APPENDIX A – NGI GoMRI Year 1, Phase 1 Final Reports

NGI GoMRI Year 1, Phase 1 covered initial NGI year 1 funded projects from May through December 2010. Several projects received no-cost extensions due to difficulties obtaining samples or due to unanticipated delays analyzing data.

The following reports are primarily in an initial format designated by NGI. However, the GoMRI program office provided a common GoMRI reporting format in spring of 2012. NGI subsequently provided the opportunity to principal investigators to reformat their reports in this updated format so several appear in the GoMRI format.

Most but not all of Phase 1 projects consisted of large umbrella efforts led by one academic organization as identified in the project names. The large umbrella project was typically subdivided into multiple stand-alone tasks. The reporting is therefore mixed. Some projects simply provide a comprehensive summary of the entire effort. Two just report on the individual tasks without an overall summary. Some provide an overall summary in addition to all or some task summaries.

Contents

10-BP_GRI_DISL-01: (Overall Summary): Impacts of the Deep Horizon Oil Spill on Ecosystem Structure and Function in Alabama's Marine Waters

1. NGI Project File Number: 10-BP_GRI_DISL-01 (Overall Summary)

2. Project Title: Impacts of the Deep Horizon Oil Spill on Ecosystem Structure and Function in Alabama's Marine Waters

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI	Affiliation	Email
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4. All Non-Student Personnel funded by this project (including those listed above):

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Charles Martin	Post doc	PhD	12	No
Latina Steele	Post doc	PhD	6	No
Katherine Blankenhorn	Technician	BS	12	No
Nicole Taylor	Research Technician	BS	25	No
R. H. Carmichael	Project Lead	PhD	8	No
Cammi Thornton	R&D Chemist	BS	5	No
Kenneth L. Heck, Jr.	Project Lead	PhD	8	No
Dorothy Byron	Research Associate	MS	33	No
Sharon Havard	Research Technician		33	No
Ryan Moody	Post Doc	PhD	33	No
Megan Sabal	Undergraduate Intern	BS	33	No
Whitney Scheffel	Undergraduate Intern	BS	33	No
Sara Kerner	Undergraduate Intern	BS	33	No
Lindsey Bierman	Undergraduate Intern	BS	33	No
Rod H. Condon	Research Marine Scientist	PhD	33	No
Melanie N. Taylor	Technician	BS	28	No
William Harper	Research Associate	M.S.	100 (1 mo. only)	No

*If yes, list NOAA lab

5. All Students funded by this project (including those listed above):

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Marissa Dueker	BS	MS	6	No
Larisa Lee	BS	MS	6	No
Shanna Madsen	BS	MS	6	No
Karen Fisher	BS	MS	33	No
Isabella D'Ambra	MS	PhD		No
Naomi Shelton	BS	MS		No

*If yes, list NOAA lab

5.a. Other Student and Non-Student project participants not funded by this project:

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Lei Wang	BS	MS	0	No
Rebecca Bernard	BS	MS	0	No
Agota Horel	PhD	PhD	0	No

6. Abstract

NGI funding allowed scientists at the DISL to continue their initial assessments of the impacts of the unprecedented Deep Water Horizon oil spill on the health of key ecosystem attributes in Alabama waters. Specifically, we completed seven tasks (see below) that evaluated the acute impacts of this environmental

catastrophe on the same ecologically and economically important components that were sampled before the oiling occurred. We evaluated oil and dispersant impacts on: planktonic organisms, economically and ecologically important adult fishes (both reef-associated and demersal), trophic pathways, key biogeochemical processes driven by microbial organisms, finfish and shellfish nursery habitat function, and a representative, federally listed, sentinel species found in our area (e.g., the West Indian manatee). In addition, we tested for changes in the habitat utilization patterns of organisms living within the vegetated habitats (seagrass and salt marsh habitats) of the north central Gulf of Mexico. Finally, we began to determine the extent to which the oil intruded into the northernmost reaches of Mobile Bay via the main ship channel.

7. Key Scientific Questions/Technical Issues/Tasks:

Task 1. To quantify the interactive effects of the release of oil from the Deepwater Horizon (DWH) rig, off the coast of Louisiana, and the federally-mandated closures of all commercial and recreational harvesting on the: 1) composition, abundance and/or biomass of important juvenile and adult fishes and macroinvertebrates, 2) feeding patterns of fishes and macroinvertebrates; and 3) numbers of harvestable (commercially and recreationally important) coastal species in the area.

Task 2. To quantify effects of 1) oil-derived substances on sentinel benthic and pelagic species directly exposed to DWH contaminants, and 2) oil-induced reductions in DO on oyster physiology, and manatee condition, distribution and movement patterns. Additionally, define the temporal-spatial scales of physiological (sub-lethal), biological (growth, survival), and behavioral (distribution, movement) responses by these two sentinel biota.

Task 3. To use historical, and newly created, data sets to assess the impacts of oiling on 1) the abundance of seagrass and marsh plants, as well as macroinvertebrates and juvenile as well as 2) the habitat utilization patterns of macroinvertebrates and fishes in coastal Alabama nursery habitats.

Task 4. To quantify 1) hydrocarbon and oil-dispersant signatures in planktonic organisms, 2) the effects of petroleum-driven increases in Dissolved Organic Carbon (DOC) on microbial consumption as well as the carbon isotope ratio in the Dissolved Inorganic Carbon (DIC) pool and 3) methane concentrations in Alabama waters coastal waters following oiling. Finally, to quantify changes in bacterial biomass production, temporally and latitudinally, on the Alabama shelf in the days following the DWH blowout.

Task 5. To measure the impacts of oiling on potential rates of nitrification and denitrification, during summer and fall 2010, in marsh sediments along the Alabama coast line. To measure potential nitrification rates, as nitrate and nitrite production, in ammonium-amended sediments slurries.

Task 6. To determine the effects of oiling and dispersants on biomass and growth of phytoplankton, cyanobacteria and prokaryotes in Alabama offshore sites as well as to determine impacts of these contaminants on 1) grazing and viral lysis, 2) the number and diversity of Archaea and 3) hydrocarbon degradation genes in the local coastal waters.

Task 7. To determine the probability that dissolved and particulate oil-derived substances could be transported to the inner oligohaline portions of Mobile Bay via the deeper ship channel.

8. Collaborators/Partners:

Name of collaborating organization: University of Alabama – Dr. Patricia Sobecky

Date collaborating established: July, 2010
Does partner provide monetary support to project? No Amount of support?
Does partner provide non-monetary (in-kind) support? No
Short description of collaboration/partnership relationship: Dr Patricia Sobecky is a microbial ecologist at the Department of Biological Sciences, University of Alabama. Dr Sobecky's group focuses on bioremediation of subsurface soils contaminated with radionuclide and heavy metals and life in the extreme environments of the northern continental slope of the Gulf of Mexico, a hydrocarbon seep region, that contains vast reservoirs of oil and gas deposits, areas of active gas venting and gas hydrate mounds occurring as seafloor outcroppings and in the shallow subsurface.

Name of collaborating organization: University of South Alabama – Dr. Sinead Ni Chadhain
Date collaborating established: 2009
Does partner provide monetary support to project? No Amount of support?
Does partner provide non-monetary (in-kind) support? Yes
Short description of collaboration/partnership relationship. Dr. Ni Chadhain is a microbial ecologist in the Department of Biology at the University of South Alabama. She has expertise in studying hydrocarbon degradation processes and genes in environmental microbes. She has been responsible for analyzing samples for these targets in conjunction with the other analyses carried out by Dr. Ortmann.
Name of collaborating organization: Virginia Commonwealth University – Dr. Leigh McCallister
Date collaborating established: 2010
Does partner provide monetary support to project? No Amount of support?
Does partner provide non-monetary (in-kind) support? Yes
Short description of collaboration/partnership relationship: Loan of a Picarro cavity ringdown spectrometer to analyze the carbon isotope ratio of CO_2.

Name of collaborating organization: Université du Quebec á Montreal - Dr. Paul del Giorgio
Date collaborating established: 2010
Does partner provide monetary support to project? No Amount of support?
Does partner provide non-monetary (in-kind) support? Yes
Short description of collaboration/partnership relationship: Dr. Giorgio worked on CDOM modeling of the oil in coastal waters in addition to providing additional expertise on microbial metabolism of oil.

Name of collaborating organization: Lamont Doherty Earth Observatory-Columbia University
Date collaborating established: July 2010
Does partner provide monetary support to project? Amount of support? No
Does partner provide non-monetary (in-kind) support? Some sampling logistics.
Short description of collaboration/partnership relationship: - Dr. Wade McGillis received an NSF Rapid grant to work on effects of the oil spill on sea-air gas exchange. We collaborated with him on initial sampling logistics in the Dauphin Island area.

9. Project Duration: May 1, 2010 – December 31, 2010

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

This ongoing research contributes directly to NOAA's Strategic Goal #1, to "protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management." We have documented changes in multiple response variables prior to oil reaching Alabama's coastal waters and during times at the height of the DWH event. We have also been able to get a clear assessment of the immediate, acute, effects of the oil amendment, the dispersants and government management actions on the northern Gulf of Mexico Ecosystem.

Other specific NOAA Goals to which this project may make contribution are *Ecosystems* (protect, restore, and manage the use of coastal and ocean resources through ecosystem-based management) and *Commerce and Transportation* (support the nation's commerce with information for safe, efficient, and environmentally sound transportation).

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

The research will continue to make significant contributions towards improving our understanding of regional problems and the adoption of approaches to meet regional priorities, specifically we are referring to Gulf of Mexico Alliance Priority Issues "Ecosystem Integration and Assessment" and "Coastal Community Resilience" and the Northern Gulf Institute Themes 1 "Ecosystem-based Management" and 4 "Coastal Hazards and Resiliency."

Stakeholders that may be interested in this developing information include but are not limited to: Alabama Department of Environmental Management, Mobile Bay National Estuary Program, Alabama State Port Authority, Mobile District of the U.S. Army Corps of Engineers, National Marine Fisheries Service, Northern Gulf Institute, The Nature Conservancy, U.S. EPA Gulf of Mexico Program, Gulf of Mexico Alliance, etc.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

A number of important initial findings have resulted from our ongoing assessments of the impacts of this ecosystem-wide perturbation on the waters of the northern Gulf of Mexico. This funding allowed us to begin to narrow gaps in our knowledge of how and when oil spills, and subsequent applications of dispersants, may affect the abundance and biomass of fishes and macroinvertebrates in regional nursery habitats and offshore waters of the north central Gulf of Mexico. This effort contributes significantly to not only our knowledge of how these assemblages respond to ecosystem-wide perturbations such as the oil spill, but also how these communities respond to more chronic pressures such as recreational and commercial fishing. These studies also provided critical data on the impacts of these two perturbations on a number of commercially valuable species, including red snapper. Red snapper figure prominently in the economy of the entire region. It seems clear from these efforts that both the oil spill and government management action interactively affected ecosystem structure.

We also demonstrated for the first time that passive acoustic monitoring methods can successfully detect the movement of manatees among habitats even when satellite/GPS/telemetry tags malfunction or are lost. This newly applied method will be useful for the future monitoring large-scale movements of marine mammals. We also found indicators of stress in oysters exposed to low dissolved oxygen concentrations, consistent with the presence of oil in near shore waters.

We also increased our understanding of the patterns of microbe growth and loss along salinity and nutrient gradients. We also developed a better understanding of how microbial communities respond to large uncontrolled hydrocarbon inputs both in salt marshes and in open water. We are also learning how specific members of the microbial community respond to oiling, especially the Archaea, which have only recently been identified to play a very important role in determining rates biogeochemical cycling in the ocean. We have also made some of the first measurements of dissolved methane concentrations on the Alabama shelf.

We have also begun to learn how complex interactions between meteorology, topographic complexity and freshwater inflow can affect the movement of passive pollutants in the estuaries of the north central Gulf of Mexico. Many of the estuaries in Gulf of Mexico share several common attributes, including: deep narrow ship channels, and tidal exchange with the Gulf via relatively narrow passes, etc. Finally the first, nearly simultaneous, description of the velocity, salinity, density and dissolved oxygen (DO) profiles along the ship channel between Port of Mobile and Main Pass in Mobile Bay has been completed. The type of detailed spatial and temporal (11 surveys over three months) resolution is rare for the region and is improving modeling efforts meant to improve our understanding of along-channel mass transport processes as influenced by local and watershed environmental conditions.

Contributions to BP_GRI goals:

By providing comparisons of pre- and post-spill assessments, this project adds significant contributions to meeting four major BP-GRI goals: 1) chemical evolution and biological degradation of the oil/dispersant systems and subsequent interaction with the marine and coastal ecosystems; 2) environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery; 3) fundamental scientific research integrating results from the other four themes in the context of public health; and 4) physical distribution, dispersion and dilution of petroleum, its constituents and any dispersants applied, under the action of physical oceanographic processes, air-sea interactions.

11. Milestones accomplished during entire project period:

We were successful in completing almost all of the milestones outlined in the original 2010 NGI Rapid Response Proposal.

12. Describe all significant research results, protocols developed, and research transitions:

Task 1. We found significant differences to exist in the composition of fishes and macroinvertebrates present in local waters during pre- and post-spill sampling time periods. A total of 57 species were collected before the spill reached our coastal waters, while 74 species were captured after the spill. Proportional analysis indicated that differences in community composition were primarily driven by changes in the relative abundances of a number of unexploited species (anchovies, croaker and hardhead catfish). Both total abundance and biomass increased significantly after the spill. When comparing gulf and inshore sites separately, significant differences were observed before the spill, increases seem to have throughout the ecosystem.

Abundance and CPUE of exploited species did not seem to be change significantly after the oil spill. Other unexploited species, however, did increase in abundance dramatically.

In general, species composition and CPUE conducted on samples taken using the bottom longline were similar to existing data from the same region, with the notable exception of tiger shark (*Galeocerdo cuvier*). CPUE for this species increased more than ten-fold when compared to data from 2006-2009. Vertical longline gear sampled almost exclusively teleost fish (n=13 sp.), the most common being red snapper (*Lutjanus campechanus*). Grey triggerfish (*Balistes capriscus*) and vermillion snapper (*Rhomboplites aurorubens*) were also sampled, along with eleven other species.

ROV sampling was conducted at a subset of stations fished with vertical longline gear, and was able to enumerate additional fish not captured with vertical longline gear. In addition, ROV lasers were used to record lengths of fishes swimming perpendicular to the camera. These data identified fish of a size not sampled with trawl, vertical longline or bottom longline gear.

Tissue samples were taken from organisms collected in vertical and bottom long lines for stable isotope analysis.

Task 2. Potential biomarkers that can be used to identify contaminants impacts on oysters were tested at two sites in Mobile Bay, Alabama. The primary focus of these efforts was on expression of both constitutive (HSC77 and 72) and inducible (HSP69) isoforms of heat shock protein 70. Importantly, dissolved oxygen (DO) conditions were documented at a historical reef site located in south Mobile Bay post-spill (2010) which were significantly lower than recorded before the oil spill (2008). Field analyses of transplanted oysters documented up-regulation of HSP69 in gill tissues held under elevated temperature and temperature + hypoxia treatments, but not for hypoxia alone. Based on these results, the expression of additional biomarkers, including p38 MAP kinase and CREB, were tested on laboratory samples and field collected samples. These marker tests yielded mixed results and require further optimization. These data were further complemented by N and C stable isotope analyses, which showed shifts toward lighter $\delta^{13}C$‰ and heavier $\delta^{15}N$‰ in oysters held under low dissolved oxygen conditions, which occurred in Mobile Bay post-spill. These results are consistent with exposure to lighter C sources and catabolism of tissues under stress conditions that may be associated with oil contamination of growing waters.

We also captured, tagged, and conducted health assessments on three manatees, a second sentinel species, in Alabama waters in early August. We monitored the tagged animals in near real time via satellite/GPS and tracked their location on the ground ~ every 4 days. We programmed and deployed 7 passive acoustic monitors (PAMs) at strategic locations throughout Alabama waters to further document the movements of manatees in the area, even if they were tagged outside Alabama. PAMs recorded the cold-season migratory movements of three belted manatees within and out of AL coastal waters. Movement patterns of telemetry-monitored (GPS and belted) animals during and after the DWH spill was consistent with patterns seen in previous years, using habitat in Apalachicola, FL and Mobile Bay, AL. Animals traveled to Crystal River, FL at the onset of cold temperatures in late November and early December 2010. We collected and sent water and sediment samples from known manatee habitat areas to UM for PAH and contaminant testing. PAMs will remain in place to collect data for the subsequent spring 2011 migration. We also plan to continue tracking tagged manatees as long as the tags remain functional. Future manatee movement data will be analyzed and compared to previous patterns.

Water, sediment, and oyster samples were collected approximately bimonthly between May 26 and November 30 from two sites in Mobile Bay (Denton and Sand Reefs) at 1.0 or 0.1 m above the bay floor. Additional periodic water and sediment samples were collected at key oyster and manatee habitats in Alabama waters with varying likelihood of exposure to oil contaminants. Water was extracted for quantification of 26 PAHs with methylene chloride and analyzed by GC/MS. Highest water concentrations for total PAHs were observed on 28 June 2010 at Sand Reef (1 m), 4 August 2010 at Sand Reef (0.1 m), 21 July 2010 at Denton Reef (1 and 0.1 m), and 9 September 2010 at Perdido Pass/ Orange Beach. Sediment was also collected from these sites and the percent carbon to nitrogen ratio ranged from 9 to 138. Overall, values were relatively low, ranging 3 – 300 ng L-1 at Denton Reef (mid-bay) and 10 – 270 ng L-1 at Sand Reef (south-bay); within the range expected for background contamination in Mobile Bay.

Task 3. Oil from the DWH was not observed to have impacted Alabama's coastal habitats with the severity seen in Louisiana (Corn and Copeland 2010) and, despite the presence of tar balls and light sheens, major oiling did not occur in the locations studied. Additionally, we failed to detect no significant losses of seagrass and marsh plants in these locations or changes to the structure provided to the associated fauna.

Sampling efforts revealed continued high levels of shellfish and finfish productivity in the seagrass/marsh systems along the coast of western Alabama, in accordance with results found elsewhere in the northern Gulf of Mexico (Valentine and Heck 1993; Heck et al. 1995). In total, we have identified 41 marsh-associated species and 36 seagrass-associated species of fish and macroinvertebrates. Marsh catches were dominated by grass shrimp *Palaemonetes pugio*, blue crab *Callinectes sapidus* and white shrimp *Litopenaeus setiferus.* Seagrass catches were dominated by pinfish *Lagodon rhomboides*; bay anchovy *Anchoa mitchilli*; and silver perch *Bairdiella chrysoura*. Surveys have also confirmed the continued important role of these systems as nursery habitat for commercially and recreationally important species (Heck et al. 2003; Minello et al. 2003). Indeed, the seagrass beds and fringing marsh in all four locations supported juveniles of species with commercial and recreational value, such as penaeid shrimp, blue crab, spotted sea trout, and southern flounder. It is also important to note that juveniles of gray snapper, *Lutjanus griseus* and red drum, *Sciaenops ocellatus* were also collected in the seagrass beds.

Task 4. Significant findings include documenting dramatic increases in water column DOC levels from June-August that were coincident with the introduction of oil to the northern Gulf off Alabama. The timing of these increases was also consistent with 1) decreased bottom water oxygen levels, 2) increases in CDOM and 3) shifts in $DI^{13}C$ values. These findings are significant because they indicate that carbon from the oil was probably respired by the microbial communities. The added microbial production likely served as an important trophic pathway for this new carbon to pass to larger net-sized zooplankton.

We also measured bacterial biomass production, dimethylsulfoniopropionate (DMSP; a phytoplankton constituent) and the dissolved gases, dimethylsulfide (DMS) oxygen, and methane in the water column. We measured O_2 using the classic Winkler method because of concerns about the performance of membrane-based dissolved oxygen sensors placed in oil. It is of note that our results revealed that CTD-based DO measurements were not always accurate (whether from oil or other reasons). Nevertheless, Winkler O_2 measurements confirmed the presence of persistent hypoxia on the Alabama shelf through September. Bacterial production rates in bottom waters were low suggesting that activities in the sediments, alternatively, could also have been responsible for the low bottom water DO.

Bacterial production rates in surface waters along the transect were very high in June & July 2010, but comparisons made between these 2010 data and a limited set collected in 2009 show that these rates were not unusually high. The same can be said for bacterial production in bottom water samples.

Methane concentrations (5-30 nM) at shelf sites were significantly above atmospheric equilibrium values of ~2 nM. The highest values were observed in high salinity bottom waters at offshore stations. This could indicate transport of offshore methane onto the shelf. However, the latitudinal distribution of the bottom water methane showed that the highest concentrations were present at a nearshore site where dissolved oxygen concentrations were lowest. Additionally, ethane or propane, indicators of thermogenic natural gas, were not detectable (< 1 nM) in the bottom water samples. Thus, our preliminary conclusion is that the methane probably came from the sediments rather than DwH. Methane was also high in central Mobile Bay, $\leq$106 nM. Importantly, we have learned that Mobile Bay and the Alabama shelf are significant sources of methane to the atmosphere. These are the first water column methane data to be reported from the Mobile Bay-Alabama Shelf region. The concentrations of DMS and DMSP along the transect during 2010 have shown concentrations comparable to those measured in previous years.

Task 5. The influence of vegetation type and microbial community composition on key aspects of nitrogen cycling in a saltmarsh ecosystem was investigated in the fall of 2010. Plants, by providing organic matter and oxygen to the sediments, can influence rates of nitrification and denitrification along with the ability of marsh sediments to retain nitrogen. The four sites selected for this study included unvegetated sediment patches, and patches containing marsh grasses, *Spartina* and finally *Juncus*. At all sites, oxygen was consumed within the top few mm of sediment. Sulfide concentrations approached millimolar concentrations within the top 3 cm of the sediments as well. Porewater sediment nutrient profiles at the unvegetated and seagrass sites were similar to each other but were lower than concentrations measured in *Spartina* and *Juncus* plots. Potential nitrification rates were undetectable at all sites. Maxima in potential denitrification rates were measured at the *Juncus* plots (3 nmols $gwet^{-1}$ hr^{-1}) with all other sites exhibiting similar rates (range: 0.1 to 1 nmol N $gwet^{-1}$ hr^{-1}). These low rates were consistent with sulfide inhibition of nitrification and denitrification and suggest that sulfate reduction may be the determining process for nitrogen cycling in this ecosystem. The microbial community composition was investigated using functional genes associated with nitrogen and sulfur cycling. Genes involved in nitrification, sulfate reduction and dissimilatory reduction of nitrate to ammonium were quantified for each sample site to determine if the microbial community reflected the measured rates of biogeochemical cycling.

