply. The purpose of this study is to assess the presence of genotoxins in the environment in the area of the DWH Spill impacted shoreline for four years and the potential impact on public health. In order to determine the levels of genotoxicity of air samples collected from contaminated areas of coastal Louisiana, portable air samplers were used, and a genetically engineered bacterial reporter system. The areas sampled were Grand Isle, Port Fourchon, and Elmer's Island during the spring, summer and fall seasons from 2011-2014. As a control area, samples were collected from non-contaminated Sea Rim State Park, Texas. When comparing the contaminated areas to our control, there was a significant increase in air genotoxicity with the highest values being registered in July 2011, 2013, and 2014 in all three locations. This seasonal trend was disrupted in 2012, when the highest genotoxic values were detected in October after the landfall of Hurricane Isaac in August. The data presented three major points, (1) over four years post-DWH spill, high levels of air genotoxicity persists in the monitored areas, (2) temperature and humidity correlate with a peak of genotoxicity in the summers, and (3) the trend was affected by Hurricane Isaac, informing us further that there is continuous negative impact of the oil spill in this region and it is influenced by the weather conditions. There is a need to continue to monitor the genotoxic levels on the Gulf shorelines and what effects they are having in the areas.

Retention of DOSS and Primary Metabolites by Sheepshead Minnows (*Cyprinodon variegates*)

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During the Deepwater Horizon Oil Spill of 2010, approximately 1.84 million gallons of Corexit 9500 and 9725 were applied at both surface and subsea levels in an effort to facilitate the oil dispersing into the water column. DOSS (dioctyl sulfosuccinate) is an anionic surfactant and one of the major components of Corexit formulations. Subsequent analysis has demonstrated DOSS to also be one of the more stable components of Corexit. Therefore as part of ongoing work assessing the breakdown and toxicity of Corexit components, we considered it important to also evaluate retention of both DOSS and its major metabolites in our model fish species, the sheepshead minnow (*Cyprinodon variegates*). Adult minnows weighing 3 to 5 g (wet weight) were exposed in duplicate 2 L glass beakers to 1,500 mL of solutions of 5 mg/L DOSS, and then transferred to clean water and depurated for up to 48 hrs. Fish were sacrificed at the end of the exposure period and after 4, 12, 24, and 48 hrs of depuration. Body burdens of DOSS and one of the major hydrolysis metabolites were determined after extraction by a modified QuEChERS method and subsequent analysis by liquid chromatography coupled to a triple quadrupole mass spectrometer. Preliminary analysis indicates the BCF was approximately 1 and the half-life of DOSS and

the metabolite were both approximately 12 hrs. Measurable levels of both were still present at the end of the depuration period, indicating the potential for trophic transfer to fish consumers. Follow up experiments will further examine the kinetics of depuration and the formation of other metabolites.

Adsorption and Photodegradation of Polycyclic Aromatic Hydrocarbons in Seawater using a New Class of Activated Charcoal Supported Titanate Nanotubes

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Oil spills release large amounts of polycyclic aromatic hydrocarbons (PAHs) into the marine environment, posing a major threat on the marine eco-system and human health. In this study, we developed a new class of activated charcoal supported titanate nanotubes (TNTs@AC) through a one-step hydrothermal method. The new composite material not only offers high adsorption capacity for PAHs, but also serves as a highly effective photochemical catalyst facilitating rapid photochemical degradation of the adsorbed PAHs under natural light. Using phenanthrene as a model persistent PAH, TNTs@AC offers a maximum Langmuir adsorption capacity of 12.1 mg/g, and 92% of phenanthrene (*C*₀=500 µg/L) can be rapidly (within 60 min) adsorbed on the material at a material dosage of 0.5 g/L. Subsequently, the adsorbed PAH is completely photodegraded under simulated natural solar light within two hours. The photo-regenerated material can be then be reused for another adsorption-photodegradation cycle. The material can perform well over a wide range of pH, ionic strength, and dissolved organic matter. The material was characterized using SEM, XRD, XPS and FT-IR, and the compositions were confirmed to be sodium titanate bonded with activated charcoal. The material is also effective for other persistent oil components, and the adsorption-photodegradation process represents an innovative technology for remediation of oil contaminated seawater and sediment.

Reducing Uncertainty in Multibeam Sonar Depth Estimates through Integration with High Resolution Numerical Modeling

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The calculation of depth from acoustic instruments in the ocean environment requires knowledge of the change in speed of sound through the water column to convert a two-way travel time (TWTT) measurement to a range. The calculation of sound speed in water is often obtained from measurements of pressure, temperature and salinity, and the spatial and temporal dynamics of these variables must be known. Obtaining sound speed profile data traditionally requires the vessel to stop and lower an instrument to observe the change in sound speed from the surface to the seabed. This is a time consuming process that must be done with sufficient frequency to capture variability in the water masses. Applying incorrect sound speed profiles to the multibeam data will result in incorrect depth estimates and data artifacts, which hinders the ability to use the acoustic data for additional analysis. High frequency multibeam sonar data will be collected along a series of corridors in Mississippi Bight during the GoMRI CONCORDE project. As with many collaborative research cruises, multiple concurrent activities will not allow for physical sampling of sound speed profiles during multibeam data collection. An alternative source of sound speed information must be investigated to accurately reduce the sonar data and minimize data uncertainty. A parallel numerical modeling effort is underway for the CONCORDE project domain that reproduces the physical oceanographic environment in the Bight. The

model outputs include three-dimensional, temporally varying fields of temperature and salinity, which can be used to calculate a sound speed field along the data collection corridors. This project will examine the integration of the numerical model output to the multibeam sonar data processing stream. The evaluation and application of this processing methodology will minimize data uncertainty while improving the ability to collect opportunistic and autonomous acoustic data when physical sampling of sound speed profile data is not possible.