Characterization of Hydrocarbon Degraders from Coastal Alabama Marsh Sediments – The aim of the project was to assess post oil spill microbial abundance of the marsh study site at Point Aux Pines, AL with a focus on enumerating aerobic alkane degraders, total hydrocarbon degraders, and polycyclic aromatic hydrocarbon (PAH) degraders by the Most Probable Number method. Sediment and nutrient samples were collected along a transect from the vegetated marsh above the high tide line to below the low tide zone in October and December of 2010. Alkane and total hydrocarbon degraders were detected in the sediments; however, PAH degraders were below the detection limit. The highest microbial counts for alkane degraders ranged between 3.04×10^4 and 9.50×10^3 and for total hydrocarbon degraders between 5.62×10^3 and 1.14×10^5 of bacteria (g-1 dry weight sediment) for October and December, respectively. The data showed that most samples collected in October had a higher number of alkane degraders, while most December samples showed at least a magnitude higher number of total hydrocarbon degrader per gram of sediment. These data provide evidence for the presence of hydrocarbon-degrading microbial community at this marsh ecosystem with potential to mineralize a fraction of hydrocarbons derived from crude oil.

Task 6. While the optimizing of protocols for the flow cytometer required more time than initially thought, sample and data analysis are now complete.

Four sites were chosen for this task assessment, three of which has previously been used and one which was further offshore and definitely exposed to oil and dispersants. The selected sites represent a gradient of nutrients and salinity extending from within Mobile Bay out onto the shelf. Experiments were carried out in July, September, November (2010) and January (2011). Previous data, collected in July and November 2009 and January, March and May of 2010 served as comparisons of pre-exposure conditions. Biomass, as estimated from the concentration of chl *a,* was usually highest at the inshore sites and lowest at the offshore sites. This mirrors the nutrient concentrations, although concentrations of N and P sometimes increase elsewhere when river discharge was high. July chl *a* concentrations at one site was 2.2 x higher in 2010 than in 2009, but by November 2010 the concentration was only 1/5 the 2009 concentration. The July peak does correspond with oil exposure and inshore concentrations of chl *a* are only ~1/2 their 2009 values.

Analysis of the rates of growth, grazing and viral lysis shows these two processes were high variability at most study sites. Remarkably, the highest μ_{Net} (growth-total losses) are detected at the location furthest offshore, even though the biomass and nutrients were lowest. The least variability was seen at the mouth of the bay. Although large differences in rates were seen within Mobile Bay between July 2009 and July 2010, μ_{Net} was only 1.3 x higher in 2010 than in 2009. Preliminary patterns would suggest that there was little oil impact on phytoplankton biomass and production when compared to the high variability detected at the unexposed sites. This is a preliminary conclusion and may change when more time points are analyzed giving us a better understanding of how variable these sites are. These rates are also for phytoplankton, which would not directly utilize the carbon from the oil and dispersants. It might be expected that phytoplankton biomass could be negatively impacted by the oil, but there was no indication this was the case. The high growth rates measured at the further station could be due to the prokaryotic community utilizing the oil and dispersants and regenerating inorganic nutrients.

Along with these experiments, four sets of additional experiments were used to determine rates of lysogeny and how they change in response to oil. Experiments have been carried out at all four sites, with two sites having documented oil exposure, while two sites are not known to have been exposed. These samples are presently being analyzed by flow cytometry to determine rates of lysogeny in both heterotrophic prokaryotes and cyanobacteria.

Preliminary results from experiments describing the diversity and abundance of specific groups of microorganisms in Alabama waters were also conducted with NGI Rapid Response Funding. Samples were collected prior to, during oiling and just after Deep Water Horizon was capperd?. These samples have been analyzed for several genes including *nifH* (nitrogen fixation), archaeal 16S rRNA, and hydrocarbon degredation genes. These genes include genes associated with aerobic degradation (*P450 and alkB* (aerobic alkane degradation), *Rieske* (aerobic PAH degradation) and pmoA (methane degredation)) and assA/bssA which are associated with anaerobic hydrocarbon degredation. .

For most of these genes, analysis has so far been limited to determining their presence or absence based on standard PCR detection. The *nifH* is presently being optimized for quantitative detection and the abundance of this gene will soon be determined. *nifH* and *P450* were detected in most of the samples tested, including those from samples taken before the oil exposure. The Rieske fragment was detected in fewer samples. Detection of genes associated with alkane and PAH degradation suggests that the northern Gulf of Mexico may indeed be 'primed' to respond to oil inputs. To date, *alkB*, *pmoA* and *assA/bssA* have not been detected in any of these samples. Further analysis is being carried out to confirm that these results are accurate and not due to technical issues with the primer sets or samples.

Analysis of the Archaea has included both quantification and diversity measures. The Archaea are poorly studied in the oceans and few studies have addressed the effects of oil on this community. The studies that do exist suggest that Archaea are negatively affected by oil and so may be good indicators of recovery. To this end, the 24 samples were analyzed for the abundance of Marine Group 1 (MG1) Archaea and the diversity of total Archaea. MG1 were not detected in samples collected from heavily oiled sites (FM transect, June), but were found in bottom water samples and samples collected after oil exposure. Surprisingly, an abundant MG1 community was detected in the bottom waters of the Alabama shelf. Estimates from the qPCR analysis suggest that Archaea may comprise 50% of the total prokaryotic community, a finding that has only been detected in deep (>100m) waters until now. Analysis of the diversity of the archaeal communities indicate that there are 2-10 different groups, with a distinct community present in the deeper samples. Surface and coastal samples clustered together, with some separation based on when the samples were collected. The abundance and diversity of the archaeal communities were negatively correlated with DOC (MG1 abundance = -0.79, Richness= -0.73) which may be an indicator of oil exposure. This data supports the hypothesis that Archaea may be an indicator species for recovery from oil. In addition to the initial 24 samples analyzed for Archaea, several more samples are being analyzed. This includes more pre- and post-exposure samples as well as several samples collected along Gulf Shores, AL and Dauphin Island, AL for a separate project. These samples will be analyzed for the abundance of Archaea as well as the diversity to verify the pattern seen in the first 24 samples. This data will be used to prepare a manuscript for submission to the ISME Journal. It is expected that the manuscript will be submitted in early summer.

Task 7. Eleven surveys were conducted, approximately at weekly intervals, between August and October 2010. At each survey, a profiling CTD was cast at 16 stations selected along the 58-km reach of the Mobile Bay ship channel to characterize the vertical profiles of salinity, temperature, density, and dissolved oxygen (DO). On the return trip, an ADCP was towed at a speed of about 5 knots to characterize current velocity vertically along the channel. Forcing conditions data was also collected during the study period. Daily river discharge data were obtained for the Mobile River system at two U.S. Geological Survey's gauging stations for Alabama River (USGS 02428400: 31°32'48"N, 87°30'45"W) and Tombigbee River (USGS 02469761: 31°45'25"N, 88°07'30"W) (http://waterdata.usgs.gov/nwis). It should be noted that only provisional data are currently available for river discharge at these two stations. Their sum was used as a total river discharge into Mobile Bay. Hourly data for wind and air temperature were also obtained

During the study period, water discharge varied between 113-742 $m^3 s^{-1}$; during only two days was discharge higher than 620 $m^3 s^{-1}$ (i.e., long-term mean discharge in August-October). Hence, these surveys reflect channel conditions during dry period.

The data for water level show tidal variation in tropic-equatorial cycle (~13.66 days), ranged from < 0.1 m during equatorial tides to about 0.6-0.7 m during tropic tides. The tidal range was a little larger at Mobile State Docks than at Dauphin Island. The data also show sub tidal variation was affected mostly by wind.

The data show two strong north wind events around day 276 and 301 resulting in an estimated maximum wind stress of over 0.4. These events were responsible for the drop in air temperature and water level. The drop in water level was more pronounced at Mobile State Dock than at Dauphin Island. There were four relatively weaker north wind events around day 227, 246, 255 and 286, which showed the same but weak response in air temperature and water level. The wind data also show several southeast wind events around day 224, 228, 239, 258, 265 and 296. The south wind component pushed water landward and the east wind promoted Ekman onshore transport, which combined to result in an increase in water level. Again, the signal was more pronounced at Mobile State Docks than at Dauphin Island.

Salinity was found to vary greatly both vertically and along the channel. The effect of river discharge was apparent on August 18, 2010. Relatively fresh water occupied the entire water column in the upper Bay and the surface water down to about km 40. There was an indication of intrusion of salty bottom water just outside of Main Pass. Five days later on August 23, the influence of surface fresh water was further extended downstream and intrusion of salty bottom water also extended upstream, resulting in extraordinarily strong stratification with the bottom-surface salinity difference as large as 22 psu. The water column inside the Bay generally was able to maintain strong stratification, supported by both seaward advection of fresh surface water and landward intrusion of salty bottom water. Around Main Pass, however, the water column sometimes was relatively well mixed. It is worth noting that there's an indication of upwelling around the Mobile River entrance, with the surface water around km 4-8 was saltier than either up or downstream water. The water around the ship channel is shallower than 4 m, and the surface salinity in this area was higher than that at the depth of 4 m either up or downstream. Then, lateral advection of high salinity water is not likely, leaving upwelling the only plausible mechanism. A previous study (Schroeder and Wiseman, 1988 in *Hydrodynamics of Estuaries* edited by B. Kjerfve) suggested the possibility of upwelling in the upper Mobile Bay.

Variation in water density was almost entirely determined by that in salinity, with minimal contribution from temperature. However, water temperature is an important factor affecting biological activity: e.g., oxygen consumption in this study. Temperature was relatively high in August and September, ranging between 27-31°C. The survey on September 30 showed signature of surface cooling, and water temperature remained at 20-25°C in October. The coldest temperature of 20-24°C was observed on October 7.

The DO distribution on August 23, 2010 shows the water deeper than 4 m and upstream of Main Pass had DO < 4 mg l^{-1}, and some water in the upper Bay was even hypoxic (< 2 mg l^{-1}). The DO distribution on September 9 shows typical DO variation along the channel in which as the bottom water intruded upstream its DO kept decreasing with continued oxygen consumption and no supply of high DO surface water due to stratification. On October 7 when the water temperature was lower than 24°C, the DO was higher than 5 mg l^{-1} throughout the ship channel. As water temperature rose again, low DO condition returned in the bottom water of the middle to upper Bay on October 27.

The survey on August 23, 2010was conducted during the 2nd half of the falling tide, and ebbing current existed inside the Bay upstream of km 45. It took 6-7 hours to cover the 58-km reach while towing an ADCP at a speed of about 5 knots. In this seaward transecting survey, by the time we got to the lower portion of the Bay, the current already turned to flood. This flooding current from the Gulf of Mexico through Main Pass appeared to be reinforced by the flooding current from Mississippi Sound through Pass-aux-Herons. Once outside of Mobile Bay, the along-channel direction was no longer the principal axis, making both the along- and the across-channel velocities having about the same order of magnitude. The current data still need further processing. For example, between km 20-40, the top 2-4 m of the water column had slower velocity that the water below. We are currently examining if this is a real signal or a result of blanking distance of the ADCP and/or of rolling/pitching of the vessel.

In the water column deeper than 4-5 m upstream of about km 43, although contaminated by noises, once can still see the existence of the ebbing current. These noises need to be cleaned up. The bigger challenge is for the lower Bay downstream of about km 45 where the along-channel velocity shows no coherent structure. This is the region that directly faces Mississippi Sound and thus is affected by the transport through both Main Pass and Pass-aux-Herons. Water in this wide region can get quite rough in windy days. We are currently applying several algorithms to filter out the noises and isolate the signals.

13. Outreach activities

Dauphin Island Sea Lab's "Boardwalk Talks" Series (November 2010) A series of public, informal conversations about current scientific activities at the DISL. Presented by the Northern Gulf Institute and hosted by The Estuarium, DISL's public aquarium. “Salt Marshes: Refuge or Buffet?” Talk presented by Ryan Moody.

University Fellows Experience Program (February 2011) A program hosted by the University of Alabama, Tuscaloosa, dedicated to leadership and service. Discussion led by Ryan Moody addressing the Deepwater Horizon oil spill, oil-related research at the DISL, and its effect on coastal communities.

14. Peer Reviewed Articles:

Aven, A., R. Carmichael, and others. Manuscript in prep. Evidence for seasonal migration and site fidelity by West Indian manatees (*Trichechus manatus*) between the northern Gulf of Mexico and western Florida coasts.

Aven, A. and R. Carmichael. Manuscript in prep. Detection of belted manatees using passive acoustic monitors.

Condon, R.H., W.M. Graham, R. Kiene, S.L. McCallister, and J. Brandes, (In Prep). Priming effect: Oil stimulates microbial metabolism of refractory organic matter and planktonic food web processes. *Science*

Condon, R.H. and W.M. Graham. (In Prep). Hydrocarbons as a subsidy energy source for increased food web production. *Science*.

Graham, W.M., R.H. Condon, R.H. Carmichael, I. D'Ambra, H.K. Patterson, L.J. Linn, F.J. Hernandez, Jr. (2010) Oil carbon entered the coastal planktonic food web during the Deepwater Horizon oil spill. *Environmental Research Letters*. 5: 045301 (6pp)

Horel, Agota, Behzad Mortazavi, and Patricia Sobecky. (in prep). Characterization of Hydrocarbon Degraders from Coastal Alabama Marsh Sediments.

Mortazavi, Behzad, Alice Ortmann, Lei Wang, Rebecca Bernard. (in prep). Nitrification and Denitrification Potential Along a Vegetation Gradient in a Saltmarsh Ecosystem.

Shelton, N.L., R.H. Condon, W.M. Graham, L.J. Linn and S. Cecil. (In Prep). Source-sink dynamics of oil-derived chromophoric dissolved organic matter in coastal Gulf of Mexico waters. *Global Biogeochemical Cycles*

15. Non-refereed articles and report:

Dolinar, L."Sea life flourishes in Gulf" National Review 15 Nov 2010. (<http://www.nationalreview.com/articles/253233/sea-life-flourishes-gulf-lou-dolinar>)

Douban, G. "Alabama and the oil spill: Gulf fish numbers up" 90.3FM WBHM. 4 Feb 2011 (<http://www.wbhm.org/News/2011/FishNumbersUp.html>)

Ferrara, D. "Scientists to begin yearlong study of oil spill's impact on Gulf" Mobile Press Register [Mobile, AL] 12 Dec 2010. (<http://blog.al.com/live/2010/12/scientists_to_begin_yearlong_s.html>)

Judge, P. "Scientists debate real impact of oil spill" Mississippi Public Broadcasting News 2 Dec 2010. (<http://www.mpbonline.org/news/story/scientists-debate-real-impact-oil-spill>)

Raines, B. "Researcher: fish numbers triple after oil spill fishing closures" Mobile Press Register [Mobile, AL] 7 Nov 2010. (<http://blog.al.com/live/2010/11/researcher_fish_numbers_triple.html>)

Raines, B. "Scientists puzzle over fish increase after oil spill fishing ban" Mobile Press Register [Mobile, AL] 21 Nov 2010. (<http://blog.al.com/live/2010/11/scientists_puzzle_over_fish_in.html>)

Thomas, M. "Good Gulf oil-spill news: the fishing is fabulous" Orlando Sentinel [Orlando, FL] 10 Nov 2010. (<http://articles.orlandosentinel.com/2010-11-10/news/os-mike-thomas-gulf-oil-111110-20101110_1_fishing-ban-chemical-dispersants-low-fish-counts>)

16. List conference presentations and poster presentations for this project.

Aronson RB, Moody RM (2011) Effects of a major oil spill on nektonic assemblages of salt marshes and adjacent SAV habitats in Florida and Alabama. Oral presentation. Florida Institute of Oceanography BP/FIO Principal Investigator Coordination Workshop. Orlando, FL., March 2011.

Aven, Allen, and Ruth H. Carmichael. 2011. Detection of belted manatees using passive acoustic monitors. Benthic Ecology Meeting, Mobile, AL, March 2011. Poster presentation.

Condon, R.H., W.M. Graham, R. Kiene and J. Brandes. Priming effect: hydrocarbons as a subsidy energy source for increased food web production and microbial metabolism. NGI Annual Conference, Mobile AL, May 2011.

Dailey, Meghan, Cammi Thornton, Heather Patterson, Ruth Carmichael, and Kristine L. Willett. 2011. Assessment of water and sediment for PAH concentrations and embryo toxicity following the Deepwater Horizon oil spill. Abstract submitted to Gulf Oil Spill SETAC Focused Meeting, April 2011, Pensacola, FL. Poster presentation.

Graham, W.M., R.H Condon, R.H. Carmichael, I. D'Ambra, H.K. Patterson and J. Brandes. Oil carbon entered the coastal microbial and planktonic food web during the Deepwater Horizon oil spill. IMBER Integrating Biogeochemistry and Ecosystems in a Changing Ocean Conference, Crete, October 2010 (Poster).

Graham, W.M., R.H Condon, R.H. Carmichael, I. D'Ambra, H.K. Patterson and F. J. Hernandez, Jr. Entry of Oil to the Coastal Planktonic Food Web During the Deepwater Horizon Spill (*Invited*). AGU Fall Meeting, San Francisco. December 2010.

Graham, W.M., L. Carassou, R.H Condon, I. D'Ambra, F. J. Hernandez, Jr. and A. Hunter. Can injuries to the water column by the Deepwater Horizon spill be resolved from zooplankton community analysis?. Bureau of Ocean Energy Management, Regulation and Enforcement Information Transfer Meeting, New Orleans. March 2011.

Horel, Agota, Behzad Mortazavi, and Patricia Sobecky. (2011). Characterization of Hydrocarbon Degraders from Coastal Alabama Marsh Sediments. Benthic Ecology Meeting, 40th Annual Meeting in Mobile, AL March 16-20.

Kronmiller, Kelsie, Heather Patterson, and Anne Boettcher. 2010. Stress response in the eastern oyster due to hypoxia and temperature. University of South Alabama 12th Annual Undergraduate Symposium. October 2010, Mobile, AL. Poster presentation.

Kronmiller, Kelsie, Heather Patterson, and Anne Boettcher. 2011. Biomarkers of oxygen and combined oxygen and temperature stress in oysters. Benthic Ecology Meeting 2011. March 2011, Mobile, AL. Poster presentation.

Martin, C.W., J. F. Valentine, and S.L. Madsen. 2010. Changes to coastal fish communities following Deepwater Horizon oil spill. Poster presentation at Mississippi-Alabama Bays and Bayous Symposium, December 1-2, 2010.

Martin, C.W., J. F. Valentine, and S.L. Madsen. 2011. Changes to coastal fish communities following Deepwater Horizon oil spill. Poster presentation at the Benthic Ecology Meeting, March 17-20, 2011.

Moody, RM. "Impact of the Deepwater Horizon Oil Spill on ecosystem services of coastal marshes". Oral presentation. Sustainability 2011: 8th International, Interdisciplinary Sustainability Conference. Melbourne, FL., March 2011.

Moody RM, Kerner S, Biermann L, Cebrian J and Heck Jr K. (2011) The nursery role of fringing salt marshes and submerged aquatic vegetation in coastal Alabama. Poster presentation. Collaborative Scientific Research Opportunities Relative to the Gulf Oil Spill (LA EPSCoR, LA Board of Regents, AL and MS EPSCoR, and NSF). New Orleans, LA., November, 2010.

Moody RM, Kerner S, Biermann L, Howard J, Cebrian J, Heck Jr K, Powers S. "Temporal dynamics of nekton abundance in a coastal fringing marsh: Impact of the oil?" Poster presentation. Alabama Fisheries Association. Mobile, AL., February 2011.

Mortazavi, Behzad, Alice Ortmann, Lei Wang, Rebecca Bernard. (2011). Nitrification and Denitrification Potential Along a Vegetation Gradient in a Saltmarsh Ecosystem. Benthic Ecology Meeting, 40th Annual Meeting in Mobile, AL March 16-20.

Ni Chadhain, S. N. Ortell, L. Wang, A. C. Ortmann (2010) Microbial community response to the Deepwater Horizon spill, a functional gene approach. Southeastern Branch of the American Society of Microbiology Meeting, Montgomery, AL (poster presentation).

Ortmann, A.C. (2010) Coastal Archaea: More common and not so extreme. ASM South Central Branch 2010 Annual Meeting, Hattiesburg, MS (invited oral presentation)

Ortmann, A.C., N. Ortell, S. Ni Chadhain (2010) Archaea as a sentinel group to measure recovery from the Deepwater Horizon spill. Southeastern Branch of the American Society of Microbiology Meeting, Montgomery, AL (oral presentation)

Patterson, Heather, Anne Boettcher, and Ruth Carmichael. 2010. Measuring dissolved oxygen stress in the Eastern oysters, *Crassostrea virginica*. Gulf Estuarine Research Society meeting, Port Aransas, TX, November 2010. Oral presentation.

Patterson, Heather, Anne Boettcher, and Ruth Carmichael. 2010. Measuring dissolved oxygen stress in the Eastern oysters, *Crassostrea virginica*. Bays and Bayous Symposium, Mobile, AL, December 2010. Poster presentation.

Patterson, Heather, Anne Boettcher, and Ruth Carmichael. Can stable isotopes detect low oxygen stress in oysters? Benthic Ecology Meeting, Mobile, AL, March 2011. Oral presentation.

Shelton, N.L., R.H. Condon, W.M. Graham, L.J. Linn and S. Cecil. Source-sink dynamics of oil-derived chromophoric dissolved organic matter in coastal Gulf of Mexico waters. American Society of Limnology and Oceanography 2011 Winter Meeting, San Juan, Puerto Rico (Poster).

17. Has anyone from this project been hired by NOAA during this reporting period?

No

10-BP_GRI_DISL-01 (Task 1): Impacts of the Deep Water Horizon oil spill on ecosystem structure and function in Alabama's marine waters

John Valentine, Sean Powers and Marcus Drymon

SCIENCE ACTIVITIES

1. General Summary: To document the impacts of oil inundation on reef and demersal fishes, we conducted both bottom and vertical longline sampling at historically occupied stations in the nearshore and inshore waters of coastal Alabama. Post-inundation catch data was compared with existing data, collected by DISL scientists, to quantify the immediate (acute) impacts of uncontrolled releases of oil on the abundance and species composition of adult fishes.

Both vertical longline sampling and bottom longline sampling were used to conduct a complete assessment of the oil inundation on larger predators historically common within the Alabama artificial reef zone. Replicate vertical longline (bandit) samples were used to characterize reef fish assemblages in the water column at multiple randomly-selected locations in coastal Alabama. Bottom longline gear was used to conduct the same analyses on larger fishes such as sharks, red snapper *Lutjanus campechanus*, gag *Mycteroperca microlepis* and red drum *Sciaenops ocellatus*. In addition to vertical longline sampling, video recording of the habitats at each station were made using a remotely operated vehicle (ROV).

For all sampling efforts, we recorded species identification, condition, size (standard, fork and total lengths) and weight. Tissues were extracted from replicates (n=3) of 20 of the most common species of demersal fishes for carbon and nitrogen stable isotope analysis. Comparisons of these data were made with samples collected in concert with an ongoing NGI project which supported the collections of demersal fishes prior to the inundation of oil in Alabama's coastal waters. This allowed us to determine if current levels of oil inundation have altered demersal fish abundances or feeding patterns.