Coupling a High Resolution Circulation Model, Ocean Color Satellite Imagery and Field Data to Characterize the 3-Dimensional Mississippi River Plume

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The Mississippi River Plume (MRP) is responsible for creating a highly dynamic environment in the northern Gulf of Mexico. The MRP is not only responsible for the transport of rich-nutrient waters, but in cases of unfortunate events such as the Deep Horizon Oil Spill it may contribute to the transport and fate of hydrocarbons. We characterized the 3-Dimensional MRP using modeled salinity data from the 1 km resolution Navy Coastal Ocean Model (NCOM). Ocean color data (e.g., Chlorophyll-a) from the Visible Infrared Imaging Radiometer Suite (VIIRS) was used to understand the surface response of the river plume. Field data from ships and gliders were used to validate the model and satellite data. An initial step for this study was to determine how to define a "river plume". We selected several study cases of 7 to 10 days in which the river plume was visible in the satellite imagery and examined the vertical salinity distribution at selected cross sections along the river plume. Different salinity thresholds were used to define a river plume and characterize the 3-D dilution and dispersion of the MRP during the study cases. Our results improved understanding of the formation of the mixed layer depth in the MRP and how we can integrate model and satellite data to delineate the 3D structure of the river plume. The output of this study highlights how circulation models and satellite data can be integrated to better understand the connectivity, transport and fate of sediments, nutrients, and pollutants in the Gulf of Mexico.

Using Multiple-frequency, Broadband Acoustic Backscatter to Identify and Quantify the Organisms Composing the Deep Sea Mesopelagic Scattering Layers in the Gulf of Mexico

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Acoustic backscatter data were collected using multiple-frequency (18 kHz and 70 kHz broadband and narrowband, 38 and 120 kHz narrowband) scientific fisheries echosounders from the surface to 1500 m in the Gulf of Mexico in August 2015 as part of the GOMRI DEEPEND project. By combining acoustic backscatter spectra, 10 m2 MOCNESS net tows, and acoustic scattering models; scattering layers were categorized into broad, taxonomic groups (e.g. swim-bladdered fish, fish without swim bladders, crustaceans). In some locations, targeted net tows were used to sample a particular backscattering layer revealing (in some cases) the specific species responsible for the scattering layer. The vertical movements of these layers relative to hydrographic water column properties (primarily temperature and dissolved oxygen) were quantified. Additionally, the biomass of the various taxonomic categories was calculated from the acoustic data and compared with previous estimates from net tows and the

literature. We also assessed the benefits and limitations of broadband echosounders for deep-sea mesopelagic surveys.

Blue Crab Larval Dispersal during the Deepwater Horizon Oil Spill in Context of Interannual Variability from 2003-2012

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The 2010 Deepwater Horizon oil spill occurred during the spawning season of blue crabs (*Callinectes sapidus*) in the northern Gulf of Mexico. Blue crab larvae are found mainly within 2 m of the water surface during the first 4 weeks after hatching. We modeled blue crab larval dispersal trajectories during the 2010 spawning season to determine the proportion of larvae that were potentially exposed to surface oil slicks during their time in the plankton. In total, 38.1% of simulated larvae were exposed to oil, mostly east of the Mississippi River. We then examined the interannual variability in larval dispersal patterns from 2003-2012. Using network analyses, we identify scenarios in which an oil spill during a different year or in a different location might have had strong local or regional effects on planktonic larvae. In some years (2004, 2007, 2008, and 2009), 1-2 estuaries (Adams Bay and Chandeleur Sound) had high (>0.3) betweenness centrality. The presence of surface oil near one of these estuaries on one of these years likely would have had a large regional effect on larvae, since more than 30% of larval pathways would have passed through oil. Connectivity matrices suggest that some estuaries have consistently high larval retention rates. These include West Cote Blanche Bay, Chandeleur Sound, and, in some years, Pensacola Bay and Atchafalaya Bay. Oil near one of these estuaries likely would have had a strong local effect but a more limited regional effect on larvae.

Identifying the Most Effective Strategies in Tracking the DWH Deepwater Plume from a Natural Resource Damage Assessment (NRDA) Perspective

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Due to the unprecedented depths and scale of the Deepwater Horizon (DWH) blowout, it was necessary to develop a number of adaptive sampling strategies to document the oil's fate and transport in the deep ocean over three dimensions and time. As we sampled and later forensically examined analytical chemistry results for 5,300 offshore water-column samples collected during the Natural Resource Damage Assessment (NRDA), we identified several practices regarding workplans, sampling designs, field detection and sampling methods, shipboard sample processing, handling and logistics, lab analytical methods, data management, and forensic assessment techniques that ensured the most complete and useful data. From the NRDA perspective, we summarize the final DWH oil fate and transport in the deepwater plume. Optimal sampling approaches included: Collecting filtered, phase-separated water samples to aid in parsing out dissolved versus particulate signatures in unfiltered samples; combining multiple real-time sensors (DO, fluorometry, CTD, particle-size-analyzers, and video) with ROV and rosette-based sampling systems to detect and collect oil at depth; and using ROVs for sampling near-bottom water and identifying and collecting floc samples, burn residues, and sediments without disturbing the ephemeral oil layer at the sediment-water interface.

LES of Langmuir Supercells under Constant and Oscillating Crosswind Tidal Forcing

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Langmuir turbulence is characterized by a wide range of Langmuir cells (LCs) that are generated by the interaction between surface waves and the wind-driven shear current. The LCs consist of parallel counter rotating vortices roughly aligned in the direction of the wind that are well known to play and important role in the vertical and lateral dispersion of spilled material. The passage of storms can lead to Langmuir supercells (LSCs) which are LCs that engulf the entire water column in shallow water, giving rise to an important mechanism for oil sedimentation. These cells have been observed in shallow continental shelf regions ranging between15 and 30 meters in depth. We report on the impact of a crosswind tidal current on LSCs in shallow water computed via large-eddy simulation (LES). Without tides, LES reveals that the typical crosswind width of a LSC is ∼4 times the water column depth (H). Under a relatively weak crosswind tidal current (weaker than the downwind current), the constant crosswind tidal forcing applied causes a merging of cells leading to cells of width ∼8H. The opposite occurs under a crosswind tidal current stronger than the downwind current as the constant crosswind tidal force is able to break up the LSCs giving rise to smaller scale cells with different turbulent structure than that associated with LSC. Statistics of the turbulence during strong and weak crosswind tides will be contrasted. Furthermore, preliminary results of LES of LSC with an oscillating crosswind tidal force will be discussed.

Marine Nematode Assemblages in the Gulf of Mexico Continental Shelf

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A long term meiofauna survey is being conducted at Troy University to better understand the fauna of the Gulf shelf, particularly in the aftermath of the Deepwater Horizon oil spill. Meiofauna were collected at 54 -187 m depths on the northern Gulf of Mexico (GOM) continental shelf in 2013 on the NOAA ship Pisces. Twenty one sediment samples were collected with a multicorer and were analyzed for grain size characteristics, trace metals, and nematode diversity. The data were analyzed with Primer ® 6 software. Nematode diversity analysis resulted in 13 new genus records for the GOM among the 122 genera and 30 families recorded. Cluster analysis revealed distinct nematode assemblages in the eastern study areas (Florida) versus western areas (Louisiana) that correlated strongly with two distinct sediment profiles, and significant groupings of sites that were geographically close to each other. The nematode assemblages grouped into eastern (Florida) locations with carbonate sediment and high levels of calcium and strontium, and western (Louisiana) locations with silty sediments characterized by aluminosilicate compounds. Further, significantly distinct groups of sites within Louisiana were identified and located either close to the outflow of the Mississippi river or further away. The most abundant genera in Louisiana were *Sabatieria*, *Dorylaimopsis*, and *Pselionema*, and the most abundant genera in Florida were *Sabatieria*, *Desmoscolex*, and *Pselionema*. Overall, a number of factors correlated with nematode assemblage patterns, particularly trace metals, sediment grain size and proximity to the Mississippi River and indicate the effect of environmental factors on nematode diversity.

The Combined Effect of Oil Exposure and Environmental Stressors on Reproduction of Sheepshead Minnow (*Cyprinodon variegatus*)

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The 2010 Deepwater Horizon oil spill resulted in the release of 4.9 million barrels of crude oil into the Gulf of Mexico (GOM), affecting hundreds of miles of coastline. Estuaries of the northern GOM experience constant fluctuations in temperature, dissolved oxygen, and salinity. While fish can adapt to environmental stress common to estuarine environments, it is unknown how fish will respond to the additional stress of chronic oil exposure. Sheepshead minnow (SHM) are small-bodied fish found in northern GOM estuaries, are easily adaptable to laboratory conditions, and have an extensive toxicological database. The purpose of this study is to determine the impact of oil high-energy water accommodated fraction (HEWAF) on SHM reproduction under four different environmental scenarios. During the short-term reproductive test, eggs were collected daily to determine total egg production, fertilization rate, egg hatch success, time to hatch, length at hatch, and larval survival and growth post-hatch. Following HEWAF exposure, adult fish were sacrificed and tissues were harvested to determine liver somatic index, gonad somatic index, and contaminant uptake, as well as to measure changes in gene expression, immune function, and histology. These data will be used to determine the effects of oil exposure on SHM reproduction under different environmental scenarios, which can result in more accurate risk assessment concerning the impact of oil on the reproductive health of estuarine fish.

Diversity and Connectivity of a Mesopelagic Shrimp as Proxies for Ecosystem Health and Recovery in the Gulf of Mexico

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Genetic measurements, such as diversity and connectivity, have been useful in predicting population recovery after an anthropogenic or natural disturbance and are frequently used to manage marine populations. Changes in genetic diversity can be used as proxies for ecosystem health because diversity is closely tied to ecosystem function and resilience. Genetic structure and connectivity can describe the distribution of diversity across a system and indicate barriers to gene flow between adjacent populations. In this study we will use the mesopelagic shrimp, *Acanthephyra purpurea* to study the health and recovery potential of mid-water crustaceans in the Gulf of Mexico (GOM) across small spatial and temporal scales. Traditional molecular methods consist of sequencing thousands of nucleotides in search of a handful of informative sites. However, our research utilizes RADseq, a cutting-edge next-generation sequencing technique capable of discovering tens of thousands of single nucleotide polymorphisms. Using samples collected from 2010-2011 and 2015-2017, we will quantify changes in diversity across time, both short-term (one year) and long-term (5-7 years). We will also characterize connectivity between populations in the Atlantic and in the GOM. Investigating diversity and population connectivity in *A. purpurea* will provide insight into the timescales across which GOM health fluctuates, improving our understanding of ecosystem recovery and resilience in the region.