2. Results and scientific highlights:
During the period July 15 - December 31, we were able to successfully complete the sampling outlined in our proposal. This sampling allowed for identification of the demersal fish fauna in the Alabama reef permit zone using three gear types: bottom longline, vertical longline and ROV. Data from the longline gear will be instrumental in assessing potential changes to coastal Alabama's fish assemblage, while ROV data will be essential in determining if benthic structure off the coast of Alabama has come in contact with oil from the leak. Samples collected from these field studies are currently being analyzed for stable isotope ratios of carbon and nitrogen.

Field: From July 15 through December 31 2010, 25 stations have been sampled with bottom longline gear and 62 stations (3 replicates/station) have been sampled with vertical longline gear (Image 1). Bottom longline gear sampled predominately elasmobranch fish (n=8 species), the most common of which was Atlantic sharpnose shark (*Rhizoprionodon terraenovae* CPUE = 2.48 fish/100 hooks/hour). In general, species composition and CPUE from the bottom longline were similar to existing data from the same region, with the notable exception of tiger shark (*Galeocerdo cuvier,* CPUE = 2.04 fish/100 hooks/hour). CPUE for this species has increased greater than ten-fold compared to data from 2006-2009. To further investigate this trend, we have begun collecting stomachs from tiger sharks. Preliminary analysis shows a wide range of gut contents, including teleost fish, squid, gastropods and bird feathers.

Vertical longline gear sampled almost exclusively teleost fish (n=13 species), the most common being red snapper (*Lutjanus campechanus,* CPUE = 2.95 fish/12 hooks/5 minutes). Grey triggerfish (*Balistes capriscus,* CPUE = 0.17 fish/12 hooks/5 minutes) and vermillion snapper (*Rhomboplites aurorubens*, CPUE = 0.05 fish/12 hooks/5 minutes) were also sampled, along with ten other species.

ROV sampling was conducted at a subset of stations fished with vertical longline gear, and was able to enumerate more fish than were captured with vertical longline gear. In addition, ROV lasers were used to obtain length data for fish swimming perpendicular to the camera (Image 2). These data identified fish of a size not sampled with trawl, vertical longline or bottom longline gear. In addition to red snapper, the ROV identified other reef associated species (Image 3).

Laboratory: Tissue samples for stable isotope analysis have been removed from all fish retained during vertical and bottom longline sampling and are currently being prepared for analysis. In addition, identifiable contents from the stomachs of tiger sharks are being sampled for stable isotope analysis. These data will provide an estimate of relative trophic position, which can then be compared to pre-spill data.

3. Cruises & field expeditions:

Ship or Platform Name	Chief Scientist	Objectives	Dates
DISL R/V E.O. Wilson	Marcus Drymon	Fish population sampling via bottom longline	7/19/2010
DISL R/V E.O. Wilson	Marcus Drymon	Fish population sampling via bottom longline	7/20/2010
DISL R/V Alabama Discovery	Marcus Drymon	Fish population sampling via bottom longline	8/18/2010
DISL R/V Alabama Discovery	Marcus Drymon	Fish population sampling via bottom longline	8/19/2010
DISL R/V Alabama Discovery	Marcus Drymon	Fish population sampling via bottom longline	9/03/2010
DISL R/V Alabama Discovery	Andrea Kroetz	Fish population sampling via bottom longline	9/24/2010
DISL R/V Alabama Discovery	Andrea Kroetz	Fish population sampling via bottom longline	10/22/2010
DISL R/V Alabama Discovery	Andrea Kroetz	Fish population sampling via bottom longline	10/27/2010
F/V Escape	Kevan Gregalis	Fish population sampling via vertical longline	8/10/2010
F/V Escape	Kevan Gregalis	Fish population sampling via vertical longline	8/19/2010
F/V Escape	Kevan Gregalis	Fish population sampling via vertical longline	8/23/2010
DISL R/V Alabama Discovery	Nicholas Bawden	Fish population sampling via trawl	11/22/10
DISL R/V Alabama Discovery	Nicholas Bawden	Fish population sampling via trawl	11/23/10

4. Peer-reviewed publications, if planned:

N/A

5. Presentations and posters, if planned:

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Fisheries independent sampling program in the northern Gulf of Mexico: Alabama's reef permit zone	Kevan Gregalis	Kevan Gregalis, Sean Powers, Marcus Drymon, John Mareska	Mississippi/Alabama SeaGrant Consortium (MASGC) Bays and Bayous Conference	N	December 1-2, 2010

6. Other products or deliverables:

N/A

7. Data:

All data are archived at the Dauphin Island Sea Lab in accordance with the lab's metadata policies.

PARTICIPANTS AND COLLABORATORS

8. Project participants:

First Name	Last Name	Role in Project	Institution	Email
John	Valentine	PI	DISL	jvalentine@disl.org
Sean	Powers	Co-PI	DISL	spowers@disl.org
Kevan	Gregalis	Technician	DISL	kgregalis@disl.org

MENTORING AND TRAINING

9. Student and post-doctoral participants:

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Marcus	Drymon	Post-doc	N/A	DISL	Sean Powers	N/A
Andrea	Kroetz	MS	*	DISL	Sean Powers	2012
Christina	Walker	MS	**	UNF	Jim Gelsleichter	2011

10. Student and post-doctoral publications, if planned:

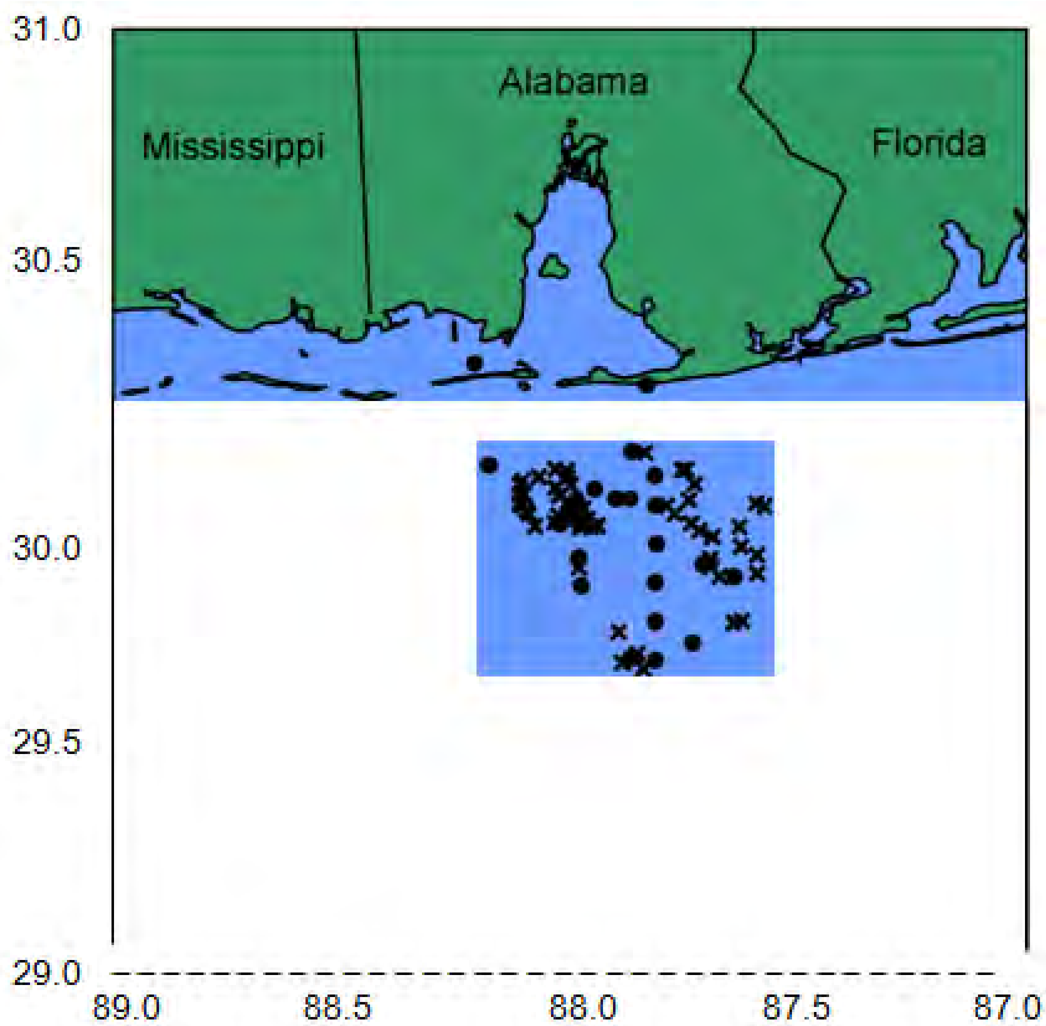
Walker CJ, Gelsleichter J, Drymon JM. 2011. Assessing the impacts of the Deepwater Horizon Oil Spill on sharks caught off the coast of Alabama. Manuscript in prep.

Kroetz AK, Drymon JM, Powers SP. Did the closure of Katrina Cut impact the foraging ecology of a coastal shark? Manuscript in prep.

11. Student and post-doctoral presentations and posters, if planned:

	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Multiple Gear Fisheries Independent Assessment of the Red Snapper Population in Alabama's Reef Permit Zone	Lela Schlenker	Lela Schlenker, Kevan Gregalis, Marcus Drymon, Sean Powers	Annual Benthic Ecology Meeting	N	March 16-20, 2011
Fisheries Independent Assessment of Red Snapper Populations in Alabama's Reef Permit Zone	Marcus Drymon	Lela Schlenker, Kevan Gregalis, Marcus Drymon, John Mareska, Sean Powers	Annual Northern Gulf of Mexico (NGI) Conference	N	May 17-19, 2011
Assessing the impacts of the Deepwater Horizon Oil Spill on sharks caught off the coast of Alabama	Christina Walker	Christina Walker, Jim Gelsleichter, Marcus Drymon	Annual Meeting of the American Elasmobranch Society	N	July 6-11, 2011

12. Images:



Location of vertical (x, n=62) and bottom (●, n=25) longline stations fished from July – December, 2010. Map credit Dauphin Island Sea Lab.

Example of footage from the ROV taken on August 19, 2010 showing the laser-based method of obtaining length data. Image credit Dauphin Island Sea Lab.

Example of ROV footage taken on August 10, 2010 showing multiple species on an artificial reef structure. Image credit Dauphin Island Sea Lab.

10-BP_GRI_DISL-01 (Task 2): Impacts of the Deep Horizon Oil Spill on Ecosystem Structure and Function in Alabama's Marine Waters - Task 2: Effects of oil contaminants on sentinel benthic and pelagic species in Mobile Bay

1. NGI Project File Number: 10-BP_GRI-DISL-01

2. Project Title: Impacts of the Deep Horizon Oil Spill on Ecosystem Structure and Function in Alabama's Marine Waters Task 2: Effects of oil contaminants on sentinel benthic and pelagic species in Mobile Bay

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI?	Affiliation	Email
Ruth H. Carmichael	PI	Dauphin Island Sea lab	rcarmichael@disl.org
Anne Boettcher	Co-I	Univ. of South Alabama	aboettch@jaguar1.usouthal.edu
Kristie Willett	Co-I	Univ. of Mississippi	kwillett@olemiss.edu

4. All Non-Student Personnel funded by this project (including those listed above):

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Nicole Taylor	Research Technician	BS	25	No
R. H. Carmichael	PI	PhD	8	No
Cammi Thornton	R&D Chemist	BS	5	No

*If yes, list NOAA lab

5. All Students funded by this project (including those listed above):

N/A

6. Project Abstract:

In Mobile Bay two key species were at risk for contamination as oil intruded on the estuary after explosion of the Deepwater Horizon (DWH) oil rig; the commercially important oyster, *Crassostrea virginica*, and the federally listed endangered West Indian manatee, *Trichechus manatus*. These species were worthy sentinels by which to measure potential effects of oil exposure because they are species of special interest throughout the northern Gulf and represent distinct habitat niches and life-styles (sessile benthic-dwelling vs. mobile pelagic-dwelling) typical of species in local waters. We quantified the potential direct and indirect effects of oil contamination on these sentinel species by measuring key indicators of physiological stress in oysters

(protein expression and stable isotope ratios) and condition, distribution, and movement patterns of manatees in Alabama waters before, during and after the DWH oil spill. We found that dissolved oxygen (DO) conditions at a historical reef site in south Mobile Bay post-spill (2010) were significantly lower than before the oil spill (2008). Accordingly, oysters at the low DO site in 2010, showed N and C stable isotope ratios that reflected this increased stress and potential oil exposure. Tests for protein expression in response to low DO stress among these oysters were inconclusive. In contrast, manatees showed normal condition in response to capture and tagging and typical movement patterns during the post-spill period we measured. Passive acoustic monitors (PAMs) proved successful and highly valuable to detect manatee locations and movement patterns when tags malfunctioned or were lost. PAH concentrations in water were relatively low, but showed post-spill peaks that require additional analysis and comparison to sediment and tissue samples for clarification. PAH, protein and stable isotope analyses are ongoing for sediments and oyster tissues. Overall, these results suggest sedentary species (in this case oysters) may be at greater risk from oil exposure even due to indirect effects on environmental conditions (low DO) than migratory species (manatees) despite their potential to encounter oil in the water column.

7. Key Scientific Questions/Technical Issues:

To quantify effects of oil-derived substances on sentinel benthic and pelagic species by measuring responses to direct contaminant exposure and oil-enhanced low DO on:

a. oyster physiology, and

b. manatee condition, distribution and movement patterns

To define temporal-spatial scales of physiological (sublethal), biological (growth, survival), and behavioral (distribution, movement) responses by these sentinel biota.

8. Collaborators/Partners:

Collaborators are Co-Is listed above, Dr. K. Park at DISL, who consulted on physical transport processes, and Dr. Sean Powers, who shared additional passive acoustic monitors to supplement our array.

9. Project Duration:
1 Jul 2010 – 31 Dec 2010

10. Project Baselines:

Relationships to NOAA/NGI/BP goals: These data are important to understand the thresholds and temporal-spatial scales of physiological (sublethal), biological (growth, survival), and behavioral (distribution, movement) responses by local biota. These data have management and conservation implications because *a)* oysters are commercially valuable, and oyster restoration is championed nationwide for ecological services; and *b)* manatees are an endangered species, recognized as an umbrella species for which management and conservation will broadly affect the local ecosystem.

Gaps filled: We demonstrated for the first time that passive acoustic monitoring methods successfully detect movements of tagged manatee even when satellite/GPS/telemetry tags have malfunctioned or been lost. This newly applied method will be useful for monitoring large-scale movements of marine mammals in relation to timing and location of natural and anthropogenic disasters in the future.

We found indictors of stress in oysters exposed to low dissolved oxygen concentrations, consistent with the presence of oil in near shore waters.

11. Milestones accomplished during entire project period:

We completed all major project tasks including: PAH analysis on water (61 samples completed), sediments (also C:N and particle size analysis on 75 samples), and oysters transplanted in Mobile Bay; conducted protein expression analyses to detect stress in oysters; captured and tagged 3 manatees and determined their condition post-spill; deployed passive acoustic monitors to enhance detection of movement patterns post-spill; and conducted PAH analysis on water and sediments in known manatee habitat in AL waters.

12. Describe all significant research results, protocols developed, and research transitions:

Oysters—We identified potential biomarkers and optimization of methods for use in assessing the impact of oil-exposure and habitat contamination on oysters at two sites in Mobile Bay, Alabama (Fig. 1). The primary focus was on expression of both the constitutive (HSC77 and 72) and inducible (HSP69) isoforms of heat shock protein 70, which are general stress response markers that may detect stress associated with direct or indirect oil exposure. Importantly, we found that dissolved oxygen (DO) conditions at a historical reef site in south Mobile Bay post- spill (2010) were significantly lower than before the oil spill (2008) (Fig. 2). Field analyses of oysters transplanted the affected reef site were calibrated with laboratory studies that revealed upregulation of HSP69 in gill under elevated temperature and temperature + hypoxia treatments, but not for hypoxia alone. Based on these results, the expression of additional biomarkers, including p38 MAP kinase and CREB, were tested on both the laboratory samples and field collected samples. These markers yielded mixed results and require further optimization. These data were further complemented by N and C stable isotope analyses, which showed shifts towardlighter $\delta^{13}C$‰ and heavier $\delta^{15}N$‰ in oysters under low dissolved oxygen conditions, which occurred in Mobile Bay post-spill (Fig. 3). These results are consistent with exposure to lighter C sources and catabolism of tissues under stress conditions that may be associated with oil contamination of growing waters. Additional analyses are needed to corroborate these findings.

Manatees—We captured, tagged, and conducted health assessments on three manatees in Alabama waters in early August. Health assessments of all animals were conducted by the University of Florida Veterinarians who attended captures, at no cost to this project. We monitored the tagged animals in near real time via satellite/GPS and tracked their location on the ground roughly every 4 days. We programmed and deployed 7 passive acoustic monitors (PAMs) at strategic locations throughout Alabama waters to will detect movements of any manatees in the area, even if tagged outside Alabama. Manatees showed typical stress in response to capture and tagging, but did not show additional stress or aspects of condition that were attributed to oil exposure or contamination. PAMs recorded cold-season migratory movements of three belted manatees within and out of AL coastal waters (Fig. 4). For the four visually assessed GPS-monitored manatees, we found no instances of co-occurrence between animals and surface oil (either visually observed or from the NOAA NESDIS oil surface coverage data layers). Movement patterns of telemetry-monitored (GPS and belted) animals during and after the DWH spill was consistent with patterns seen in previous years, using habitat in Apalachicola, FL and Mobile Bay, AL extensively and occasionally traveling between the two areas (Fig. 4). Animals traveled to Crystal River, FL at the onset of cold temperatures in late November and early December 2010. We collected and sent water and sediment samples from known manatee habitat areas to UM for PAH and contaminant testing. PAMs will remain in place to collect data for the subsequent spring 2011 migration. We also plan to continue tracking tagged manatees as long as the tags remain functional. Future manatee movement data will be analyzed and compared to previous patterns.

PAH analyses—Water, sediment, and oyster samples were collected approximately bimonthly between May 26 and November 30 from two sites in Mobile Bay (Denton and Sand Reefs) at 1.0 or 0.1 m above the bay floor. Additional periodic water and sediment samples were collected at key oyster and manatee habitats in Alabama waters with varying likelihood of exposure to oil contaminants: Pointe aux Pines, Perdido Pass/ Orange Beach, Fairhope Pier, and in the Mobile- Tensaw delta. Water was extracted for quantification of 26 PAHs with methylene chloride and analyzed by GC/MS. Highest water concentrations for total PAHs were observed on 28 June 2010 at Sand Reef (1 m), 4 August 2010 at Sand Reef (0.1 m), 21 July 2010 at Denton Reef (1 and 0.1 m), and 9 September 2010 at Perdido Pass/ Orange Beach. Sediment was also collected from these sites and the percent carbon to nitrogen ratio ranged from 9 to 138. Overall, values were relatively low, ranging 3 – 300 ng L-1 at Denton Reef (mid-bay) and 10 – 270 ng L-1 at Sand Reef (south-bay); within the range expected for background contamination in Mobile Bay. Quantification of sediment and oyster total PAHs is ongoing and expected to reveal a more time- integrated pattern of contamination, if present.

13. Outreach activities:

Outreach activities are included below under presentations

14. Peer Reviewed Articles: List peer reviewed articles about this project published during this period of reportin g. If this is the final report for the project, list all peer reviewed articles published about this project's work. D o not include any publications before the start date of this project.

Aven, A., **R. H. Carmichael**, M. Ajemian, S. Powers. Submitted. Passive acoustic monitoring mitigates GPS tag loss by tracked manatees. *J. Acoust. Soc. Am.*

Aven, A., **R. Carmichael**, and others. Manuscript in prep. Evidence for seasonal migration and site fidelity by West Indian manatees (*Trichechus manatus*) between the northern Gulf of Mexico and western Florida coasts.

15. Non-refereed articles and reports for this project: List all other articles about this project.

N/A

16. List conference presentations and poster presentations for this project:

Kronmiller, Kelsie, Heather Patterson, and Anne Boettcher. 2010. Stress response in the eastern oyster due to hypoxia and temperature.

University of South Alabama 12th Annual Undergraduate Symposium. October 2010, Mobile, AL. Poster presentation.

Patterson, Heather, Anne Boettcher, and Ruth Carmichael. 2010. Measuring dissolved oxygen stress in the Eastern oysters, *Crassostrea virginica*. Gulf Estuarine Research Society meeting, Port Aransas, TX, November 2010. Oral presentation.

Patterson, Heather, Anne Boettcher, and Ruth Carmichael. 2010. Measuring dissolved oxygen stress in the Eastern oysters, *Crassostrea virginica*. Bays and Bayous Symposium, Mobile, AL, December 2010. Poster presentation.

Kronmiller, Kelsie, Heather Patterson, and Anne Boettcher. 2011. Biomarkers of oxygen and combined oxygen and temperature stress in oysters. Benthic Ecology Meeting 2011. March 2011, Mobile, AL. Poster presentation.

Aven, Allen, and Ruth H. Carmichael. 2011. Detection of belted manatees using passive acoustic monitors. Benthic Ecology Meeting, Mobile, AL, March 2011. Poster presentation.

Patterson, Heather, Anne Boettcher, and Ruth Carmichael. Can stable isotopes detect low oxygen stress in oysters? Benthic Ecology Meeting, Mobile, AL, March 2011. Oral presentation.

Dailey, Meghan, Cammi Thornton, Heather Patterson, Ruth Carmichael, and Kristine L. Willett. 2011. Assessment of water and sediment for PAH concentrations and embryo toxicity following the Deepwater Horizon oil spill. Abstract submitted to Gulf Oil Spill SETAC Focused Meeting, April 2011, Pensacola, FL. Poster presentation.

17. Has anyone from this project been hired by NOAA during this reporting period?

N/A

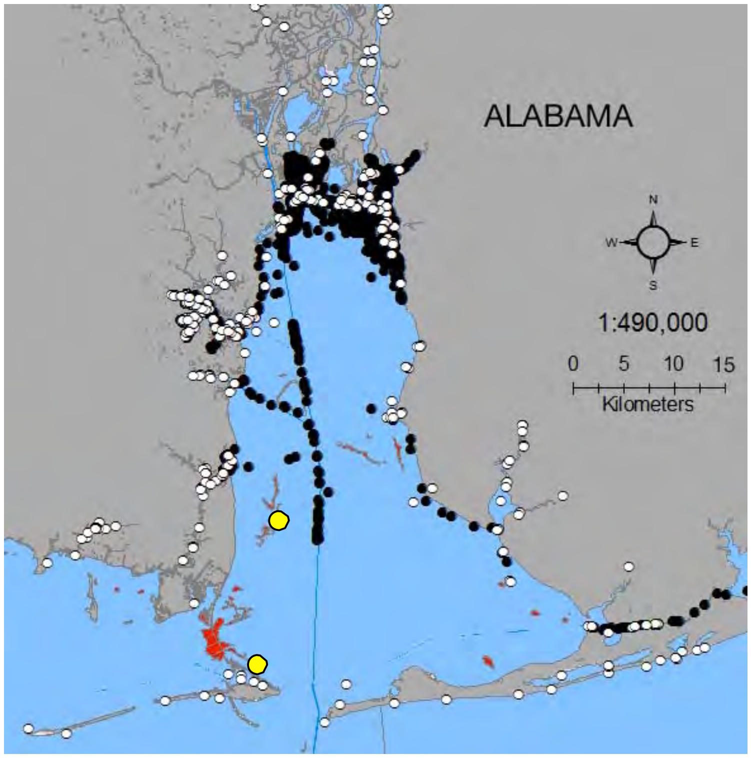


Fig. 1. Mobile Bay, showing oyster sampling and transplant locations (○) at historical reef sites (red) and known manatee distribution and movement patterns based on sightings (○) and GPS tracking of tagged manatees (●)relative to the ship channel (blue line).