Exposure to PAHs during Early Stages of Development of the Chicken (*Gallus gallus*) Affects Cardiovascular Structure

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Following the Deepwater Horizon Oil Spill, very few studies have examined the effects of oil on avian physiology and development. Yet, crude oil exposure causes detrimental cardiovascular effects in avian and other species. Not always fatal, these effects may permit otherwise normal development, though even slight cardiac impairments from embryonic exposure to stressors may impact fitness later in life (i.e. fetal programming). These experiments determine the most sensitive times during embryogenesis (i.e. critical windows) where exposure to crude oil is most cardiotoxic to avian model species. A significant effect on cardiovascular structure and function was found in chick embryos that were exposed to oil by either direct application to the egg shell or by sub-shell injection of water accommodated fractions during early embryogenesis. This effect appears to decrease in severity as embryo development progresses. Additionally, so-called shell-less culture in vitro permits direct access to early-stage embryos to closely examine the effect of oil early cardiac developmental physiology within this most critical window of development. Chemical analysis of tissues is underway to determine toxicant loading, transport and storage in embryonic tissues. These studies provide benchmark data on the influence of exposure timing and route of delivery on the cardiotoxicity of oil in a model avian species as it develops.

Quantifying the Impacts of Deepwater Horizon on Commercial Reef-fish Fisheries: Spatial Patterns before, during, and after the Spill

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In the months following the Deepwater Horizon spill (DWH), emergency fishery closures were put in place to assure that potentially tainted seafood did not reach the market. These closures forced fishermen to move fishing grounds, or to stop fishing altogether. The height of the closures encompassed an area of 229,270 square km, or 37% of the U.S. Gulf of Mexico EEZ. Shifts in commercial fishing effort in the aftermath of DWH have been largely undescribed, or evaluated at relatively coarse scales with limited datasets. Here, we report on analyses for commercial reef-fish vessels that use complementary observer, catch logbook, and high-resolution satellite tracking data. By comparing fishing patterns before, during, and after DWH, we describe temporal and spatial shifts that resulted from closures and quantify concomitant changes in total catch, catch composition, catch per unit effort (CPUE), and revenue. We also correlate fishery patterns to various explanatory variables, such as vessel size and length of fishing trips. Initial results indicate that average per-trip landings, revenue, and CPUE of snappers, groupers, and tilefish (as a group) increased steadily from 2009-11; landings and revenue for the group were particularly high in winter months. However, there were varying landings, catch composition, and CPUE among individual species over time (ie, Red snapper, Gag, and Golden tilefish). Our results are discussed in the context of altered fishing effort distribution during and after DWH closures, as well as changes in the fishery's overall management structure in the years during and post-DWH.

Fluid Dynamic Behavior of Methane-saturated Oil Jets under Deep-sea Conditions

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Deep-sea drilling accidents can cause oil and gas blowouts that spill large amounts of oil droplets and gas bubbles into the ocean. For the prediction of the oil propagation some near- and far-field models have been developed, based on the assumption of a certain particle size distribution and rising velocity. For the estimation of oil droplet sizes many experiments have been conducted with crude oil jets at ambient conditions (dead oil). However one fact that has been neglected so far is that crude oil within the reservoir (life oil) is saturated with methane. When saturated oil is released through an orifice at high pressure, the pressure drop within the jet might cause an expansion of the gaseous phase, which dramatically changes the physical properties and fluid dynamic behavior of the oil jet. To study the fluid dynamic behavior of Louisiana Sweet Crude Oil oversaturated with methane during jet formation, an experimental facility has been developed at Hamburg University of Technology. The experiments have been performed at 4 °C and 20 °C and with pressures up to 15 MPa, in accordance to the Deepwater Horizon accident in 2010. In this presentation, a comparison between the fluid dynamic behavior of life oil and dead oil will be given. It will be shown that the saturation of oil with methane should be taken into account in further investigations. This research was supported by the Gulf of Mexico Research Initiative, C-IMAGE.

Determinants of Genetic Diversity and Historical Demography in Deep-sea Fishes

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Deep-sea fishes remain poorly studied, due in large part to the difficulty of accessing the environment in which they reside. Genetic data for many deep-sea fishes is still absent or restricted to a small sample size from a limited geographic range. We will be collecting DNA sequence data from the estimated 500 species present in the pelagic environment of the Gulf of Mexico. Currently, 2275 individuals representing 375 species have been taken using MOCNESS trawls sampling at depths up to 1500 meters. Our molecular data will be used to characterize the population genetic diversity and historical demography (i.e. population size changes) of these hundreds of fish species. This will be done in a manner so that species that differ in life history traits such as migration, feeding, generation time, and reproductive mode will be compared to one another, and correlates between life history traits and population genetic parameters will tested. This presents us with the opportunity to make inferences on how the life histories of hundreds of these understudied species contributes to the historical process that have generated the genetic diversity we observe today.

Long-term Response of Coastal Salt Marsh Vegetation to the Deepwater Horizon Oil Spill

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Louisiana's coastal shoreline salt marshes bore the brunt of impact from the Deepwater Horizon (DWH) oil spill. We have conducted a series of field studies for more than 5 years to assess oil impacts to coastal salt marshes and their subsequent recovery. In salt marshes of northern Barataria Bay, we established replicated field stations that received heavy, moderate and no oiling. Surface soil total

petroleum hydrocarbon concentrations in the heavily oiled marshes were >500 mg g-1 9 months after the spill, and decreased to about 100 mg g-1 5 years after the spill. Species-specific oil impacts indicated that *Juncus roemerianus* was more severely affected by the spill than *Spartina alterniflora*. Heavy oiling changed vegetation structure of shoreline marshes from a *Spartina-Juncus* community to mostly *Spartina*. Total live aboveground and belowground biomass in the heavily oiled marsh did not fully recover 5 years after the spill. In contrast, moderately oiled marsh plants were able to recover within two years after the spill. Great impacts of heavy oiling on marsh plants resulted in significantly weaker soil shear strength compared to reference marshes, thus potentially affecting the stability of the oiled shoreline marshes.

Surface Ocean Variability and Transport Pathways in the Gulf of Mexico

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Decade-long satellite observations of sea surface temperature, sea surface height, ocean color and ocean winds are combined with in situ subsurface data from autonomous underwater gliders and shipboard surveys and with surface drifter trajectories to investigate variability and transport pathways in the Gulf of Mexico. Results indicate that nonlinear mesoscale eddies, which are characterized by rotational geostrophic velocities exceeding their translation speeds, are observed in the area around GC600 almost 20% of the time. Nonlinear eddies can trap water in their interior as they propagate, establishing a mechanism for transporting oil in the water column for long distances. Sea surface temperature frontal variability, ocean color images and in situ data reveal that low-salinity waters from the Mississippi river are often found at over 100 km from the coast. Mechanisms responsible for the offshore transport of riverine water are discussed.

AUV Jubilee 2015: An Exercise in Adaptive Sampling Using Integrated Ocean Observations

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The Autonomous Underwater Vehicle (AUV) Jubilee was an inaugural event to coordinate glider as well as other in situ and remote ocean data operations in the Gulf of Mexico for the month of July 2015. This cooperative effort to join disparate ocean research efforts facilitated an opportunity for mutually beneficial collaborations with various academic, industry, private, and government partners across the Gulf of Mexico, in addition to supporting the increased characterization of ocean processes. The provision of glider support products, including real-time ocean circulation models and satellite ocean color data, enabled the optimization of glider flights, and showcased how multiple technologies can be used to optimize the adaptive sampling of specific ocean processes. Select gliders were also able to submit data to the National Glider Data Assembly Center (NGDAC), thereby enhancing the capabilities of physical circulation models by making real-time data available for assimilation. The integration of real-time observations with AUV, model, and satellite data created an enhanced ocean monitoring capability for dynamic waters.

Microbial Community Dynamics of a Coastal Alabama Salt Marsh Impacted by the Deepwater Horizon Oil Spill

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The oil from the Deepwater Horizon (DWH) oil spill impacted marshes along the Gulf of Mexico (GoM) covering approximately 45% of the oiled shoreline from Louisiana to Florida. Also, the use of dispersants to mitigate the effects of the DWH spill was controversial. Research focused on the long-term effects of an oil spill on the salt marsh microbial community are surprisingly limited. The goal of this research project was to monitor and determine microbial responses to oil spills and dispersant on salt marsh ecosystems in the GoM. Temporal variations in the phylogenetic composition, structure and functional potential of the microbial community in salt marsh sediments were examined using next generation sequencing methods. Results indicated an overall decrease in the number of operational taxonomic units (OTUs) when oil was detected in the salt marsh sediments. Concomitantly, an increase in abundance of selected taxonomic groups in oiled sediments as well as seasonal trends in abundance of functional gene groups were also detected. Additionally, the effects of Corexit on marine bacterial populations were investigated using culture-based methods and microscopy. Exposure of marsh microbial community and pure cultures (Bacillus and Vibrio) to Corexit revealed strain dependent differences in dispersant impacts on bacterial cell growth. The research findings presented demonstrates the importance of understanding and predicting microbial responses to oil spills and highlights the potential of using genome-enabled microbial data to evaluate and monitor natural attenuation as well as remediation strategies in coastal ecosystems at present and in future. It also underscores the importance of establishing microbial community baselines in coastal areas that are prone to oil spills.

Differential Response of Pseudomonas aeruginosa Cells to Interfacial Stress

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Microorganisms help to alleviate the ecological impacts of oil spills by degrading hydrocarbons. When exposed to the oil-water interface, bacteria become trapped due to the high interfacial energies. We hypothesize that the associated stresses on the bacteria can induce changes in genetic pathways, leading to the formation of appropriate protective films or the alteration of the metabolic performance of cells. This study contrasts the responses of Pseudomonas aeruginosa PAO1 and PA14 cells to confinement at hexadecane-water interfaces. Our results show that P. aeruginosa PAO1 cells remodel the interface as they attach, making Films of Bacteria at Interfaces (FBI) with physico-chemical characteristics including elasticity and bending moduli. In contrast, rather than forming FBI, the PA14 cells remained highly mobile at the oil-water interface, as evidenced by super-diffusive behavior of colloidal tracers which are moved about owing to hydrodynamic interactions with swimming bacteria. While FBI formation by PAO1 is independent of cellular features such as pili, flagellum, exopolysaccharides and biosurfactants, the deletion of some of these functions strongly impacts the ability of PA14 to form FBI, and alters their mode of association within these layers. We have further investigated changes in the transcriptional profile of the cells using RNA sequencing to establish which pathways in P. aeruginosa are affected by the interfacial confinements. The understanding of such differences in the response to stresses associated with interfacial trapping is relevant to optimizing the performance of the bacteria in the oil field, and thereby improves ecosystem recovery.