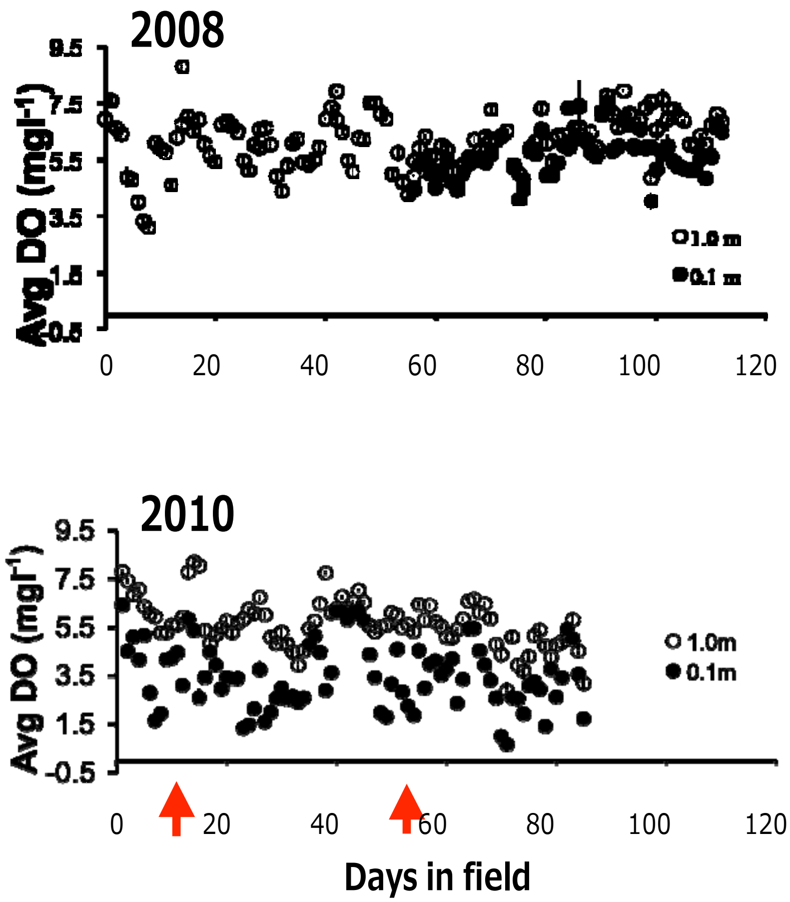


Fig. 2. Dissolved oxygen concentrations in near bottom waters at Sand Reef in south Mobile Bay during 2008 (prior to the DWH oil spill) and in 2010 (during and post-spill). Red arrows indicate the period of active oil input to the northern Gulf of Mexico.

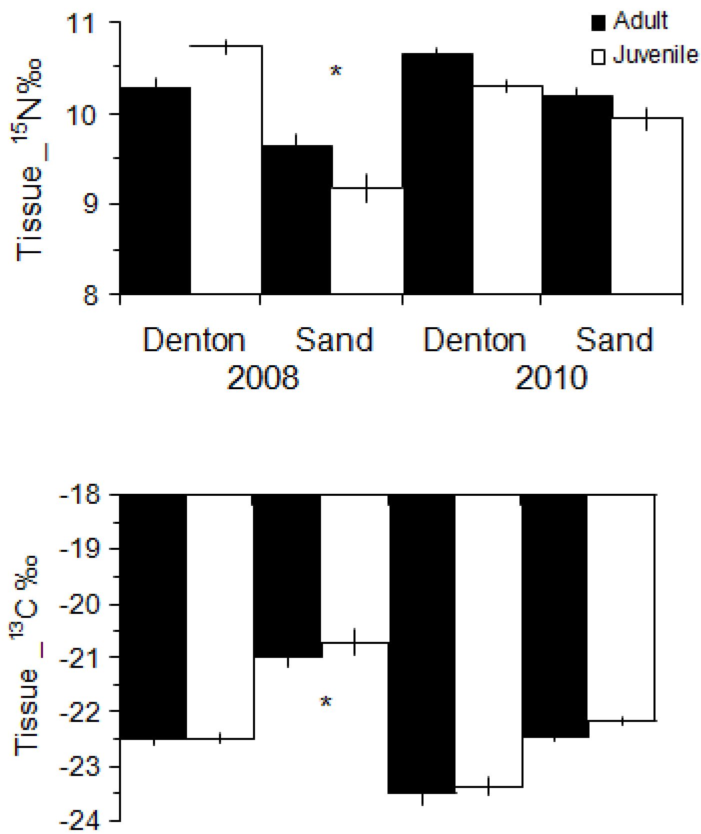


Fig. 3. δ^{15}*N‰ and* δ^{13}*C‰ values in tissues of oysters grown at Denton (mid-bay) and Sand (south-bay) Reefs in 2008 and 2010. N values are significantly lighter and C values heavier at Sand Reef before the DWH oil spill (2008) compared to after (2010), despite similar available diet (data not shown).*

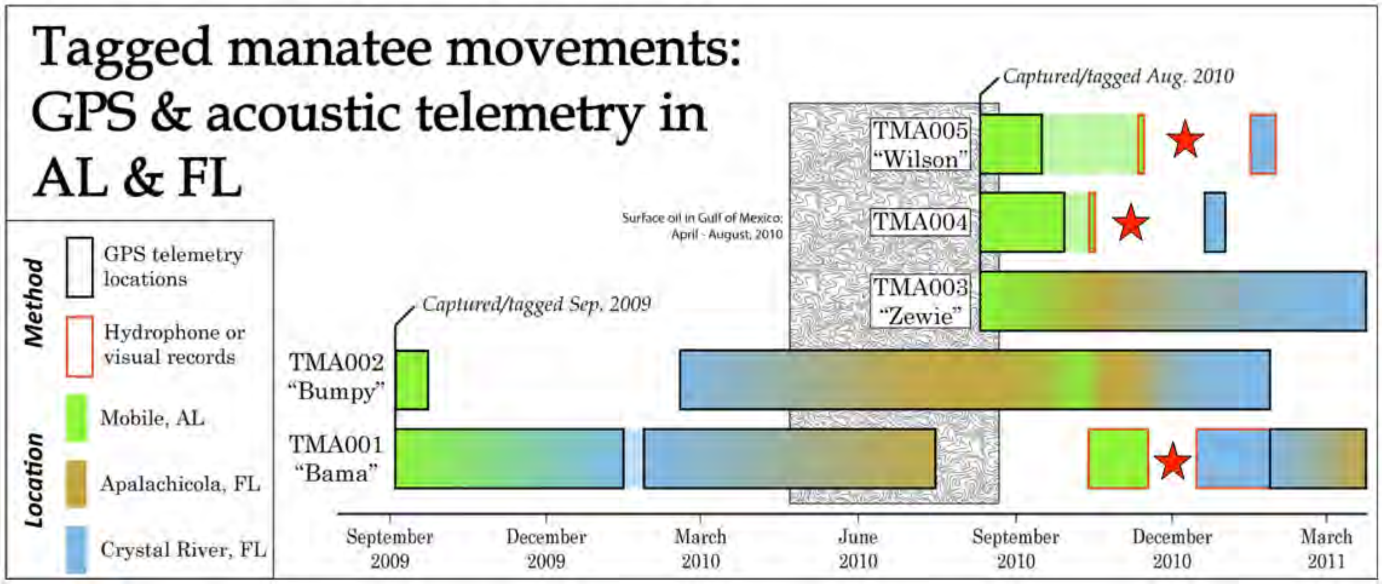


Fig. 4. Locations, movement patterns, and method of detection for 5 manatees tagged in Alabama waters in 2009 and 2010. Grey shaded box indicates the period of estimated surface oil present in Alabama waters (NOAA NESDIS 2010). Red stars indicate locations detected by passive acoustic monitors (PAMs) deployed during this study. PAM data indicate that up to 4 manatees (TMA001, TMA003, TMA004, TMA005) were in Alabama waters coincidental with surface oil.

10-BP_GRI_DISL-01 (Task 6): Impacts of the Deep Horizon Oil Spill on Ecosystem Structure and Function in Alabama's Marine Waters, Task 6: Quantifying the effects of oil on the microbial community structure and processes in Alabama coastal waters

Alice C. Ortmann

SCIENCE ACTIVITIES

1. General Summary: The oil and dispersants introduced into the environment as a result of the Deepwater Horizon oil spill may have affected the pelagic microbial community by introducing large amounts of organic material. This material would have been available to microbes with specific genes capable of degrading hydrocarbons. Once these microbes had begun to break down the oil and dispersants, the organic matter would have been available to other members of the microbial community and thus stimulated growth. If grazers were also stimulated, this excess organic matter could be transferred to higher trophic levels, representing a pulse of energy available to zooplankton and larval fish. A stimulation of viral lysis would have a different impact, with increased transfer to the dissolved organic matter pool. This could increase prokaryotic growth, but would likely result in increased respiration and a decrease in the total carbon and energy moving to higher trophic levels. The rates of transfer and the ability of the microbial community to respond to the oil and dispersants would be determined by the presence of organisms able to digest the hydrocarbons, and thus is tied to community composition. To address these questions we used a series of dilution incubations to estimate the growth rate of phytoplankton (eukayotes and cyanobacteria)and prokaryotes along with the rates of grazing and viral lysis on each group. In conjunction with the experiments we investigated the abundance and diversity of specific genes, including those associated with nitrogen fixation and hydrocarbon degradation. Experiments were carried out at four different stations, two of which received no oiling: one within Mobile Bay (MB) and one at the mouth of Mobile Bay (DI), and two which received light oiling: one in 20 m water depth (CP) and one in 35 m water depth (T35).
The key questions we asked were:

A. Is the biomass and growth rate of phytoplankton, cyanobacteria and prokaryotes in offshore sites affected by oil and dispersants different from the previous year? To include the effects of annual variation, we are asking if the range of biomass and rates is larger than the variability seen within sites not affected by the oil and dispersants.
B. How do estimates of grazing and viral lysis at the offshore sites compare to the previous year? Is the variation on the same level as seen at the inshore sites?
C. Archaea have been suggested to be potential sentinels for oil exposure and recovery, how does the number and diversity of Archaea change at sites exposed to oil and dispersants?
D. The ability of microbes to degrade hydrocarbons and dispersant is dependent on the presence of the hydrocarbon degradation genes in the environment. How does the number and diversity of these genes change as water is exposed to oil and dispersants?

2. Results and scientific highlights

Hypothesis 1: The exposure to oil will cause a shift in the microbial loop to higher rates of viral lysis and lower grazing rates resulting in less transfer of carbon to higher trophic levels.

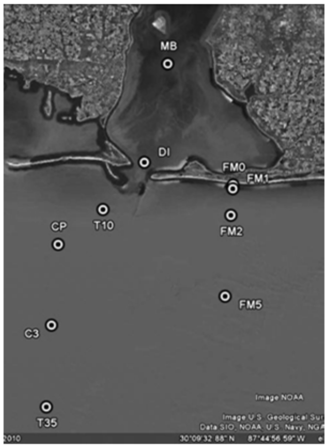


Figure 1 Map showing sample sites along the FOCAL transect extending from Mobile Bay to the northern Gulf of Mexico. The FM transect was sampled

To determine the rates of growth, grazing and viral lysis, modified dilution experiments were used. This approach combines the traditional Hassett and Landry dilution experiment to determine microzooplankton grazing rates, with a second parallel dilution of both grazers and viruses. By using chlorophyll a, we can get estimates of rates for phytoplankton (eukaryote and cyanobacteria). The purchase of a flow cytometer (BD FACSCalibur) enabled us to separately look at the heterotrophic prokaryotes. Data from the prokaryotes was not completely analyzed by the end of the Phase I grant, but was completed by early 2011.

Four sites were chosen for these experiments, three of which has previously been used and one which was further offshore and definitely exposed to oil and dispersants. The sites (MB, DI, CP and T35 in Figure 1) represent a gradient of nutrients and salinity from within Mobile Bay to the shelf. CP and T35 were documented to have been exposed to some oil and dispersants, while DI and MB were not. The variability at these sites will be used as a way to determine if the values seen at CP and T35 are outside of normal annual variability.

Experiments were carried out in May, July, September and November 2010. Previous data, collected in July and Novmeber 2009 and January and March 2010 are included as comparisons to pre-exposure conditions. Phase II funding from NGI supported a second full year of sampling and experiments were carried out bimonthly through the end of 2011. Biomass, as estimated from the concentration of chl a, was usually highest at the inshore sites and lowest at the offshore sites (Figure 2). This mirrors the concentrations of nutrients, although concentrations of N and P sometimes increase at CP when river discharge is high. July chl a concentrations at CP were 2.2 x higher in 2010 than in 2009, but by November 2010 the concentration was only 1/5 the 2009 concentration. The July peak does correspond with oil exposure and inshore concentrations of chl a are only ~1/2 their 2009 values.

Analyses of growth, grazing and viral lysis rates show high variability at MB and CP (Figure 3). The highest µNet (growth-total losses) are detected at T35, even though the biomass and nutrients are lowest. The least variability in rates is seen at the DI site, right at the mouth of the bay. Large differences in rates were seen at MB between July 2009 and July 2010, µNet at CP was only 1.3 x higher in 2010 than in 2011. Preliminary analyses suggest that there was little impact in biomass and production for phytoplankton exposed to oil when compared to the high variability detected in the unexposed sites. This is a preliminary

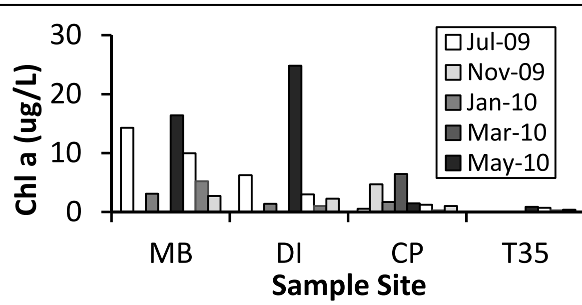


Figure 2 Concentration of Chl *a* at t=0 for each of the experiments from July 2009 through November 2010. Experiments at T35 were stated in May 2010. November 2009 and March 2010 are missing

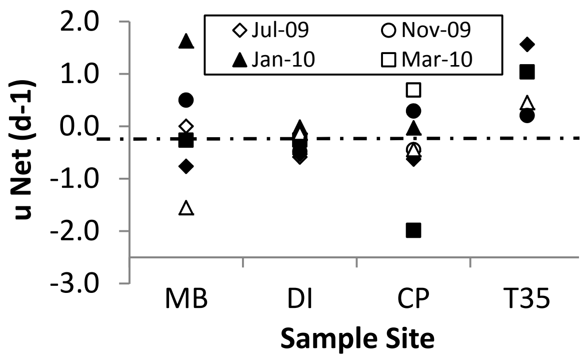


Figure 3 μ_{Net} (d^{-1}) for all experiments. The dashed line indicates the zero, with values below suggesting net loss of

conclusion, and analysis of experiments carried out through 2011 may result in a different conclusion. The addition of prokaryotic growth and losses to the data set should provide clues as to how the rest of the microbial community responded to oiling.

Hypothesis 2: The exposure to oil will result in low levels of lysogeny compared to microbial communities not exposed to oil.

The second hypothesis put forward in this project focused on lysogeny. It was thought that oil would induce temperate phages to enter the lytic cycle. This would decrease the percentage of lysogens that could be experimentally induced, but increase the role of lysis in the functioning of the microbial food web. Although several experiments were carried out to measure lysogens at these four stations, we were not able to obtain estimates from any of the experiments. This suggests that lysogeny is low in this region, even in the absence of oiling, or that our experimental set up was not sufficient to detect induction events in the background of 'normal' virus production.

Hypothesis 3: The diversity and abundance of specific groups of microorganisms will shift in response to oil exposure.

From samples collected along the FOCAL transect and second transect in June (FM Transect, Figure 1) a set of 24 were selected for preliminary analyses. These samples have been analyzed for three genes at this point: nifH (nitrogen fixation), P450 (aerobic alkane degradation) and the archaeal 16S rRNA gene.

For nifH and P450, analysis has so far been limited to determining presence or absence based on standard PCR detection. The nifH is presently being optimized for quantitative detection and the abundance of this gene will soon be determined. Both of these genes were detected in most of the samples tested, including those from before the oil exposure. Detection of genes associated with alkane degradation suggests that the northern Gulf of Mexico may indeed be 'primed' to respond to oil inputs. To confirm these conclusions, more genes will be studies and the diversity of these communities will be determined.

Analysis of the Archaea has included both quantification and diversity measures. The Archaea are poorly studied in coastal oceans and few studies have addressed the effects of oil on this community. The studies that do exist suggest that Archaea are negatively affected by oil and that they may be good indicators of recovery. To this end, the 24 samples were analyzed for the abundance of Thaumarchaeota and the diversity of total Archaea. Thaumarchaeota were not detected in samples collected from heavily oiled sites (FM transect, June), but were found in bottom water samples and samples collected after oil exposure (Figure 4). Analysis of the diversity of the archaeal communities using DGGE indicate that there are 2-10 different Operational Taxonomic Units (OTUs), with a distinct community present in the deeper samples. Surface and coastal samples clustered together, with some separation based on when the samples were collected. The abundance and diversity of the archaeal communities were negatively correlated with DOC (Thaumarchaota abundance = -0.79, Richness= -0.73) which may be an indicator of oil exposure. This data supports the hypothesis that Archaea may be an indicator species for recovery from oil. Based on this preliminary data, further samples will be analyzed for Thaumarchaeota. All of the selected samples will be analyzed for Euryarchaeota, the other major marine group of Archaea. Diversity of select samples will be further explored through sequencing of the 16S rRNA genes from both of these groups.

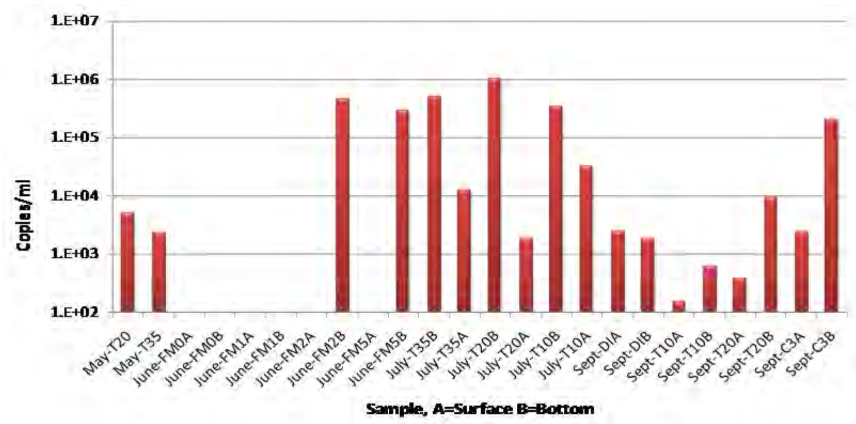


Figure 4 Plot of the number of copies of Thaumarchaeota 16S rRNA genes detected in the 24 samples analyzed. Values are corrected to represent number of copies per ml of seawater. Samples are shown from May through September, with samples for each transect moving from coastal to offshore. 'A' samples were collected from the surface, while the 'B' samples were collected 1 m above the bottom.

3.Cruises & field expeditions:

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
E.O. Wilson		DISL	Collect water samples along the FOCAL transect to carry out dilution experiments and extract community DNA	May, July, September and November 2010

4. Peer-reviewed publications, if planned:

a. Published, peer-reviewed bibliography
N/A

b. Manuscripts submitted or in preparation

Grazing is the dominant process controlling the abundance of prokaryotes and phytoplankton across the Alabama shelf. Aquatic Microbial Ecology, submission July 2012

5. Presentations and posters, if planned:

Title	**Presenter**	**Authors**	**Meeting or Audience**	**Abstract published (Y/N)**	**Date**
Coastal Archaea: more common and not so extreme	A. C. Ortmann	A. c. Ortmann	ASM South Central Branch Meeting, 2010	N	Oct 2010
Archaea as a sentinel group to measure recovery from the Deepwater Horizon spill	A. C. Ortmann	A. C. Ortmann, N. Ortell and S. Ni Chadhain	Southeastern Branch of ASM	N	Nov 2010
Microbial community response to the Deepwater Horizon spill, a functional gene approach	S. Ni Chadhain	S. Ni Chadhain, N. Ortell, L. Wang and A. C. Ortmann	Southeastern Branch of ASM	N	Nov 2010

6. Other products or deliverables:
N/A

7. Data:
Metadata is being compiled and will be submitted to the Mermaid system following the protocols and procedures of the Dauphin Island Sea Lab.