CONCORDE: Enabling Slocum Glider Flight on a River-Dominated Continental Shelf

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Teledyne-Webb Slocum gliders have become robust sampling platforms for the world's oceans and providing real-time information to researches globally. These systems have been successfully deployed in depths as shallow as 6 meters and as deep as 1000 meters for durations on the order of hours to days during storm events to months when crossing ocean basins. Many research projects using Slocum gliders have included extreme environments such as the Arctic and Antarctic, beneath hurricanes, and on highly stratified continental shelves. Deployments near freshwater plumes on continental shelves, such as the Mississippi Bight, have been limited. Gliders are buoyancy driven autonomous underwater vehicles that rely on small changes in volume to profile through the water column. Typical Slocum gliders, when ballasted properly, can accommodate surface to bottom density differences of as much as 8 kg m-3, which is sufficient to sample much of the world's oceans. Continental shelves with large freshwater inputs can have pycnoclines that exceed this threshold. In order to overcome these limitations new technologies have been developed including larger capacity pumps and thruster technologies for lens penetration. The Gulf of Mexico Research Initiative CONCORDE project has obtained an advanced technology glider, which was deployed in conjunction with research cruises in October and November. Glider results demonstrate utility and capabilities on the Mississippi Bight, leading the way for future autonomous sampling networks in the region.

Changes in Sedimentary Barium Following the BP DWH Blowout Event

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This presentation will focus on the role of barium in sediments in the northern Gulf of Mexico. It will also examine if and how barium levels were affected by the BP DWH Blowout event and subsequent capping efforts involving pumping large amounts of drilling muds into the wellhead, known as "Operation Topkill." Drilling mud is mainly composed of barite (BaSO4), leading to increased barium in the sediments. Sediment cores collected in the NE Gulf of Mexico from August 2010, just after the event, to August 2015, were sampled at high resolution (2 mm), microwave digested in concentrated nitric acid at high temperature and pressure, and analyzed via ICP-MS. We focus on four sites including the well head (DWH01), two impacted sites within 60 km of the wellhead (DSH10 and PCB06) and a control site (NT1200). Barium levels range from 200ppm, an apparent background level, to over 1500ppm. Barium levels were 7 times higher at the wellhead than the control site in 2010. In general, barium decreases both down core and temporally. We will constrain different processes that control changing barium concentrations in sediments in the northern Gulf of Mexico following the blowout event.

A Preliminary Trophic Analysis of Deep-Pelagic Assemblages in the Northern Gulf of Mexico

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The Deepwater Horizon oil spill, which released hydrocarbons into the deep-pelagic environment of the Gulf of Mexico (GoM), revealed significant data gaps with respect to the Gulf's largest habitat and resulted in a concerted effort to understand the structure and function of deep-pelagic assemblages. As part of a larger collaborative effort tasked with characterizing assemblage structure of the GoM deep-pelagic fauna and determining the biotic and abiotic drivers underlying that structure, we examined the isotopic ratios of model taxa in order to (1) establish an isotopic baseline for bathypelagic (>1,000 m), mesopelagic (200 - 1,000 m), and epipelagic (0 - 200 m) assemblages of the northern GoM, (2) trace the vertical flow of organic matter among these three depth domains via active (vertical migration) and passive transport (sinking marine snow), and (3) investigate potential spatial and temporal variation in trophic structure of deep-pelagic assemblages. In 2015, samples were collected during two oceanographic cruises in the northern GoM using a 10-m2 MOCNESS midwater trawl sampling specific stratified depths from the surface to 1500 m. Here we present preliminary isotopic data from the deep-pelagic food web which represent several distinct trophic levels including carbon sources (particulate organic matter, *Sargassum spp*.), zooplankton, gelatinous zooplankton, cephalopods, and fishes encompassing an array of feeding strategies (planktivores, gelativores, piscivores), and vertical distributions (migratory vs. non-migratory). By describing the trophic structure of deep-pelagic assemblages and evaluating the nature of vertical trophic connectivity in the GoM, this project will provide baseline trophic data to inform ecosystem models and identify taxa that may serve as important "vectors" among depth domains in offshore waters of the GoM.

Chemical Characterization of the Natural Oil Seeps From GC-600 Lease Block by FT-ICR MS, GC/MS, and API-GC/MS-MS

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We first utilize Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR MS), gas chromatography/ mass spectrometry (GC/MS), and Atmospheric Pressure Gas Chromatography (APGC) combined with tandem mass spectrometry for a comprehensive analysis of natural oils seeps (Megaplume and Birthday Candles) from the GC-600 lease block. The seeps produce an oily bubble plume that rises in the water column to form surface oil slicks that were collected with a clean Teflon mesh. Additionally, oily bubbles emerging from the seafloor (27° 22.466' N, 90° 30.689'W) were collected at a depth of 1220m.

Biomarker analysis (steranes and hopanes) by GC/MS and API-GC/MS-MS enabled diagnostic ratios to be calculated for fingerprinting crude oils and source identification. However, GC/MS analysis is limited to volatile and semi-volatile compounds (mostly hydrocarbons); thus, FT-ICR-MS was employed for the compositional analysis of fields samples over the full boiling range. It revealed increased complexity with noted improvement in the compositional coverage of aromatic and heteroatomic (nitrogen, sulfur, oxygen) compounds, which comprise a significant mass fraction of petroleum. Combined, the analytical

data supports that oil released from the seafloor relates to the reservoir oil as well as oil collected from surface sheens.

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Stable Carbon Isotope Composition of Remineralizing Organic Matter in the Hypoxic Zone of the Northern Gulf of Mexico

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We examined stable carbon isotope composition (δ13C) of organic matter that was remineralized in the hypoxic zone of the Northern Gulf of Mexico (nGOM). We used both shipboard incubation experiments (water and sediment) and a three-endmember mixing model to elucidate the source of organic matter that drives subsurface water oxygen consumption. Based on our 2014 data, sediment and water incubations yielded disparate δ13C signatures in the respiration produced CO2, with the sediment incubation producing substantially more 13C-enriched CO2 (-16~-21‰ vs. -27~-29‰), though water column particulate organic matter (POM) had a δ13C range of -23~-25‰. However, based on a three-endmember mixing model, our calculated δ13C of reaction produced CO2 in the entire surveyed nGOM shelf was -18.5‰. This value was consistent with the results obtained in previous three cruises in 2011-2013 (-17.2~-19.5‰). The close agreement between bottom water respirational CO2-δ13C (from the mixing model) and that from sediment incubation suggested that benthic process likely played a dominant role in subsurface respiration on the nGOM shelf. This result also confirmed that hydrocarbon degradation was insignificant on the ecosystem level one year after the spill.

Effects of Crude Oil on Growth Rate and Variable Fluorescence of Marine Cyanobacteria

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The effects of Macondo surrogate crude oil were studied in dose-response experiments measuring growth and photosynthetic physiology of three strains of the marine cyanobacteria, *Synechococcus* (an estuarine, coastal and an open ocean strain), and an open ocean strain of Prochlorococcus. Oil was added (0-250 ppm by weight) as freshly-made water-oil emulsions. Physiological reaction time to oil addition was quantified using variable chlorophyll fluorescence (Fv, Fv/Fm) following oil additions. Decrease in physiological state (measured by Fv) occurred almost immediately (within 2 minutes) following oil addition. Growth rates were measured over several days of oil exposure. For the three *Synechococcus* strains, all strains exhibited significantly decreased growth rates at 100 ppm and 250 ppm. The open ocean and estuarine strain also exhibited significant decreases in growth rate at 50 ppm, while the coastal strain only showed a significant decrease in growth rate at 100 ppm and above, suggesting some strain-specific differences in oil tolerance. However, a single dose response curve adequately fit all three species, demonstrating a fairly consistent overall negative relationship between oil concentration and *Synechococcus* growth across strains isolated from different habitats. Significant declines in growth rate measured over several days were consistent with significant decreases in Fv/Fm after only 2-4 hours, suggesting that variable fluorescence could be used as a rapid assay for oil effects on cyanobacteria. Results for *Prochlorococcus* will be considered in the context of the *Synechococcus* results.

Oxygen Fluxes in Gulf of Mexico Sediments

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Quantifying the linkages between individual organisms, communities, and ecosystem function is of fundamental importance for ecology. In shallow water marine systems, biogeochemical fluxes at the sediment-water interface are an especially important component of ecosystem function. We seek to link oxygen fluxes to community composition in the northern Gulf of Mexico while simultaneously examining the effects of oil exposure on community structure and function. Sediment metabolism was measured in vegetated and unvegetated shallow subtidal habitats in Tampa Bay and in the Chandeleur Islands. The Chandeleurs are a chain of uninhabited barrier islands that experienced variable oiling during the Deepwater Horizon spill; Tampa Bay, in contrast, experienced minimal oiling. Measurements were made in 6-inch cores, which were subsequently sieved for infauna. Emerging patterns suggest that oxygen uptake by sediments is generally higher in seagrass habitats than unvegetated ones, an effect which persists even when aboveground seagrass biomass is removed. Substantial variability exists among sites, however, and may well be explained by the community composition within cores and/or by the history of oiling from the Deepwater Horizon spill at each site. Together, these data will provide further insight into linkages between communities and ecosystem function in benthic habitats, while also providing a baseline for understanding how ecosystems are affected by anthropogenic events such as oil spills.

Buoyancy and Diameter of Bay Anchovy, Mahi-mahi, Red Drum, and Red Snapper Eggs Found in the Northern Gulf of Mexico

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During the Deepwater Horizon (DWH) oil spill, fish eggs near the ocean surface were exposed to oil slicks as well as oil entrained in the water. The exposure of pelagic eggs to toxic polycyclic aromatic hydrocarbons (PAHs) is dependent on the vertical distribution of eggs in the water column. Factors that determine the vertical distribution of pelagic fish eggs include egg buoyancy, egg diameter, and upper-ocean turbulence. We conducted a number of studies on eggs from various Gulf of Mexico species to determine the relative egg buoyancy, based on the difference between the specific gravity of the water and the specific gravity of eggs. This presentation will discuss the methods we used to determine egg buoyancy and diameter, and the results of the analyses on red drum (*Sciaenops ocellatus*), mahi-mahi (*Coryphaena hippurus*), red snapper (*Lutjanus campechanus*), and bay anchovy (*Anchoa mitchilli*). We found that the egg buoyancy and diameters for these species fell within previously published ranges for these and other marine species. These data were included in the Natural Resource Damage Assessment water column exposure and injury modeling.