PARTICIPANTS AND COLLABORATORS

8. Project participants:

First Name	Last Name	Role in Project	Institution	Email
Alice	Ortmann	Principle Investigator	DISL	aortmann@disl.org
Courtney	Metzger	Technician	DISL	cmetzger@disl.org
Sinead	Ni Chadhain	Co-Principle Investigator	University of South Alabama	snichadhain@usouthal.edu

MENTORING AND TRAINING

9. Student and post-doctoral participants:

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Natalie	Ortell Cumbaa	PhD	Archaeal distribution in the northern Gulf of Mexico	University of South Alabama	A. C. Ortmann	2014
Lei	Wang	PhD	Factors controlling pathways of nitrogen cycling in the Mobile Bay	University of South Alabama	A. C. Ortmann	2015

10. Student and post-doctoral publications, if planned
a. Published, peer-reviewed bibliography
N/A

b. Manuscripts submitted or in preparation
Exposure to oil from the Deepwater Horizon spill had a significant impact on the archaeal community in surface waters of the Alabama shelf. ISME J, submission May 2012

11. Student and post-doctoral presentations and posters, if planned:
N/A

12. Images: See above

10-BP_GRI-FSU-01 (Task 1): Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge

1. **NGI Project File Number:** 10-BP_GRI-FSU-01 (Task 1)

2. **Project title**: Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge

3. **Project Lead (PIs and Co-PIs):**

Name	Project Lead or Co-PI?	Affiliation	Email
Eric Chassignet	Subgroup lead	COAPS/FSU	echassignet@coaps.fsu.edu
Ian McDonald	Co-PI	FSU	imacdonald@fsu.edu
Mark Bourassa		COAPS/FSU	mbourassa@coaps.fsu.edu

4. **All Non-Student Personnel funded by this project:**

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Dmitry Dukhovskoy	Asst Scholar Scientist	PhD	21%	No
Oscar Garcia-Pineda	Asst Scholar Scientist	PhD	23%	No
Steven Morey	Assoc Scholar Scientist	PhD	19%	No

*If yes, list NOAA lab

5. **All Students funded by this project:**

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
None				
James Nelson	PhD	PhD	21%	No
Austin Todd	BS	PhD	21%	No

*If yes, list NOAA lab

6. **Project Abstract:**

The oil spill from the BP well is an imminent threat to marine ecosystems and living marine resources throughout the NEGOM and perhaps beyond. However, the unprecedented release of oil at a fixed point, coupled with a massive collection of satellite and oceanographic data also provides an immediate opportunity to better understand the geochemistry and physics that govern the fate of the oil on the ocean's surface, and the impact of this event on coastal and marine biological communities. The oil from the Deepwater Horizon well is currently moving both onshore, where it is approaching Florida beaches, saltmarshes, oyster reefs, and other foundation habitats of the NEGOM, and offshore, where it is being distributed throughout the water column to the seabed, potentially impacting economically important fishery species. Initiating the investigations prior to the oil contamination is critical for establishing baseline data to enable quantification of the changes caused by the oil and the determination of the degradation rates, and provides the greatest impact on mitigation efforts by informing environmental managers. Reliable data on the changes caused by the oil, the duration of the oil degradation process and toxic substances release are critical for remediation, planning and decision processes, and these data can only be generated by conducting research at the affected sites now. Environmental effects include impairing and killing organisms that live in sediments, on the surface, or extending above the waterline (e.g. anaerobiosis and resulting shifts toward anaerobic microbial guilds; toxicity effects on macrofaunal invertebrates, meiofauna, and benthic microalgae (Satoh et al. 1999, Oh et al. 2003); as well as impacts on predator-prey interactions (Stagg and Mcintosh 1996, Barron and Ka'aihue 2001, Golet et al. 2002). Toxins can also percolate into ground water (Eganhouse et al. 1993). Delayed sampling either inshore or offshore would be ineffective because some impacted habitats (especially demersal and benthic communities) could disappear after extended exposure to the oil. All of these habitats provide critical ecosystem services that will be impaired by the presence of oil. Recovery times for all these habitats will vary. Thus, it is critical that we identify those factors contributing to recovery so that there is a proper focus on remediation and restoration efforts in affected areas to help restore ecological services and therefore economic wellbeing. Any remediation following from the spill requires a quantitative assessment of the processes that control uptake, degradation and release of crude oil components.

7. Key Scientific Questions/Technical Issues:

The immediate need to evaluate the impact of the physical environment on oil transport is clear because the opportunity to acquire critical data exists only for the duration of the release and dispersion phases of the oil. For this reason, the modeling group proposes to investigate how oil and similar surface microlayers of differing thicknesses damp capillary waves that can be measured by satellite microwave radar (principally synthetic aperture radar – SAR), and alter the wind stress (and thus thermodynamic fluxes) at the ocean surface. This proposed work will use satellite remote sensing, *in situ* sampling, and numerical modeling of isolated nearshore rafts of oil (Figure 1). Results will have immediate broader impacts on identification, tracking, and forecasting of the oil slick to aid in response to the disaster, as well as provide a better understanding to the scientific community of the dynamics of the ocean in the presence of a surface microlayer. The specific scientific objectives of the proposed research are:

- To determine the impact of oil and other similar surface microlayers (e.g. surfactants) on capillary wave damping, and how this changes with differing thicknesses and composition of the microlayers.
- To explore how the surface oil modification of capillary waves affects SAR microwave backscatter used for oil detection and for measuring surface fluxes.

- To make preliminary estimates of how surface oil impacts air-sea fluxes of heat and momentum, the dependence on wind speed, and impacts on the subsurface thermodynamic properties of the ocean.

8. Collaborators/Partners:

Name of collaborating organization

N/A

Date collaborating established

Data from satellite remote sensing was shared and utilized

N/A

Does partner provide monetary support to project? Amount of support?

N/A

Does partner provide non-monetary (in-kind) support?

N/A

9. Project Duration:

06/15/2010

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

To improve the modeling and tuning of the physical parameters that influence the distribution and persistence of oil;

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

Results will have immediate broader impacts on identification, tracking, and forecasting of the oil slick to aid in response to the disaster, as well as provide a better understanding to the scientific community of the dynamics of the ocean in the presence of a surface microlayer.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

The locations of the oil slick are better known, methods for tuning model parameters related to forecasting surface oil slick movement have been developed, and they have been applied to improve tuning related to wind and waves.

Contributions to BP_GRI goals:

To determine the impact of oil and other similar surface microlayers (e.g. surfactants) on capillary wave damping, and how this changes with differing thicknesses and composition of the microlayers.

• To understand how the surface oil modification of capillary waves affects SAR microwave backscatter used for oil detection and for measuring surface fluxes.

• To make preliminary estimates of how surface oil impacts air-sea fluxes of heat and momentum, the dependence on wind speed, and impacts on the subsurface thermodynamic properties of the ocean.

11. Milestones accomplished during entire project period:

a. Use data from SAR and the ASCAT Scatterometer to find the location of the oil slick(s)
b. The wind speed characteristics required for dampening of the oil were not determined because while sufficiently great wind speeds (e.g., 8m/s for some types of surface oil) caused ripples to form, there location of the slick was still identifiable. There is a low wind speed limit of roughly 1.5 m/s, below which there are few ripples on the ocean surface, making the oil free surface appear similar to the damped surface from the perspective of active microwave techniques. We speculate that such conditions are often associated with clear skies, which should make detection through visible and infrared imagery practical.
c. Methods for determining the accuracy of tuning were developed. Tunings for oil drift were assessed.

12. Describe all significant research results, protocols developed, and research transitions:

Oil Spill Modeling

A simplified oil spill model was applied to develop and test methods of using SAR-derived oil maps to objectively quantify the performance of the model and to be used for parameter estimation. The oil spill model was developed to purposefully be simple yet include a large enough parameter space to facilitate development and testing of the model comparison metrics. This model consists of a particle tracking algorithm in which discrete particles representing a set volume of oil are advected in a velocity field constructed from surface currents from the HYbrid Coordinate Ocean Model (HYCOM) 1/25° Gulf of Mexico data assimilative hindcast. To the surface current is added a commonly-used wind drift parameterization: 3.5% of the wind speed directed 20° to the right of the wind vector (Samuels et al., 1982). Here, winds are taken from the Rapid Update Cycle (RUC) forecast. New oil particles are added at a prescribed rate (typically 50 per hour, or 1200 per day, for these experiments). As the oil is advected, a random walk algorithm is applied consistent with a Laplacian diffusion, allowing for parameterization of horizontal spreading through a diffusion coefficient, which is increased near source to account for gravitational spreading. Particles are removed from the computation randomly based on a prescribed half-life (a parameterization for weathering effects). Oil positions are saved each hour for analysis.

Several metrics were developed to objectively compare results from the model with Synthetic Aperture Radar (SAR) satellite data. SAR-derived maps of surface oil location were produced by Garcia and MacDonald's TCNNA method. Problems with developing metrics to use these maps include the fact that sometimes the satellite only sees part of the oil spill due to its orbital pattern and observational swath width. Thus, a time-integrated metric was developed. SAR TCNNA-derived oil slick maps are collected for the period from 22 April, 1200UTC, to 14 July, 0000UTC. For each cell in a spatial grid consisting of 0.05° x 0.05° bins, the total number of times the cell was observed by an overpass with useful data from the Envisat satellite is counted. Next, for each cell, the number of these observations that had oil present is computed, multiplied by the fractional areal coverage of oil. Dividing this array by the number of overpasses produces a map approximating the percent of time oil was detected at each location in the northern Gulf (Figure AA1).

One can clearly see the spreading of oil from the source toward the central U.S. Gulf Coast, impacting roughly from Atchafalaya Bay in the west to the Florida Panhandle in the east. Oil in the Loop Current is evident by the southeastward branch. From this gridded map, it is straightforward to calculate quantities such as areal coverage and dispersion. Shape-descriptive quantities, such as eccentricity, area, and bulk dispersion must be modified to account for the varying scalar quantity, the normalized detection rate. As an illustration, a quantity related to the bulk dispersion is the *Weighted Time-Averaged Mean Displacement,* calculated as

$$\bar{D} = \frac{1}{T}\int_0^T \sigma \, dt$$

where

$$\sigma = \frac{1}{n}\sum_{i=1}^{n} f_i \sqrt{(x_i - x_0)^2 + (y_i - y_0)^2}$$

is the mean displacement of each bin location (x_i, y_i) with normalized oil detection f_i from the source (x_0, y_0). To illustrate this model evaluation metric, the oil spill model is run from the beginning of the oil spill (22 April, 1200UTC) to 14 July, 0000UTC. The model oil positions are time composited in a similar manner as the SAR images, and the relevant metrics were calculated for varying parameters (Figure AA2).

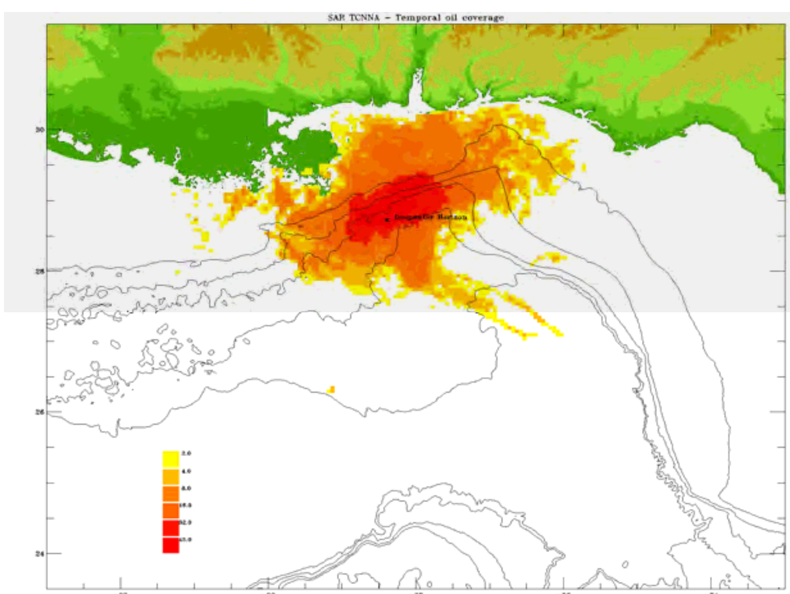


Figure AA1. Normalized detection rate of oil by the SAR TCNNA algorithm over the period 22 April, 1200UTC, to 14 July, 0000UTC. The fractional coverage of each grid cell is summed for all satellite observation times, and normalized by the total number of observation times for each cell.

Figure AA2. Percentage of time oil is present in each 0.05° x 0.05° cell from the oil spill model with half-life parameters of 72 hours (left) and 144 hours (right).

These, and other metrics, are being used to quantify improvements in the model by adding varying complexity, test different atmospheric and ocean current data sources, and tune parameters. During this project, a student intern (Perrine Rayet) was supported and work on development of these metrics formed the basis for her summer intern project. The model and metrics developed during this project are being shared with other NGI-funded investigators (K. Gallivan) to develop additional methods of quantifying uncertainty in oil spill models. This work was also presented at the 2011 American Society of Limnology and Oceanography conference.

A center of mass test was used to evaluate the impacts of various forcing mechanisms: currents plus wind drift vs. currents plus Stokes drift. Stokes drift is believed to be a bigger player for large oil slicks, because the oil severely damps wind stress, whereas Stokes drift is due to waves. The oil has relatively small impact on long waves. These results indicate that Stokes drift may be an important factor in the transport of oil at the sea surface. Unfortunately, there were not enough valid satellite-derived oil locations to test a wider variety of cases. That being said, for the available cases, the Stokes trajectory does match the observed oil locations better than the wind trajectory does when using the center of mass comparison method. Furthermore, the directional component of the Stokes trajectory looks to be more accurate than that of the wind trajectory when compared to observations.

These results also suggest that the effect of the wind drift still does need to be accounted for, though it may not be as strong as most models predict. For two of the three cases, the distance traveled according to the wind trajectory is closer to the observed than the Stokes trajectory is. But, this is also using 2% of the wind speed, the minimum used in models. If a higher value were to be used (e.g., 3.5% or 4%), which is more common in oil trajectory models, the wind drift would have over predicted the distance traveled in every case. These results also show evidence to support the claim that wind may not have as strong a direct influence on surface drift when an oil slick is present; however, wind away from the slick generates surface waves that contribute to the motion of the slick.

References

Samuels, W.B., N.E. Huang, and D.E., Amsiuiz (1982), An oilspill trajectory analysis model with a variable wind deflection angle, *Ocean Engineering, 9*, 347-360.

13. Outreach activities:

General Description
Have you hosted speakers, workshops and/or any training? For each provide:
Type (speaker, workshop, training)
Name of event
Date
Location
Description
Approximate Number of Participants

a. Materials from this study were used to illustrate physics in two classes at Florida State University: Physics of Air/Sea Interaction (22 graduate students) and Physical Meteorology II (25 undergraduates and 9 graduate students).

b. The methods were discussed at a meeting of the 2011 American Society of Limnology and Oceanography conference

c. The remote sensing of the location of the oil slick was demonstrated at two talks at the International Ocean Vector Winds Science Team Meeting (May 2010) in Barcelona, Spain (roughly 80 attendees)

d. The drift estimates where distributed on line, and discussed in numerous television, radio and text interviews.

14. Peer Reviewed Articles:

Papers are still under development

15. Non-refereed articles and reports for this project:

N/A

16. List conference presentations and poster presentations for this project.

N/A

17. Has anyone from this project been hired by NOAA during this reporting period?

N/A

10-BP_GRI-FSU-01 (Task 2a): Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge - Subproject: Microbial analysis of sandy sediments

1. NGI Project File Number: 10-BP_GRI-FSU-01 (Task 2a)

2. Project title:

Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge - Subproject: Microbial analysis of sandy sediments

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI?	Affiliation	Email
Eric P. Chassignet	Lead	Florida State University	echassignet@coaps.fsu.edu
Felicia Coleman	Lead	Florida State University	coleman@bio.fsu.edu

4. All Non-Student Personnel funded by this:

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Eric P. Chassignet	Lead	PhD	See Chassignet report	no
Felicia Coleman	Lead	PhD	See Coleman report	no
Markus Huettel	Subproject PI	PhD	0	no
Joel Kostka	Subproject Co-PI	PhD	0	no
Cedric Magen	Post Doc	PhD	25%	no

*If yes, list NOAA lab

5. All Students funded by this project (including those listed above):

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Lindsay Chipman	MS	MS	25%	no
Chiu Cheng	BS	BS	25%	no
Andy Canion	MS	MS	20%	no
Will Overholt	undergrad	undergrad	20%	no

*If yes, list NOAA lab

6. Project Abstract:

This project addressed transport and biodegradation of Deepwater Horizon crude oil in Gulf beach sands with emphasis on the fate of oil deposited deep in Florida beaches and ensuing changes to the structure and function of indigenous microbial communities. Oil deposition into deeper, anoxic layers is expected to decrease oil degradation rates, thereby extending the period of toxin release to nearshore waters. Our research showed that oil was transported down to 73 cm into Florida sandy beach sediment, producing contamination ranging from layers with oil-coated sand grains to layers with massive concentrated oil deposits. All types of oil contamination altered sediment biogeochemical characteristics. Embedded oil layers changed the physical characteristics of the sediment by increasing the cohesiveness of the sand and reducing permeability. The potential oxygen consumption rate and inorganic carbon production rates in sand layers containing oil increased up to 5-fold and was on par with oxygen consumption of embedded algal layers. Beach oil deposition produced a gradient of potential oxygen consumption rates decreasing linearly with distance from the low water line reflecting the oil concentration gradient in the beach. The time series analysis showed that after more than six months after the accident and beach cleaning procedures oil remained in measurable amounts in the deep beach sediments. The microbial community analyses showed that the embedded petroleum hydrocarbons altered structure and function of the sand microbial communities. Twenty-four bacterial strains from 14 genera were isolated from oiled beach sands and confirmed as oil-degrading microorganisms by phenotypic characterization and phylogenetic analysis of 16S rRNA gene sequences. Isolated bacterial strains were primarily *Gammaproteobacteria*, including key genera of known oil-degraders (*Alcanivorax, Marinobacter, Pseudomonas, Acinetobacter*). SSU rRNA gene copy numbers of total bacteria were approximately 10 times higher in oiled vs. clean sand. An initial sharp increase of the abundance of *Alcanivorax* species was limited to the first 4 month of the investigation. However, the oil influenced a large number of microbial groups in the sediment and over all, a significant increase of the beach microbial population was observed in response to the oil, with the *Gammaproteobacteria* and *Alphaproteobacteria* as key players in the oil degradation. The project trained of three graduate students and one undergraduate students. Project results so far were published in national and international conference presentations, and were mentioned on numerous websites. The data collected in project will provide a data base for several follow-up proposals focusing on transport and degradation

of crude oil components in permeable shore sediments. Our goal is to generate quantitative data that permit forecasting of the oil degradation process and optimization of bioremediation procedures.

7. Key Scientific Questions/Technical Issues:

The scientific questions addressed the distribution of oil in Florida sandy beaches, the effect of the embedded oil on sediment physical and biogeochemical properties and the influence of the deposited oil on the beach sedimentary microbial community. Specifically the project addressed the following questions:

- How much and how deep was DWH oil deposited in sandy Florida beach sediment?
- How did the deposited oil change sediment cohesiveness and permeability?
- How did the deposited oil change potential oxygen consumption and dissolved inorganic carbon production rates?
- How did embedded oil change the structure and function of the sand microbial community
- Which factors determined regulation of oil degradation in marine sands

8. Collaborators/Partners:

a. Florida Department of Environmental Protection, Bureau of Laboratories

b. Coastal Research Program of the Geological Investigations Section/Florida Geological Survey/Florida Department of Environmental Protection

Date collaborating established
a. 9/8/2011
b. 9/14/2011

Does partner provide monetary support to project? Amount of support?
a. No
b. No
Does partner provide non-monetary (in-kind) support?
a. Yes
b. Yes

Short description of collaboration/partnership relationship.
a. FLDEP, Bureau of Laboratories, supported this project by student training on GC/MS and sharing information on protocols and procedures used for PAH analysis in oil-contaminated samples.
b. The Coastal Research Program of the Geological Investigations Section conducted surveys with a GPR (Ground Penetrating Radar) at our study site at Pensacola Beach in order to assess the use of this non-invasive instrument for the detection of embedded oil layers.

9. Project Duration:
Start: July 15, 2010 End: December 31, 2010

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

Contamination of sandy beach ecosystems by crude oil has severe environmental and economical consequences. Environmental effects include impairing and killing organisms that live in and on the beach (e.g. anaerobiosis and resulting shifts toward anaerobic microbial guilds; toxicity effects on macrofaunal invertebrates, meiofauna, and benthic microalgae; (Oh et al. 2003; Satoh et al. 1999) as well as impacts on predators of beach fauna (e.g. shore birds, fishes, mammals; (Barron and Ka'aihue 2001; Golet et al. 2002; Stagg and Mcintosh 1996). Toxins released by oil degradation in beach sands may also affect organisms in near shore waters and ground water (Eganhouse et al. 1993). Economical consequences include those caused by closing of fisheries (in Florida for fish, shrimp, clams and oysters) and negative impact on tourism. In the northern Gulf of Mexico, oyster and shrimp fisheries are important industries (Livingston et al. 2000), and tourism is one of Florida’s most important sources of revenue with an economic impact of $57 billion on Florida’s economy. Contamination of beaches by crude oil not only has dramatic immediate effects (e.g. oil contamination of shore birds, fish kills) but also involves processes (e.g. continuous release of toxins, establishment of a bad reputation) that cause long-lasting negative effects on the local economy through long term depression of revenues from fishing and tourism. An effective remediation of beach ecosystems requires a quantitative assessment of the processes that control uptake, degradation and release of crude oil components and this project collected these data. This project also contributed to the education and training of graduate and undergraduate students and published results at international conferences, in local outlets (newspaper, radio) and the internet. Specifically, this project addressed

NOAA Strategic Goal #1: Protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management

The project provides data on the oil deposition in Florida Beaches and the ecosystem response to the embedded oil. Our data on the oil deposition that were widely distributed over the internet were critical for the beach clean up process e.g. it provided key data for the deep cleaning procedures.

NGI Theme #4: Coastal hazards and resiliency

The time series results on the microbial community response is the first data set that shows how the microbial groups present in the beach responded to the oil, providing information on the species succession, abundance changes and spatial and temporal distributions.

Gulf of Mexico Alliance Priority: Ecosystem Integration and Assessment

Our oil and microbial community composition investigations address this GOMA priority by providing baseline and reference data for the temporal sequence of the degradation process in sandy beach sediment and the key microbial groups involved in this process.

Gulf of Mexico Research Initiative Themes: Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery

The results of this project clearly show the environmental effects of the oil that has been washed onto Florida sandy beaches. We report data on the depth of oil penetration, the quantity of the oil found and the immediate impact on the microbial community. Unique quantitative data on the species composition of the oil degrading community were generated via a substantial effort using state of the art pyrosequencing and qPCR techniques.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

This project provided the first quantitative data on the depth of oil penetration in Gulf beaches and the most detailed data on the microbial community associated with the oiled sediments and its change over time.

Contributions to BP_GRI goals:

- Spread of the oil and other contaminants and the fate of these components.
- Environmental effects of the oil spill on Gulf of Mexico ecosystems, and ecosystem recovery.
- Technology that could help detect and clean up offshore oil spills, and reduce their impact.
- Potential impact of the oil spill and response on human health

Our project contributed information and data to all of these four BP GRI goals (listed above). We showed the transport into the beach sediment and the fate of the deposited oil. We show how specific microbial groups contribute to the degradation of the embedded oil and how these communities develop over time. The microbial community analysis also provided information on species that could be used as indicators for oil contamination and species list that could indicate at which state in the temporal sequence the degradation process arrived. The analyses of the sampled oil revealed data on concentrations of polyaromatic hydrocarbons and volatile components that can have an effect on human health.

11. Milestones accomplished during entire project period:

Sandy beaches profiled at monthly intervals since June 2010

- Sediment cores for oil analysis retrieved on monthly base
- Sediment sampled for analysis of physical and biogeochemical characteristics
- Sediment profiled of microbial community structure and DNA extaction
- Measurements of potential oxygen consumption and dissolved inorganic carbon production completed on all sampled cores
- Oil analysis in sampled cores started and ongoing. This is a very labor intensive process and we have a very large number of samples to process.