Particle Size Distribution in Two-Phase Oil and Gas Jets under Deep-Sea Conditions

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The prediction of gas and oil distribution in deep oceans plays a major role in all regions of oil/gas exploitation. In particular, the information about the fate of oil and gas after oil spills as in the Gulf of Mexico in 2010 is important, for example for cleaning measures. One of the main input parameters in near- and far-field models to predict the distribution of hydrocarbons in the ocean is the particle size distribution (PSD) of oil and gas in the jet, as it influences to whole fluid dynamic behavior. In a first step, the PSD of dead oil (gas-free) and pure methane are investigated. The laboratory experiments are done in a high pressure vessel (pmax=15 MPa) with specific inner jet module. To measure the PSD, a specific endoscopic measuring system has been used, combined with a camera system. Further, a high speed camera is placed next to the cylinder to record the expansion and form of the jet. The pressure is varied from 0.1 to 15 MPa at temperatures from 4°C to 20°C. The poster shows the laboratory setup and discusses the influence of pressure and temperature on PSD in Louisiana Sweet Crude Oil and pure methane jets, respectively. A comparison of existing models with new model is given. The experiments allow the assumption that under the investigated environmental conditions the influence of pressure and temperature is low. The PSD in this case is dominated by turbulence and less by material properties.

Southwest Florida Coastal Mesocosm Oiling Experiments

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The Macondo oil spill was a devastating environmental catastrophe in the northern Gulf of Mexico that resulted in significant negative impacts on coastal ecosystems. In this study, we compare the physiological responses of primary producers and primary consumers to oil exposure representing several environments in southwest Florida (seagrass bed, black mangrove shoreline, salt marsh shoreline) with their counterparts in the northern Gulf of Mexico (Chandeleur Islands) using mesocosm-based experiments. We assume that the southwest Florida environments are naïve to oil versus those from the Chandeleur Islands, due to the latter's proximal location to oil rigs and the site of the Deepwater Horizon event. We hypothesize that the southwest Florida organisms will exhibit more evidence of negative impacts and reduced recovery capability versus the Chandeleur Island organisms due to this naivety. Additionally, we anticipate that the Chandeleur Island environments will be less diverse (due to chronic crude oil exposure and the subsequent removal of sensitive species), but more resilient to acute events (due to the absence of sensitive species). Overall, these experiments will help us address how environmental impacts (such as crude oil exposure) affect ecological diversity and resiliency.

Benthic Diatom Population Responses to the Oiling in the Chandeleur Islands, Louisiana

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The environmental impacts of the Macondo oil spill of April 20th, 2010 are still being assessed five years after the event. The goal of this study was to compare the assemblages of edaphic diatoms between

oiled and non-oiled sites in the Chandeleur Islands of Louisiana. We examined three different sites to survey the living diatom populations in order to document potential differences in diversity and absolute abundance between the sites. We predicted that there will be lower diatom diversity at the oiled sites due to a loss of less resilient species, but a higher abundance of the more tolerant forms. These data will provide useful preliminary information for further examination of the possible impacts of the Macondo oil spill on coastal, benthic diatom populations.

Large-eddy Simulation (LES) of Langmuir Supercells under Constant Surface Cooling or Heating

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LES of a wind-driven flow with Craik-Leibovch (C-L) vortex forcing representative of the shallow (10 to 30 meters deep) coastal ocean under the influences of Langmuir (wind-wave) forcing and either surface heating or surface cooling are presented. In shallow water the C-L vortex force leads to the generation of Langmuir turbulence whose largest scales consist of Langmuir supercells (LSCs) engulfing the water column. These cells present a mechanism for rapid transport of surface material to the bottom of the water column and re-suspension of sediments. Either unstable or stable stratification is imposed by a constant surface heat flux and an adiabatic bottom wall. Surface buoyancy forcing relative to wind shear will be quantified in terms of a Rayleigh number (Ra) in the case of surface cooling and a Richardson number (Ri) in the case of surface heating. The impact of these heat fluxes on the LSCs will be assessed by analysis of cell strength and structure in a case in which a surface heat flux is absent, then with a range of positive and negative surface heat fluxes at the surface. In the case with surface cooling, transition from Langmuir-dominated turbulence to convection-dominated turbulence with increasing Ra will be addressed and analyzed in terms of turbulence kinetic energy production rates. Results demonstrate that under typical wind, wave and unstable surface buoyancy forcing conditions, Langmuir-dominated turbulence is prevalent over shear- and convection-dominated turbulence regimes. In the case with surface heating (and thus stable surface buoyancy forcing) the form and extent of turbulence suppression by stable stratification will be considered. Surface heating leads to weakening of the LSCs in the lower half of the water column, allowing a stably stratified turbulent bottom layer to develop. Results are intended to assist future developments of parameterizations of Langmuir turbulence in shallow water for inclusion in coastal circulation models.

Chemical Tracers in the Mississippi Bight: Preliminary Results and Incorporation into CONCORDE

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CONCORDE is a GoMRI-funded consortium focusing on near-shore waters in the northern Gulf of Mexico. Our ultimate question: How do the complex fine-scale biological, chemical and physical structure and processes in coastal waters dominated by pulsed-river plumes control the exposure, impacts and recovery from offshore spills like the Deepwater Horizon release of 2010? A goal of the water chemistry work in CONCORDE is to differentiate among the various water sources to provide information about water sources, mixing time scales, and physical transport as well as to inform the biological studies with basic data on nutrient distributions.