- Microbial community analysis completed for all samples retrieved, multiple pyrosequencing and qPCR analyses completed, laboratory culture work completed, further cultures ongoing.
- Microbial community analysis processed and statistically analyzed

12. Describe all significant research results, protocols developed, and research transitions:

Our beach profiling showed that at in the sandy beach at Pensacola Beach, our primary study site, the concentrated oil layers occur at 10 to 72 cm sediment depth. In many locations multiple layers were found that differed in oil concentration and the fine-scale distribution of the oil. Concentrated layers were up to 3 cm thick and of soft consistency indicating that they still contained a large fraction of the lighter crude oil components, including volatiles and low molecular weight PAHs. Homogeneously stained thick sand layers above the concentrated oil layers showed relatively rapid degradation and lost most of their color and fluorescence by end of 2010, and in many locations are not detectable any more. Ongoing analyses will show to what extend oil has been degraded in this layer. Our results also show that the white layer below the dark concentrated oil layer contained oil components. The nature of these components is presently analyzed. Over the study period, the appearance of the concentrated embedded concentrated oil layers did not change visibly, however, analyses showed that the volatile and semi-volatile components decreased and that the hydrocarbon compounds that remained are aliphatic (>C16) and aromatic (>C35) fractions in the higher molecular weight ranges. The deep cleaning procedures removed most of the concentrated oil layers, the remaining oil is dispersed as fine particles in the beach or may be found in small patches that were overlooked by the cleaning process. We are in the process of analyzing sand samples that were and are still collected at monthly intervals.

In the sediment layers homogenously stained by oil and the concentrated oil layers, physical sediment characteristics were changed by the oil. The cohesiveness of the sand increased from non-cohesive in the clean, dry sand to sticky in the lightly stained sand to solid in the layers with concentrated tar. Likewise, hydraulic conductivity decreased with increasing oil content reaching zero permeability in the sediment cores with embedded concentrated oil layers.

Measurements of potential oxygen consumption rate, i.e. oxygen consumption under wetted conditions, show that the layers containing concentrated oil consume oxygen at relatively high rate (0.3 to 0.8 µmol cm^{-3} d^{-1}) indicating high aerobic microbial degradation activity (Fig. 1). Production rates of dissolved inorganic carbon (DIC) mirror the oxygen profiles and support the conclusion that microbial oil degradation is responsible for the enhanced activity in the oil contaminated sediment layers. The relatively high microbial activity around the oil layers is emphasized by the observation that the oil layer consumed a similar amount of oxygen than a relatively fresh (green) layer of deposited algae that are considered highly degradable organic matter.

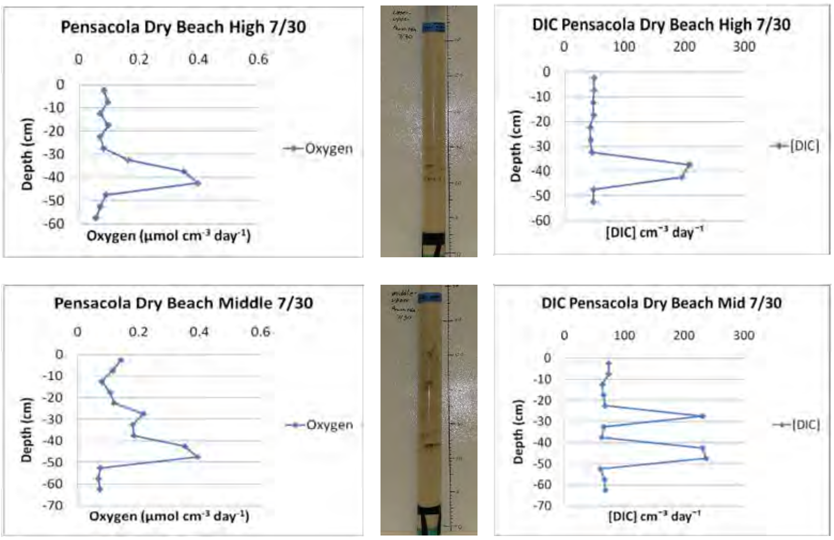


Fig. 1. Potential oxygen consumption (left panes) and DIC production rate profiles (right panes) in Pensacola Beach sediment with an oil layer embedded at 35-40 cm depth (upper panes) and in sediment from the same site with an oil layer embedded at 30 cm and a second layer at 40-50 cm depth (lower pane). The layers with increased oxygen consumption also had higher DIC production rates. Pictures depict the sediment cores that were analyzed.

Twenty-four bacterial strains from 14 genera were isolated from oiled beach sands and confirmed as oil-degrading microorganisms by phenotypic characterization and phylogenetic analysis of 16S rRNA gene sequences. Isolated bacterial strains were primarily *Gammaproteobacteria*, including key genera of known oil-degraders (*Alcanivorax, Marinobacter, Pseudomonas, Acinetobacter*). SSU rRNA sequences from oiled sands revealed phylotypes that showed high sequence identity to sequences from the oil-degrading bacterial isolates. In oiled sands that were analyzed for hydrocarbon content, SSU rRNA gene copy numbers of total bacteria were approximately 10 times higher in oiled vs. clean sand. Community analysis indicated a strong response to oil contamination, especially in the genus *Alcanivorax*. Based on a combination of culture-based and cultivation-independent molecular approaches, we could show that oil contamination from the DH spill has a profound impact on the abundance and community composition of indigenous bacteria in Gulf beach sands, and our evidence points to members of the *Gammaproteobacteria* and *Alphaproteobacteria* as key players in oil degradation.

The analysis of the microbial community associated with the oil contaminated layers using pyrosequencing identified a broad spectrum of aerobic but also anaerobic oil degrading bacteria, with well known oil-degrading strains like *Alkanivorax* but also a variety of bacteria with unknown gene sequences. All isolated bacteria that could be cultivated in the lab with oil as the sole carbon source (Fig. 2) belong to the Gammaproteobacteria. Comparisons of the microbial community structure associated with un-contaminated and contaminated beach sand showed that the oil deposition leads to a change in the community with oil-degrading bacteria becoming the dominant groups.

Isolate	% Similarity	Site of isolation	Method of isolation	Electron donor	Electron Acceptor
EN1	100% *Pseudomonas pachastrellae*	Louisiana beach	Anoxic Enrichment	Crude oil	NO_3
EN2	99.9% *Pseudidiomarina maritima*	Louisiana beach	Anoxic Enrichment	Crude oil	NO_3
EN3	99.5% *Marinobacter hydrocarbonoclasticus*	Louisiana beach	Anoxic Enrichment	Crude oil	NO_3
EN4	99.1% *Shewanella algae*	Louisiana beach	Anoxic Enrichment	Crude oil	NO_3
PN-1	97.7% *Vibrio sp. SL-23*	Pensacola beach	Anoxic Enrichment	Crude oil	NO_3
PN-2	99.7% *Pseudomonas stutzeri*	Pensacola beach	Anoxic Enrichment	Crude oil	NO_3
PN-3	100% *Alcanivorax dieselolei*	Pensacola beach	Anoxic Enrichment	Crude oil	NO_3
PN-4	99% *Vibrio hepatarius*	Pensacola beach	Anoxic Enrichment	Crude oil	NO_3
ES-1	99.2% *Marinobacter vinifirmus*	Louisiana beach	Anoxic Enrichment	Crude oil	NO_3
ES-2	99.1% *Marinobacter vinifirmus*	Louisiana beach	Anoxic Enrichment	Crude oil	NO_3
Cos-1	99% *Vibrio sp.*	Louisiana beach	Oxic-Enrichment	Crude oil	O_2
COS-2	100% *Acinetobacter sp.*	Louisiana beach	Oxic-Enrichment	Crude oil	O_2
COS-3	99% *Pseudoalteromonas sp.*	Louisiana beach	Oxic-Enrichment	Crude oil	O_2
COS-4	99% *Acinetobacter sp.*	Louisiana beach	Oxic-Enrichment	Crude oil	O_2

Fig. 2 Bacteria isolated from oiled sediments that could be cultivated in the lab with oil as the sole carbon source

13. Outreach activities

None

14. Peer Reviewed Articles: List peer reviewed articles about this project published during this period of reporting. If this is the final report for the project, list all peer reviewed articles published about this project's work. Do not include any publications before the start date of this project.

Not available yet.

15. Non-refereed articles and reports for this project:

Microbes & Oil Spills, A Report from the American Academy of Microbiology (2011). Co-authored by J.Kostka

16. List conference presentations and poster presentations for this project

Huettel, M., Kostka, J.E., Green, S., Prakash, O., Kaba, J., Canion, A. (2010). Rates and mechanisms controlling the microbial degradation of crude oil from the MC252 spill in Gulf of Mexico beach sands. Deepwater Horizon Oil Spill Conference, St. Petersburg, FL, October 5-6, 2010

Kostka, J.E. (2010). Ecosystem functional genomics: inferring environmental forcing of community structure and function, Institute for Computing in Science Workshop: Computational Methods and Terabase Genomics, Sponsored by Argonne National Lab and U.S. DOE, July, 2010.

Kostka J.E. and M. Huettel (2010). The Ecology of Hydrocarbon Degradation in Gulf Beach Sands. International Society for Microbial Ecology Symposium. Seattle, WA, August.

Ruddy, B.M., McKenna, A. M., Podgorski, D.C., Rodgers, R.P., Huettel, M., Marshall, A. G. (2011). Compositional Analysis of BP Deepwater Horizon Oil Contaminated Pensacola Beach Sand by Ultrahigh-Resolution FT-ICR-MS., 59^{th} ASMS Conference on Mass Spectrometry and Allied Topics, Denver, Colorado, June 5 - 9, 2011

Outreach activities included presentations at conferences, seminars and presentations to the general public and reports in public newspapers, radio, TV and on the internet.

Invited presentations:

Huettel, M. (2010). A heritage of muds and sands, so what? Alfred Wegener Institute for Polar and Marine Research, 5 May 2010, Sylt, Germany.

Huettel, M. (2010). Ecological functions of sandy shelf environments. Leibnitz Institute for Marine Research, Kiel, Germany, 12 May 2010.

Huettel, M., Kostka, J.E., Green, S., Prakash, O., Kaba, J., Canion, A. (2010). Deepwater Horizon Oil in Gulf Beach Sands, " Long-term monitoring of Coastal Ecosystem Responses to the Deepwater Horizon Oil Spill" -- September 10-12 2010, Turnbull Conference Center, Florida State University

Public lectures and seminars:

Huettel, M., Kostka, J.E., Green, S., Prakash, O., Kaba, J., Canion, A. (2010). The Deepwater Horizon Oil in Gulf Beach Sands. Florida State University, Public Lecture, 25 July 2010.

Huettel, M., Kostka, (2011). Crude oil in the Gulf of Mexico, oil spills, and the fate of the oil in the beach environment. Florida A&M University, March 4, 2011

Public newspaper article

FSU team studies oil in beach sand. Tallahassee Democrat 07/10/2010 front page article

Our oil research cited on websites:

http://nba.msg.com/article/04qRaRZ5QveSx?q=Tallahassee
http://pubs.acs.org/cen/news/88/i31/8831news1.html?utm_source=feedburner&utm_medium=feed&utm_campaign=Feed%3A+EnvironmentalScienceTechnologyOnlineNews+%28ES%26T+Online+News%29
http://www.innovations-report.com/html/reports/environment_sciences/fast_microbes_break_oil_washed_gulf_beaches_157441.html
http://www.upi.com/Science_News/2010/07/02/Scientists-studying-oil-eating-microbes/UPI-29741278101672/
http://www.firstscience.com/home/news/atmospheric-science/how-fast-can-microbes-break-down-oil-washed-onto-gulf-beaches-page-4-1_87458.html
http://www.microbiologynow.com/research/How_fast_can_microbes_break_down_oil_washed_onto_Gulf_beaches.asp
http://www.istockanalyst.com/article/viewiStockNews/articleid/4275244
http://www.globe-democrat.com/news/2010/jul/02/scientists-studying-oil-eating-microbes/
http://www.themoneytimes.com/20100702/scientists-studying-039oileating039-microbes-id-10119257.html
http://www.ecoworld.com/other/scientists-studying-oil-eating-microbes.html
http://greenanswers.com/news/174068/scientists-studying-%E2%80%98oil-eating%E2%80%99-microbes
http://envirolib.org/press-releases/scientists-studying-%E2%80%98oil-eating%E2%80%99-microbes/
http://news.tradingcharts.com/futures/6/5/141937156.html
http://www.fsu.com/Blogs/Gulf-Oil-Crisis-FSU-Takes-Action
http://www.physorg.com/news197219866.html
http://www.oilandgasonline.com/article.mvc/Florida-State-Investigates-How-Fast-Microbes-0001?atc~c=771+s=773+r=001+l=a&VNETCOOKIE=NO
http://www.rdmag.com/News/Feeds/2010/07/policy-how-fast-can-microbes-break-down-oil-washed-onto-g/
http://www.govtech.com/dc/articles/765876?id=765876&full=1&story_pg=2
http://www.pollutiononline.com/article.mvc/Florida-State-Investigates-How-Fast-Microbes-0001?atc~c=771+s=773+r=001+l=a&VNETCOOKIE=NO
http://wildshores.blogspot.com/2010/07/crude-oil-in-sand-how-fast-does-it.html
http://www.oceanleadership.org/2010/how-fast-can-microbes-break-down-oil-washed-onto-gulf-beaches/
http://beforeitsnews.com/story/95/078/Florida_State_Investigates_How_Fast_Microbes_Can_Break_Down_Oil_In_Gulf_Beach_Sands_and_Effect_of_Corexit_on_Microbes.html
http://coastalcare.org/2010/07/can-microbes-break-down-oil-washed-onto-beaches/
http://deepwaterhorizon.fsu.edu/ecology/huettelkostkabiodegradation.php
http://fsunews.com/apps/pbcs.dll/article?AID=/20100710/NEWS01/7100331
http://greenopolis.com/goblog/litegreen/natural-oil-eaters-helping-or-hurting-gulf-cleanup-efforts
http://news.discovery.com/earth/oil-sand-gulf-microbes.html
http://news.surfwax.com/biology/files/Oceanography.html
http://pbrla.blogspot.com/2010/07/test-delay-wednesday-july-14-bp-oil.html
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http://www.innovations-report.com/html/reports/environment_sciences/fast_microbes_break_oil_washed_gulf_beaches_157441.html

17. Has anyone from this project been hired by NOAA during this reporting period?

N/A

10-BP_GRI-FSU-01 (Task 2b): Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge - Subproject: Direct and indirect effects of oil on coastal dune vegetation and microbial communities

1. NGI Project File Number: 10-BP_GRI-FSU-01 (Task 2b)

2. Project title:

Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge - Subtask: Direct and indirect effects of oil on coastal dune vegetation and microbial communities

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI?	Affiliation	Email
Thomas E. Miller	co-PI	Florida State Univ.	miller@bio.fsu.edu

4. All Non-Student Personnel funded by this project:

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
none				

*If yes, list NOAA lab

5. All Students funded by this project:

Name	Category (i.e., highest degree already obtained:	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Elise Gornish	MS		50%	no
John Mola	undergraduate		10%	no
John Owenby	undergraduate		10%	no
Loury Migliorelli	undergraduate		2%	no
Jackie Monge	undergraduate		2%	no

*If yes, list NOAA lab

6. Project Abstract:

Coastal dunes create the prevalent habitats on the barrier islands that occur along most of the shoreline along the northern Gulf of Mexico. We extended a 12-year survey of coastal dune vegetation on St. George Island to other sites in order to quantify both the short- and long- term effects of oil across the northeast Gulf of Mexico. We expected that initial effects of oil on these terrestrial habitats would be minimal and that the primary value of this study would be to follow contaminate levels and vegetation over the next 10 years. The original work on St. George Island

quantified vegetation annually on ~350 permanent plots, spread across fore-, inter-, and backdune habitats. This work also provided methods and knowledge that were now applied to the effects of the Deepwater Horizon spill on coastal dune vegetation around the Gulf of Mexico. We have expanded this sampling to 6 sites, including Horn Island (Gulf Islands National Seashore, MS), Santa Rosa Island (Gulf Islands National Seashore, Ft. Pickens, FL), Crooked Island (Eglin Air Force Base, FL), St. George Island (the original site at St. George State Park), Anclote Key (Anclote Key Preserve State Park, FL), and Cayo Costa Island (Cayo Costa State Park, FL).

Similar types of vegetation were found across all six sites. Foredunes were dominated by species that can survive disturbance and burial, such as sea oats (*Uniola paniculata*) and dune elder (*Iva imbricata*). Other species were more common in the wetter interdune areas, including cordgrass (*Spartina patens*) and fog-fruit (*Phyla nodiflora*). The relatively protected backdune areas have more species and varied more among sites, but often included camphorweed (*Heterotheca subaxillaris*) or other Asteracea and gulf bluestem (*Shizachyrium maritumum*). Some of our soil and plant samples have yet to be processed. However, the preliminary results support previous work: foredunes were very dry and nutrient poor and relatively high in elevation, the relatively low interdunes had higher soil moisture, % organic material, and nutrients, while backdunes were more heterogenous and intermediate in soil moisture and nutrients.

Oil residue in the form of numerous tarballs was evident at Horn and Santa Rosa Islands, presumably from the Deepwater Horizon oil spill (BP crews were working at both sites) It is unclear if significant amounts of oil had moved interior from the foredunes since the spill. The managers at Crooked Island reported that significant oil had appeared on their beaches during the active spill twice, but we found no evidence of tarballs or other residues when we sampled in October 2010. The other three sites (St. George, Anclote Key, and Cayo Costa) had no reported oil. We tested soil samples from fore-, inter-, and backdune habitats at each site for Total Recoverable Petroleum Hydrocarbons (TRPH). While levels were found to be relatively low at all sites, they were highest at Horn and Santa Rosa Islands. Interestingly, they were also higher in inter- and backdune areas, relative to foredunes. At this time, we cannot say if these residues come from the Deepwater Horizon oil spill or from other anthropogenic sources.

7. Key Scientific Questions/Technical Issues:

a. Determine the vegetation in coastal dune habitats from six sites distributed around the northern Gulf of Mexico, based on methods from a long-term site on St. George Island, FL.

b. Establish permanent locations at these sites to allow long-term monitoring of vegetation for the next 10 years.

c. Quantify important edaphic factors at these sites, including elevations, soil moisture, soil nutrient levels, and % organic matter.

d. Quantify current levels of oil residues across these sites, measured as Total Recoverable Petroleum Hydrocarbons.

8. Collaborators/Partners:
N/A

9. Project Duration:

September 1, 2010 to March 31, 2011.

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives: Presumably, NOAA is concerned with effects of the Deepwater Horizon on habitats around the Gulf of Mexico. Coastal sandy habitats are the most common terrestrial habitat across this range, and so information about their general ecology, as well as potential effects the recent oil spill, is a NOAA goal.

Contributions to regional problems and priorities: Barrier islands serve to protect ecologically sensitive environments, as well as human habitats, from severe storms and ultimately may play an important role with climate change (e.g., ocean level rise). However, this narrow project does not have direct stakeholders.

Gaps: This is the only long-term study of coastal dune vegetation in the Gulf of Mexico; little is known about these plants and their interactions with geomorphology (e.g., through dune building). Since this habitat makes up >50% of the coastline from Louisiana to the Florida Keys, this study fills a significant gap in regional knowledge about vegetation .

Contributions to BP_GRI goals: The primary goal of the BP_GRI initiative was to study the impact of the Deepwater Horizon incident. This study contributes directly to those goals by studying the short effects of the oil spill, while initiating a long-term study to quantify any chronic effects that may or may not occur.

11. Milestones accomplished during entire project period.

a. The long-term data from the St. George Island site allowed us to clearly identify effects of oil at this one site (no such effects are apparent, as ultimately, oil did not reach this site). The long-term data are available at http://www.bio.fsu.edu/~miller/ HOMEPAGE/research.html.

b. Data are now collected from 5 additional sites around the Gulf, from Mississippi to south Florida. The vegetation patterns at these other locations will be calibrated using the St. George analyses and local climate data to account for recent storm effects. These sites can then be used to demonstrate the larger scale effects of oil over a gradient of exposure from relatively high (Horn Island) to low (Anclote Key and Costa Cayo Island).

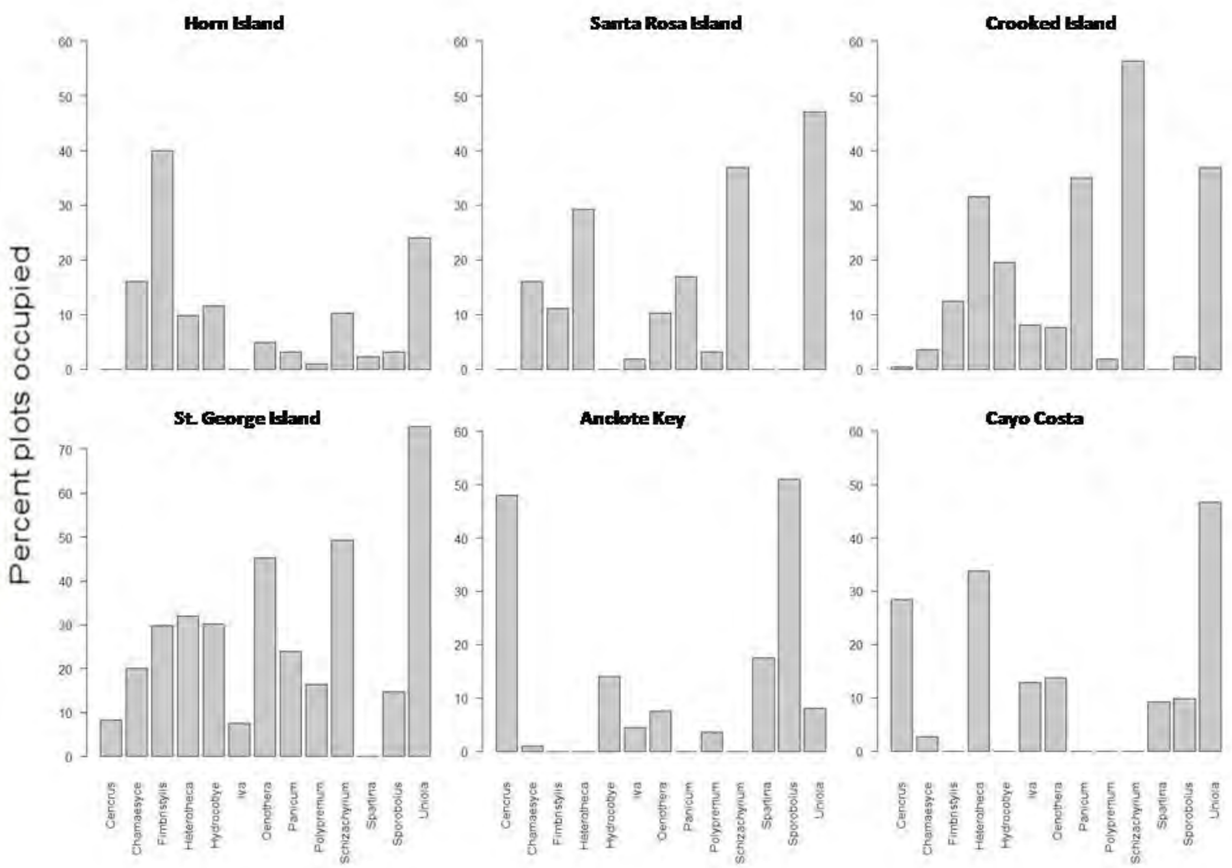
c. The oil and soil analyses to date suggest that levels of petroleum hydrocarbon residues are higher on Horn and Crooked Islands, especially in the inter- and backdunes.

12. Describe all significant research results, protocols developed, and research transitions.

We censused Santa Rosa Island in Sept, 2010, Horn and Crooked Islands in October, St. George in early November, Anclote Key in January 2011, and Cayo Costa in early March. Ideally, in the future, all of these sites would be censused in the fall, when vegetation is near peak biomass and most species have just flowered or are flowering. As noted above, Santa Rosa and Horn Islands had active BP crews extensively cleaning the beaches, while BP personnel also occasionally checked Crooked and St. George Islands.

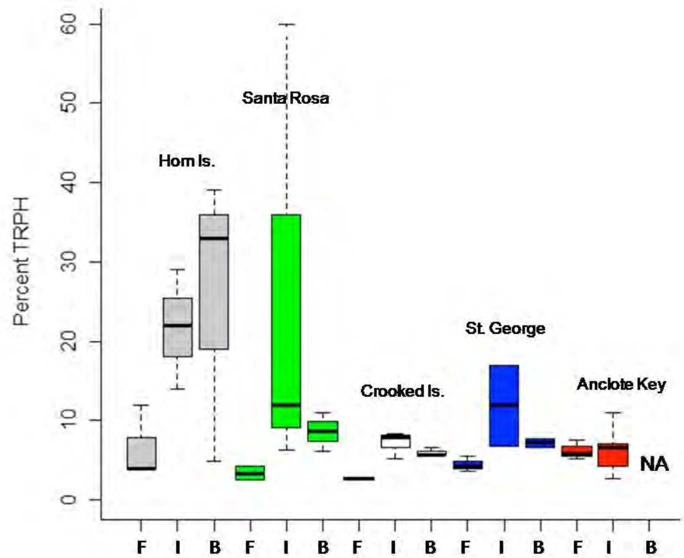
The four most northern sites shared a very similar topography, with relatively high foredunes, a low and clearly frequently flooded interdune, and a much more stable set of dunes and troughs in the backdune. Plant species diversity was always highest on the backdunes and around 50% lower in foredunes. Anclote essentially had no backdune -- what might typically have been called backdune was undergoing restoration from invasive Australian Pines and contained very little vegetation. Cayo Costa had a low foredune that was not well differentiated from the only slightly lower interdune, and a backdune that was starting to be dominated by palms and woody shrubs.

At each site, three 5 x 5 grids were set up in each of the three habitats (fore-, inter-, and backdune). At each point in the grid, vegetation was censused in a 1 m^2 plot, using both % cover of each species, as well as species specific measures of abundance (e.g., #leaves for plants with runners, # culms for grasses). The summarized abundances of dominant species in the figure below illustrated the site-to-site variation in abundance. All sites contain certain key dune species, especially important dune-building grasses such as *Uniola paniculata* but also including smaller important forbs such as *Chamaesyce* spp. and *Oenothera humifusa*. Other species varied a great deal form site to site, notably *Schizachyrium maritumum*, which was more abundant in western sites, and *Cenchrus incertus*, which was more common in the Florida peninsula. These species patterns will be further investigated by habitat using ordination approaches. Ultimately, we can use this data collected through time to determine if chronic effects of the Deepwater Horizon are affecting coastal dune vegetation.



Environmental data are still being processed and are not yet available for all sites. However, soil moisture, elevation, and % organic material data so far support patterns previously documented on St. George Island. Foredunes are generally quite dry and nutrient poor and support fewer species. Interdunes have the highest average soil moisture, are relatively nutrient rich, and can be dominated by grasses often associated with wetlands. Backdunes are stable, much more heterogeneous in moisture and nutrients, and contain the highest diversity of plants.

A primary goal of this study was to determine the levels of petroleum in dune soils; samples are not yet available from all sites. We sampled soil at each replicate plot at each site,



then quantified Total Recoverable Petroleum Hydrocarbons (TRPH) using standard methods. Because this research was, of course, initiated after the Deepwater Horizon spill, we cannot ascertain if any patterns we observed were due to this recent spill or to other past events. It is possible that oil fingerprinting methods could be later used to help determine the possible source of the observed oil in the soils. However, there were three clear patterns in the data shown in the figure below. First, almost all the samples had relatively low levels of TRPHs; our understanding is that levels of concern would be >100 mg/kg. Second, the two westernmost sites (Horn and Santa Rosa Islands) had higher levels of TRPHs. This could indicate some effects of the Deepwater Horizon incident, but could also be explained by higher levels of commercial and recreational boats in these areas over the last 20-30 years. Third, the levels of TRPH were generally higher in interdune and backdune areas than in foredunes. This is a quite interesting and could be associated with oil residues being broken down more rapidly in foredunes or to the action of waves and storms. We will be consulting with other experts about these results before attempting any broad interpretation.

13. Outreach activities:

General Description: Worked with Florida Native Plant Society to identify plants

For each of our Florida locations, we contacted the local chapter of the Florida Native Plant Society. We asked the society if 1-2 members would like to go out with us and could help identify unique local species. We had no response from one chapter, but did work with local chapters in Pensacola, Tallahassee, and Tarpon Springs. We intend to pursue these contacts to help create local plant guides.

14. Peer Reviewed Articles: List peer reviewed articles about this project published during this period of reporting. If this is the final report for the project, list all peer reviewed articles published about this project's work. Do not include any publications before the start date of this project.

Two papers were published during this period that deal with the long-term dataset. Neither directly used funds from this project.

Gornish, E. and T. E. Miller. 2010. Effects of storm frequency on dune vegetation. Global Change Biology 16:2668-2675.

Gornish, E. and T. E. Miller. 2011. Using long-term census data to inform restoration methods for coastal dune vegetation. Tentative accepted in the Journal of Applied Ecology, March 2011.

15. Non-refereed articles and reports for this project:

N/A

16. List conference presentations and poster presentations for this project.

N / A

17. Has anyone from this project been hired by NOAA during this reporting period?

N / A

10-BP_GRI-FSU-01 (Task 2c): Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge - Subproject: Effects of species diversity, consumer pressure, and bioremediation on salt marsh recovery from oil

1. **NGI Project File Number:** 10-BP_GRI-FSU-01 (Task 2c)

2. **Project title:** Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge - Subproject: Effects of species diversity, consumer pressure, and bioremediation on salt marsh recovery from oil

3. **Project Lead (PIs and Co-PIs):**

Name	Project Lead or Co-PI?	Affiliation	Email
Randall Hughes	Co-PI	FSU Coastal and Marine Lab	rhughes@bio.fsu.edu
David Kimbro	Co-PI	FSU Coastal and Marine Lab	dkimbro@bio.fsu.edu

4. **All Non-Student Personnel funded by this project:**

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Randall Hughes	Co-PI	PhD	5%	No
Hanna Garland	Research Technician	BS	24%	No
Robyn Zerebecki	Research Technician	MS	18%	No

*If yes, list NOAA lab

5. **All Students funded by this project:**

NA

6. **Project Abstract**:

Anticipating oil exposure along the northeastern Gulf coast from the DwH oil spill, we conducted large-scale surveys in natural marshes along with field and mesocosm experiments to enhance our understanding of potential impacts of this or any future oil spill and the factors contributing to marsh recovery. Despite an absence of visible oil at our study sites, sediment carbon stable isotopes indicate

likely oil exposure in July and September 2010 in the three western-most regions: Fort Walton Bay, St. Andrews Bay, and St. Joseph Bay. This oil signature was not detectable in St. Joseph Bay in May 2010, immediately after the DwH spill began. We also found significant spatial and temporal variation across the 6 regions studied (Fort Walton Bay, St. Andrews Bay, St. Joseph Bay, FSU Coastal and Marine Lab, Spring Creek, and Yates Creek) in salt marsh environmental, plant, and community measures. However, there were no clear correlations between oil contamination and marsh population or community structure in our survey data. Mesocosm experiments suggest that using nutrient additions as a bioremediation tool may not exacerbate snail grazing on the dominant marsh grass, *Spartina alterniflora*, yet additional manipulations in the field are needed to reconcile discrepancies between this finding and previous studies of snail foraging.

7. Key Scientific Questions/Technical Issues:

Salt marshes provide critical ecosystem services (e.g., primary productivity, nursery habitat, buffering against erosion), yet they are among the most vulnerable systems to the Deepwater Horizon (DwH) oil spill because of the difficulty of "cleaning" these sensitive habitats. In addition, marshes will naturally vary in their recovery time due to a range of environmental and biological factors (Pezeshki et al. 2000) as well as the severity of oil exposure. It is critical that we understand natural variation in plant communities and the animal consumers that depend upon them as well as their relationships to environmental variation in the Northern Gulf, in order to detect and quantify impacts from the spill. Anticipating oil exposure along the northeastern Gulf coast from the DwH oil spill, we conducted large-scale surveys in natural marshes along with field and mesocosm experiments to enhance our understanding of potential impacts of this or any future oil spill and the factors contributing to marsh recovery. Specifically, we: (1) quantified relationships between oil exposure (as indicated by carbon and nitrogen stable isotopes), plant species diversity, environmental variables, plant performance, and community structure in 12 natural salt marshes between Okaloosa and Taylor counties in NW Florida (~ 400 km); (2) experimentally tested the effects of marsh plant species diversity on community structure and response to oil exposure; and (3) experimentally tested the effects of nutrient additions (originally designed to bio-remediate oil effects) and plant height on consumer pressure on *Spartina alterniflora*.

8. Collaborators/Partners:

NA

9. Project Duration:
7/15/10 to 3/31/11

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

This project contributes to the following NOAA Objectives: Climate Adaptation and Mitigation and Healthy Oceans. The project generated valuable data regarding current abiotic conditions and plant and animal community structure in salt marsh communities of the northern Gulf. These data will serve as a baseline for future studies of the Deepwater Horizon oil spill and global change in general.

Contributions to regional problems and priorities: **(a)** The Environmental Protection Agency recognized the growing natural resource problems in the Gulf region in 1988 and established the Gulf of Mexico Program, which consists of a policy review board that is advised by numerous local stakeholders throughout the Gulf states including those from agricultural, tourism, environmental, fisheries, and business interests. As scientists funded by NGI, we produced research that can be used to help inform this policy review board with regards to environmental conditions along an understudied region of the northern Gulf. The Gulf of Mexico Program has six priority areas that align with those of the Gulf of Mexico Alliance priorities, and our study directly addressed two of these priority areas (i,iv) by: observationally and experimentally testing how conservation and restoration of marshes should be implemented and identifying which marshes may need these measures; and by quantifying spatial variation of nutrient loading into marshes and how this affects marsh food webs. In addition, we have promoted environmental education by collaborating with a local public broadcasting station (WFSU) to design and implement a web-video blog that conveys our research (NGI-sponsored and otherwise) to the public in an accessible and interesting way. **(b)** We also coordinated our research with the Florida Department of Environmental Protection to conduct our research in areas that would fill in knowledge gaps of the St. Joseph Bay Aquatic Preserve (Kim Wren, manager) and the Big Bend Seagrass Aquatic Preserve (Melissa Charbonneau, manager). **(c)** Similarly, we also coordinated this research with Eglin Airforce Base (Bob Miller, Endangered Species Biologist) and Tyndall Air Force Base (Gwendolyn Jones, Natural Resource Biologist) to provide information helping them assess their environmental impacts and any impacts of the DwH oil spill.

Gaps: Despite the documented ecological and economic importance of salt marshes (Pennings and Bertness 2001), there have been surprisingly few regional assessments of marsh population and community structure in the northern Gulf of Mexico. The limited evidence to date (USGS 1984, http://www.nwrc.usgs.gov/techrpt/85-7-1.pdf) suggests that results from studies in the southeast Atlantic may not be directly applicable due to variation in plant and consumer assemblages and environmental conditions. Our project provides detailed data regarding environmental conditions (salinity, oxygen availability), marsh plant assemblages (*Spartina alterniflora* abundance and tissue nutrient availability, overall plant species diversity and occupancy of space), and the effects of a key gastropod consumer (*Littoraria irrorata* density, scarring intensity) across the Panhandle and Big Bend of Florida. In addition, we show that previous documented relationships between consumer pressure and plant nutrient availability may not hold in this region and this has important implications for using nutrient addition as a bio-remediation tool to future oil spills in marshes.

Contributions to BP_GRI goals: One goal of the BP-GRI was to assess the effects of oil / dispersant on coastal waters and shallow water habitats. Our research has provided critical baseline data towards meeting this goal. Additional specifics of our research are given below.

11. Milestones accomplished during entire project period:

a. Established 12 survey sites in natural marshes in six counties and over 400 km of Florida coastline of the northern Gulf of Mexico (Okaloosa to Taylor county) (July 2010).

b. Completed first survey of marsh sites, including collection of samples for sediment and water hydrocarbon analysis (July 2010).

c. Established field experiment of marsh plant species diversity to examine resistance and resiliency of different marsh types to anticipated oil exposure from DwH (July 2010).

d. Repeated survey of marsh sites and collection of water as well as sediment samples for hydrocarbon analysis (September / October 2010).

e. Conducted mesocosm experiments at FSUCML to examine effects of fertilization (potential bio-remediation tool for oil exposure) on consumer effects on *Spartina alterniflora* (November 2010).

f. Transferred water and sediment samples to the University of Georgia for processing (November 2010).

g. Completed final survey of marsh sites (March 2010).

12. Describe all significant research results, protocols developed, and research transitions:

a. Field survey of marsh plant species diversity and community structure across the Northern Gulf of Mexico. We surveyed 12 sites along a tidal inundation gradient in the NE Gulf of Mexico for oil exposure, environmental conditions, and marsh community structure (Fig. 1). Two replicate sampling sites were nested within six overall regions that, from west to east, were: Fort Walton Beach (FWB, Diurnal 1); St. Andrews Bay (SAB, Diurnal 2); St. Joseph Bay (SJB, Diurnal 3); FSU Coastal and Marine Lab (CML, Mixed 1); Spring Creek (SC, Mixed 2); and Yates Creek (YC, Mixed 3). At each site, data collection focused on variables that could both directly cause spatial variation in *Spartina* condition (e.g., abiotic stressors of marsh including oil exposure) and indirectly cause this variation by facilitating or inhibiting grazing on *Spartina* (e.g., predator identity, *Littoraria irrorata* density, plant tissue carbon:nitrogen ratio). Of the 6 overall regions, three experience diurnal tides, and three experience mixed semi-diurnal tides. Within each region (July 2010), we established two 50 x 20 m nested sites (long edge parallel to shoreline) that were separated by at least 100 m ($n = 10$). These nested sites differed in the number of plant species, from dominated by *Spartina* to a more diverse and mixed assemblage of marsh plants (site*diversity $F = 31.06$, $P < 0.001$; Fig. 2). These sites were sampled 3 times - July 2010, September/October 2010, and March 2011.

In each site, we collected data on marsh plant and animal community structure and environmental variables (redox potential; temperature; porewater salinity concentrations; sediment organic content) within twenty 0.5 x 0.5m quadrats (40 quadrats/overall site). In the October and March sampling dates, the environmental measurements were collected from only 10 of the quadrats within each block because of time constraints. We also collected sediment cores and water samples for stable isotope analysis of carbon and nitrogen from each site in July and September/October 2010.

Within each quadrat, we quantified plant percent cover by species and also measured the maximum height of 6 haphazardly selected *Spartina* stems. Using a length:biomass index ($y = 0.018x + 0.08$, $R^2 = 0.81$), we then averaged these lengths and converted their average into an estimate of *Spartina* biomass. In order for the biomass estimate to reflect better that of the larger quadrat, we multiplied it by the percent cover of cordgrass. These six plants were tagged to prevent their re-measurement during subsequent sampling and were also measured for total length of scars by the primary consumer, the marsh snail *Littoraria irrorata*. To standardize scar length data in each quadrat, we divided the total scar lengths by the average height of the six plants. We also counted the number of live *Spartina* stems and snails within a smaller quadrat (0.25 x 0.25 m) centered within the larger quadrat.

To quantify environmental conditions, we used a probe to measure REDOX potential. We also measured porewater salinity in each quadrat by inserting a PVC pipe (capped at end with four small holes above the cap) 5 cm into the sediment, allowing the pipe to fill with porewater, and suctioning out a porewater sample. These data were collected because high porewater salinity has been shown to exacerbate the effects of snail grazing on *Spartina* (Silliman et al. 2005) and low REDOX potential is associated with high concentrations of hydrogen sulfide (Devai and DeLaune 1995), which is suboptimal for *Spartina*.

In October 2010 and March 2011, we found clear variation among regions across the Florida Panhandle in environmental conditions (Fig. 3), though none of these abiotic variables were significant predictors of marsh community structure. Salinity was lower on average in March compared to October (Fig. 3). Because our instrumentation was not in hand by July 2010, we cannot assess how physical conditions at these sites changed between July and October 2010.

Total plant percent cover was uniformly high at all regions except for FWB across both survey dates (Fig. 4). There was no clear signal for more diverse marshes to have higher percent cover, though this was the case at FWB at all sampling dates, and at YC in March 2011 (Fig. 4). *Spartina* height, a key metric for plant biomass, tended to be higher in the *Spartina*-dominated marshes, but this pattern was not consistent across all regions in July 2010 (Fig. 5a; region*diversity $F = 4.26$, $P = 0.001$), especially at St. Joe Bay where salinity stress appears to be important. In October 2010, less diverse marshes had taller *Spartina* on average (Fig 5b; diversity $F = 26.54$, $P < 0.001$), but by March 2011, the pattern was mixed (Fig 5c; region*diversity $F = 13.13$, $P<0.001$).

The density of the key marsh consumer, the snail *Littoraria irrorata*, was highly variable across sites in July 2010, and across regions in October 2010 and March 2011 (Fig. 6). Interestingly, snail density was not tightly correlated with snail damage in July (mean grazing scar length; Fig. 7), but density and scar length exhibited similar trends in October and July, with higher density/scars at SAB and YC. Snail damage was inverse-unimodally related to plant C:N ratios, with lowest snail grazing at intermediate values of C:N ($y = 0.008x^2 – 0.0427x + 0.6892$; $R^2 = 0.10$). This relationship is consistent both with high and low nitrogen levels stimulating snail grazing.

In keeping with the spatial distribution of our sites, we found evidence of sediment hydrocarbons (i.e., more depleted C13 values) in FWB, SAB, and SJB, our 3 western-most regions that have diurnal tides and are closer to the DwH oil spill (Fig. 9). Marine organic matter typically has a heavier C13 signature (-20 per mil; Claypool and Kaplan 1974) than seep sediments (-25 per mil) or oils in deep Gulf of Mexico reservoirs (-26 to -28 per mil; Kennicutt et al. 1988). CML, SC, and YC tended to have heavier C13 signatures consistent with no oil exposure. Furthermore, sediment samples taken from a range of sites in St. Joseph Bay in early May 2010 have heavier signatures consistent with no oil exposure (mean(SE) delta C13 = -15.7(0.35)), suggesting that we detected DwH-specific contamination. An interesting exception to this trend is the high diversity site at SC, which is located adjacent to a marina, and may experience persistent contamination from boat motor oil. Nitrogen isotopic values from each site were also consistent with a gradient of oil exposure from our western to eastern sites (Macko and Parker 1983), though there was not as sharp a distinction between the 3 diurnal sites and the 3 mixed sites as in the C13 values (data not shown).

b. Field experiment of marsh plant species diversity. In July 2010, we set up an experiment in St. Joseph Bay, FL, to test the community-level effects of plant species diversity. We tested 2 levels of species diversity (1-species vs. 4-species) using 5 of the common marsh plant species in this area: *Spartina alterniflora*, *Juncus roemerianus*, *Salicornia virginica*, *Batis maritima*, and *Distichlis spicata*. These levels of diversity represent the range found in natural marshes within our study area (R. Hughes, unpublished data). We established 50-1m^2 plots that each received 4 transplant units consisting either of all of the same species (monoculture) or one of each of 4 different species (polyculture). The 4-species combinations consisted of 5 different random-draws from the 5 species in our species pool. All 5 species were also grown in monoculture to allow us to partition biodiversity effects among mechanisms (e.g., Loreau and Hector 2001). Our initial plan was to also manipulate consumer abundance and sediment nutrient addition and examine their effects on the response to oil exposure, but no visible oil arrived at our experimental site and so these additional treatments were not applied.

Every 2 months we quantified plant species percent cover, consumer abundance, and porewater salinity concentration. Despite the absence of visible oil (e.g., sheen, tarballs), our sediment hydrocarbon samples indicate that our experimental site was exposed to oil. Yet to date, there has been no effect of plant species diversity on either plant species cover (diversity $F=0.14$, $P = 0.70$) or the abundance of the primary consumer in this system, *Littoraria irrorata* (diversity $F=0.11$, $P = 0.73$). Because effects of species diversity can arise over time (Stachowicz et al. 2008, Cardinale et al. 2011), we will continue to monitor this experiment at quarterly intervals for the next year (using other funds).

c. Mesocosm experiment of nutrient effects on consumer preference for Spartina. We conducted a series of mesocosm experiments in fall 2010 to test whether a potential tool for bio-remediation (nutrient addition) affects consumer preference for *Spartina* in our study region. We were also interested in the potential interaction between plant height and nutrient additions on snail foraging behavior, and so we tested all possible combinations of fertilizer treatment (addition or no addition) and plant height (tall or short). We collected tall and short *Spartina* forms from the field and maintained them in flowerpots in a greenhouse at FSUCML. Starting in November 2010, we ran 4 trials of this consumer choice experiment, with trials treated as statistical blocks. Pots were randomly assigned to fertilization treatments (fertilizer addition or no fertilizer addition). Plants in the fertilizer addition treatment received one dose of commercial water-based Osmocote fertilizer each week for 2 weeks (trial 1), 3 weeks (trial 2), 4 weeks (trial 3) or 5 weeks (trial 4); plants in the no fertilizer treatment were treated identically with the exception of the fertilizer addition. Analysis of plant tissue C:N ratios at the end of the experiment revealed that the fertilizer treatment was effective at increasing nitrogen content in trials 3 and 4, suggesting that at least one month is needed for plants to incorporate additional nitrogen into their tissue.   We present the results of trials 3 and 4 here.

For each trial, we placed 2 flowerpots of *Spartina* in 32 flow-through, outdoor mesocosms at FSUCML. We then added 20 snails to each mesocosm and recorded their behavior over the 4-day experiment. Half of the mesocosms received predators (2 crown conchs, *Melongena corona*) to determine if predator presence influences snail foraging behavior. Only plant height influenced snail behavior: more snails grazed on tall plants rather than short plants (height $F = 4.03$, $P = 0.03$). Fertilization treatment did not affect snail preferences (fertilization $F = 0.41$, $P = 0.74$). These results suggest that the use of fertilizer additions as a bioremediation technique may not have unintended negative effects on *Spartina* by increasing consumer pressure. However, this experiment should be repeated in the field in order to reconcile the observed unimodal pattern of C:N and consumption of Spartina with the lack of relationship in the laboratory experiment.

13. Outreach activities:

This research has been highlighted on our research blog (http://wfsu.org/blog-coastal-health/) developed in conjunction with the local public broadcasting station (WFSU) aimed at increasing public understanding of and appreciation for science.

14. Peer Reviewed Articles:

Kimbro, D. In review. Tidal inundation dictates how the consumptive and non-consumptive effects of multiple predators cascade to basal resources. Ecology.

15. Non-refereed articles and reports for this project:

N/A

16. List conference presentations and poster presentations for this project:

N/A

17. Has anyone from this project been hired by NOAA during this reporting period?

No

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Figures

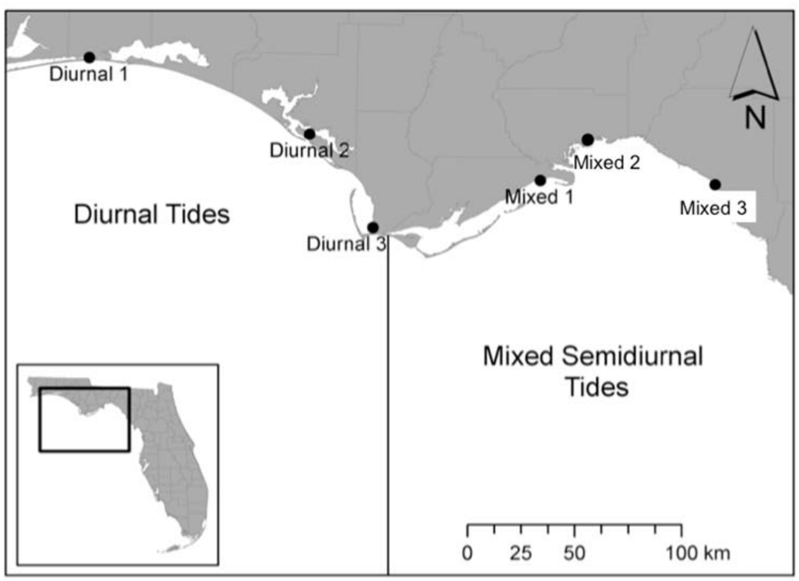

Figure 1. Map of our study sites.

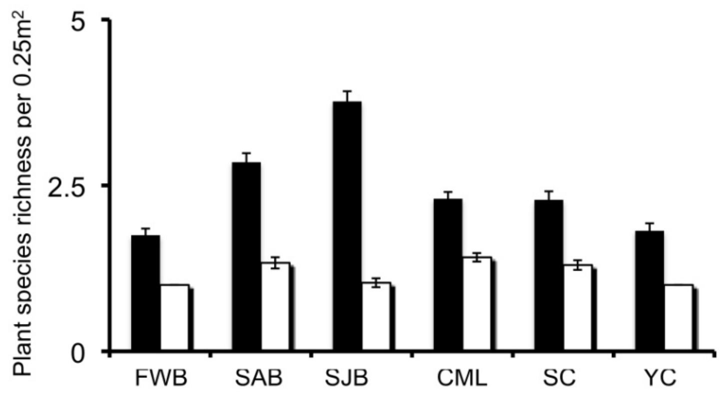

Figure 2. Plant species richness at 'diverse' (closed bars) and '*Spartina*-dominated' (open bars) marshes from Ft. Walton Beach to Yates Creek, FL. Data presented are means from 3 survey dates: July 2010; October 2010; and March 2011.

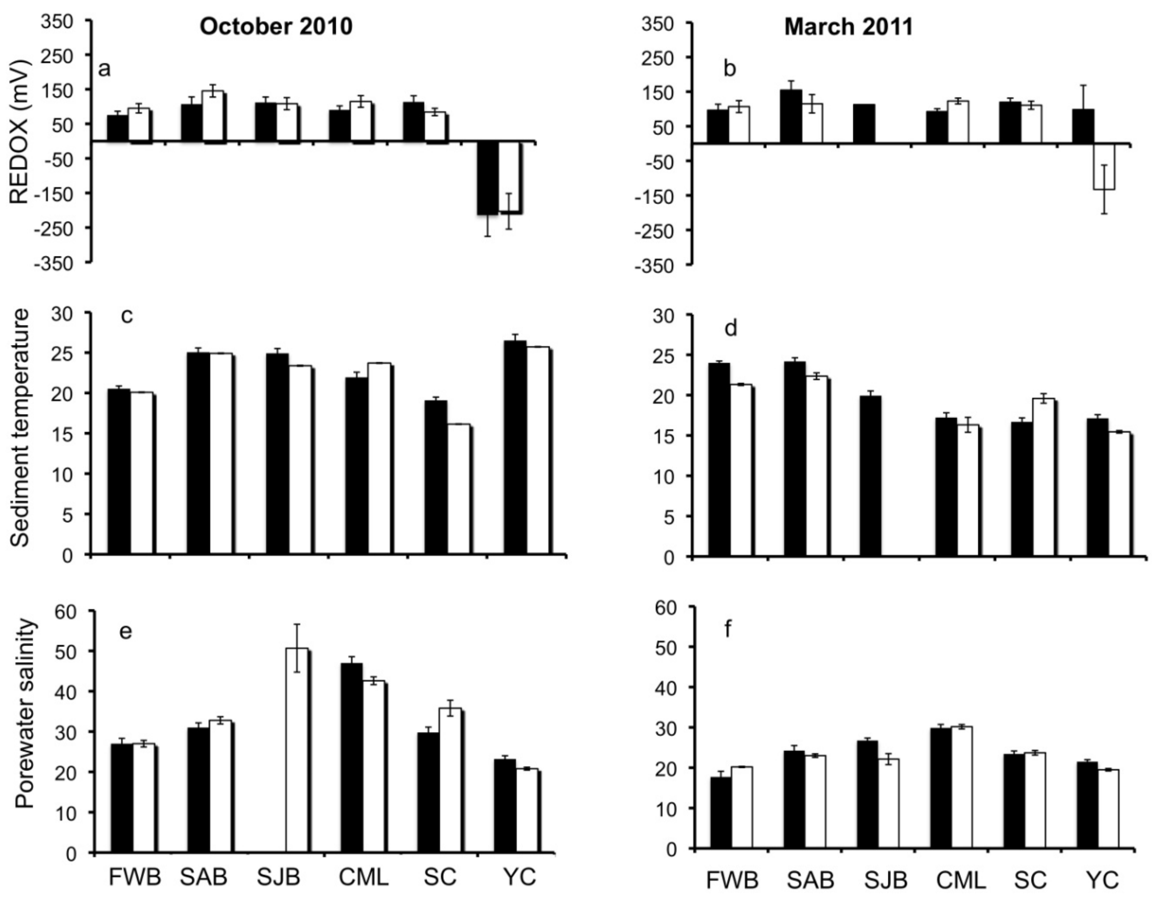

Figure 3. (a-b) Oxygen availability (REDOX potential), (c-d) sediment temperature, and (e-f) porewater salinity in October 2010 and March 2011. Closed bars are high plant species diversity sites and open bars are *Spartina*-dominated sites.

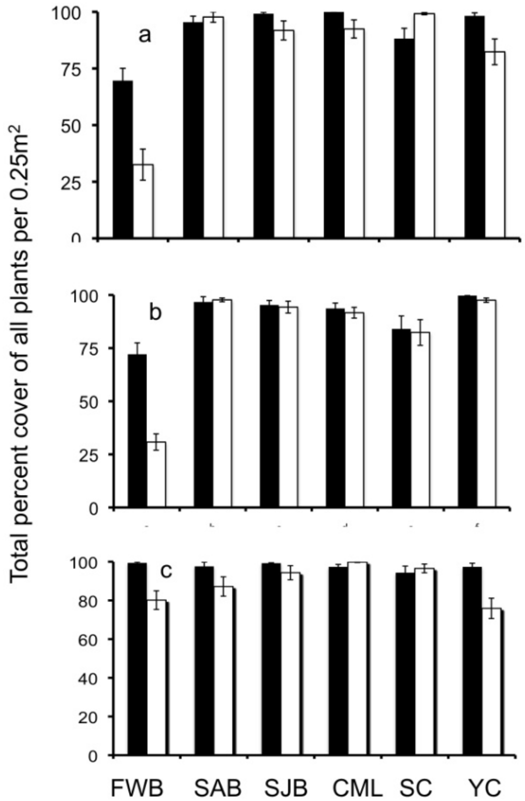

Figure 4. Total marsh plant percent cover in (a) July 2010, (b) October 2010, and (c) March 2011. There was a significant interaction between site and diversity, indicating that more diverse marshes (closed bars) do not consistently have higher plant cover than less diverse marshes (open bars). However, the one site with less than 75% cover in July and October (FWB) did have significantly higher overall cover in the diverse site, suggesting that diversity may be important to marsh dynamics in times of stress. Closed bars are high plant species diversity sites and open bars are *Spartina*-dominated sites.

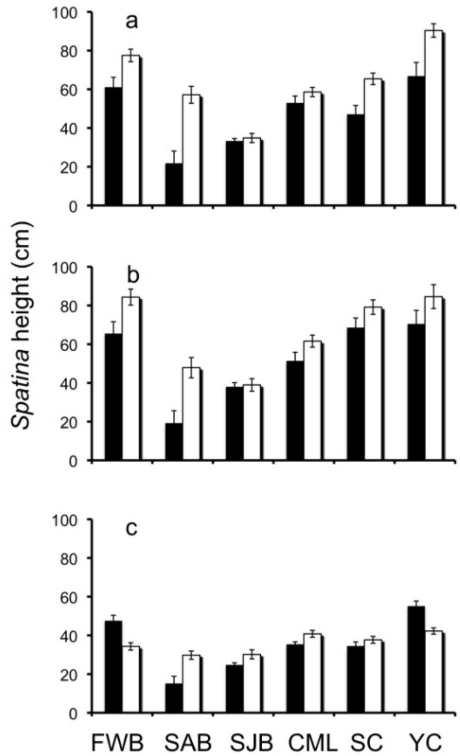

Figure 5. Average *Spartina* height in (a) July 2010, (b) October 2010, and (c) March 2011. Closed bars are high plant species diversity sites and open bars are *Spartina*-dominated sites.

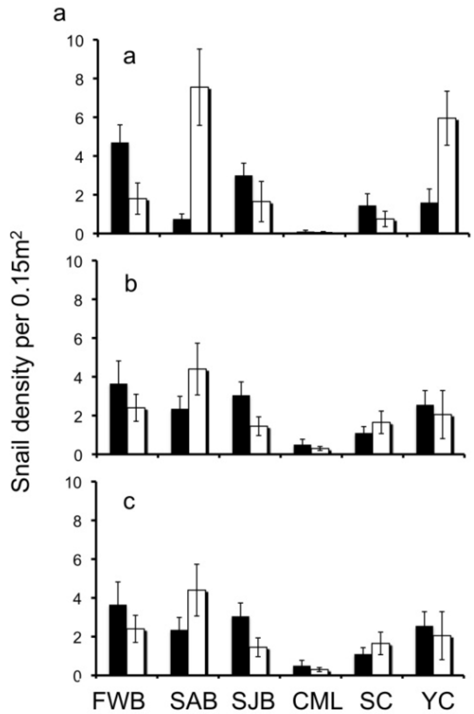

Figure 6. Mean density of *Littoraria* snails in (a) July 2010, (b) October 2010, and (c) March 2011. Snail density varied by plant diversity and site at all sampling dates. Closed bars are high plant species diversity sites and open bars are *Spartina*-dominated sites.

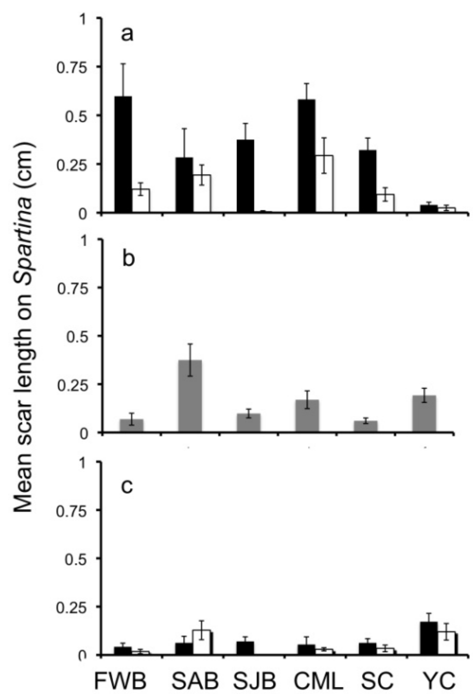

Figure 7. Mean grazing scar length caused by *Littoraria* in (a) July 2010, (b) October 2010, and (c) March 2011. Scar intensity varied by plant diversity and site in July and March, but not October. Closed bars are high plant species diversity sites and open bars are *Spartina*-dominated sites.

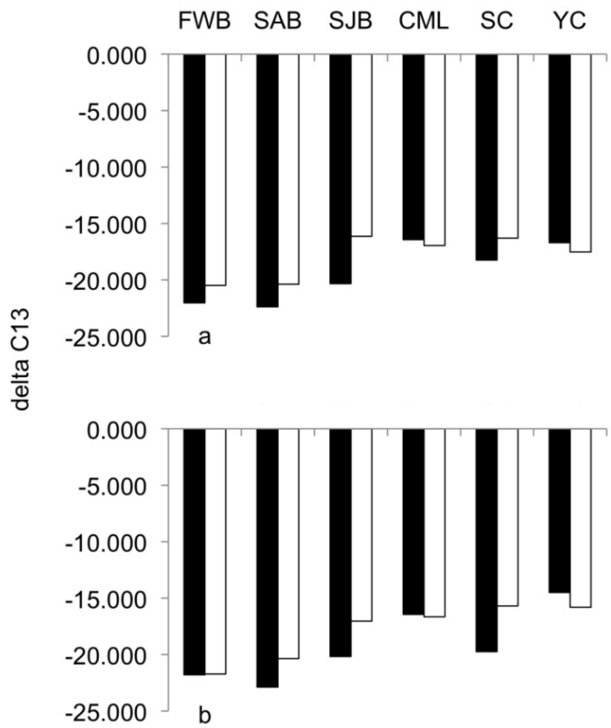

Figure 8. Delta C13 values from sediment samples at each site in (a) July 2010 and (b) September 2010. More depleted (negative) values indicate likely oil contamination. Closed bars are high plant species diversity sites and open bars are *Spartina*-dominated sites.

10-BP_GRI-FSU-01 (Task 3a): Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge - Subproject: Habitat and Oil Contamination of Shallow Coral/Sponge-Dominated Reefs of the Northeastern Gulf of Mexico.

1. **NGI Project File Number:** 10-BP_GRI-FSU-01 (Task 3a)

2. **Project title:**

Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge - Subproject: Habitat and Oil Contamination of Shallow Coral/Sponge-Dominated Reefs of the Northeastern Gulf of Mexico.

3. **Project Lead (PIs and Co-PIs):**

Name	Project Lead or Co-PI?	Affiliation	Email
Eric P. Chassignet	Lead	Florida State University	echassignet@coaps.fsu.edu
Felicia Coleman	Lead	Florida State University	coleman@bio.fsu.edu

4. **All Non-Student Personnel funded by this project:**

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Eric P. Chassignet	Lead	PhD	0	no
Felicia Coleman	Lead	PhD	0	no
Chris Koenig	Subproject PI	PhD	11	no
Markus Huettel	Subproject Co-PI	PhD	0	no

*If yes, list NOAA lab

5. All Students funded by this project:

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree Sought	% Salary funded from this project	Is individual located at a NOAA Lab?*
Chris Stallings	PhD	NA	9	no
Bob Ellis	MS	Ph. D.	13	no
Kelly Kingon	BS	Ph. D.	20	no
Jennifer Schellinger	BS	M. Sc.	0	no

*If yes, list NOAA lab

6. Project Abstract:

Biologically diverse coral/sponge-dominated rocky reefs, common throughout the shallow (9–20 m) waters of the northeastern Gulf of Mexico (NEGOM), provide a variety of ecological goods and services. These include nursery habitat for many economically important fishery species (e.g., groupers, snappers, and stone crabs), biodiversity hotspots, and coastline protection from storms; they also provide recreational opportunities for divers and fishers. Surprisingly, little is known about the shallow reefs of the northeastern Gulf of Mexico; even mapping and basic habitat descriptions are lacking. Our overall approach to the study of Apalachee Bay shallow reefs was to: (1) locate, map and characterize replicate reefs in several depth strata with the intent of using these data as a baseline to detect future anthropogenic impacts, and (2) to determine if contamination from the Deep Horizon oil spill reached these reefs. Using sidescan sonar we mapped 15 reefs in an approximate grid pattern in Apalachee Bay in depth strata 9-12, 13-16, 17-20 m with 5 reefs in each stratum. These reefs were characterized as to their sessile invertebrate and fish assemblages and depth and/or east-west patterns were noted. Sediment samples collected from the western-most reefs showed very low, near detection levels of oil contamination, but levels were too low to confirm whether or not the oil was derived from the Deep Water Horizon oil spill.

7. Key Scientific Questions/Technical Issues:

The scientific questions addressed the faunal characterization and whether DWH oil contaminated shallow water (9-20 m deep) reefs in Apalachee Bay in the northeaster Gulf of Mexico. Specifically, the project addressed the following questions:

a. How do the biological characteristics (fish and macro-invertebrate species composition, diversity, percent cover, and abundance) of shallow reef communities vary relative to spatial (by depth and east-west location), temporal (seasonal, interannual), and physical (depth, geomorphology, substrate composition) characteristics?
b. What sensitive community characteristics and/or species of fish and invertebrates can be used as indicators of environmental change?

c. Has the Deep Horizon oil spill contaminated these shallow reefs, and if so, has it impacted the biological community to a measurable degree?

8. Collaborators/Partners:

Name of collaborating organization

Florida Department of Environmental Protection, Bureau of Laboratories

Date collaborating established

9/8/2010

Does partner provide monetary support to project? Amount of support?

No

Does partner provide non-monetary (in-kind) support?

Yes

Short description of collaboration/partnership relationship:

FLDEP, Bureau of Laboratories, supported this project by student training on GC/MS and sharing information on protocols and procedures used for PAH analysis in oil-contaminated samples.

9. Project Duration: List the start and end date of this project:

Start: July 15, 2010

End: December 31, 2010

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

The shallow reefs in the northern region of the Big Bend provide many human services, including those supporting fisheries and coastal protection. These reefs have been neglected scientifically, but are clearly significant not only in direct human services, but also in terms of biodiversity hotspots. We expect that these reefs and the faunal assemblages they support and services they provide would be compromised by oil contamination. However, we detected very low levels of oil contamination and observed no obvious impacts on the biological component of the reefs. A comprehensive damage assessment of the Deep Water Horizon (DWH) oil spill requires quantitative data from subsurface environments and data on the distribution and degradation of crude oil components. In this project, shallow reef sites were targeted that are now considered beyond significant oil contamination. Results of this project indicate, however, that small amounts of DWH oil may have reached the area. This project also contributed to the education and training of graduate and undergraduate students.

NOAA Strategic Goal #1: Protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management

Shallow water reefs in the northern Big Bend region of the northeastern Gulf of Mexico provide significant human services, including high biodiversity and nursery habitat for gag grouper (*Mycteroperca microlepis*), an important species to the reef fish fishery of the southeastern US. This project provides data on the oil deposition on shallow reefs and possible effects of oil contamination. These data are important for the assessment of potential oil impacts on the shallow-water faunal assemblages of the northeastern U.S.

NGI Theme #4: Coastal hazards and resiliency

Due to extensive oil exploration in the Gulf, habitats in the eastern Gulf may be threatened by possible oil spills. This project provides data showing whether spills in the Mississippi region can influence sensitive habitats in the northern Big Bend area of the West Florida Shelf.

Gulf of Mexico Alliance Priority: Ecosystem Integration and Assessment

We are just beginning to understand the ecological importance of benthic communities of the rocky reefs in the northeastern Gulf of Mexico. These initial results indicate that these reefs provide valuable human services, are key nursery habitats, and biodiversity hot spots. The destruction of this habitat could potentially have far reaching consequences. A thorough understanding of the processes that can affect these ecosystems is critical for their protection.

Gulf of Mexico Research Initiative Themes: Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery

The results of this project show that some oil may have reached sensitive shallow reef habitat in the northern Big Bend region of the West Florida Shelf. However, based on this limited data set, it is unlikely that direct negative effects occurred.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

There is virtually no information available on shallow reef systems off the Big Bend and on the effect of DWH crude oil on these systems. Therefore, the data produced in this project provide important insights into the nature of the habitat and on potential effects of the DWH spill on these habitats.

Contributions to BP_GRI goals:

- Characterization of shallow reef habitats in Apalachee Bay of the northeastern Gulf of Mexico
- Spread of the oil and other contaminants and the fate of these components.
- Environmental effects of the oil spill on Gulf of Mexico ecosystems, and ecosystem recovery.
- Technology that could help detect and clean up offshore oil spills, and reduce their impact.
- Potential impact of the oil spill and response on human health

The project directly addressed three of the four BP_GRI goals listed above. The project directly characterized ecologically important shallow reefs of the northern Big Bend that were not in the direct impact zones of the oil spill but that could have been impacted by the subsurface oil plumes. The project also addressed potential ecological effects on important reef ecosystems. The analyses of PAHs conducted in this project relate directly to potential human health impacts as these reefs are important to the recreational fishery of the northeastern Gulf of Mexico.

11. Milestones accomplished during entire project period:

Shallow reefs of the northern Big Bend characterized as to the faunal assemblages

- Sediments sampled from western reefs in October 2010.
- Sediments analyzed for total petroleum hydrocarbons, volatile and semi-volatile hydrocarbons
- Sediment analyzed for potentially toxic polyaromatic hydrocarbons

12. Describe all significant research results, protocols developed, and research transitions:

Study Reefs

Location—Our study reefs are located in Apalachee Bay, northeastern Gulf of Mexico, at depths rangingfrom 9 to 20 m (Fig. 1). Apalachee Bay is a broad open embayment with extensive salt marshes and seagrass beds inshore and many rocky reefs (hard-bottom) offshore. The bay and surrounding areas are relatively undisturbed, biologically rich and diverse, and provide nursery habitat for economically important species and refuge for other cold-intolerant species egressing in the fall from shallow seagrass beds. This part of the Big Bend region is considered to be among the more productive and diverse coastal habitats in the United States (Stein et al. 2000) and a prime candidate for conservation efforts. Apalachee Bay is situated between two watersheds, the Apalachicola River to the west and the Steinhatchee River to the east, and is additionally supplied by fresh water via several smaller rivers including the Ochlockonee, St. Marks, Econfina, Aucilla and Fenholloway Rivers. Inshore estuarine waters have variable temperature (10°C winter to 30°C summer), salinity (0 to 33 ppt), and turbidity; sediments grade from mud to sand with seagrass extending 16-24 km offshore in depths of 4-6 m.

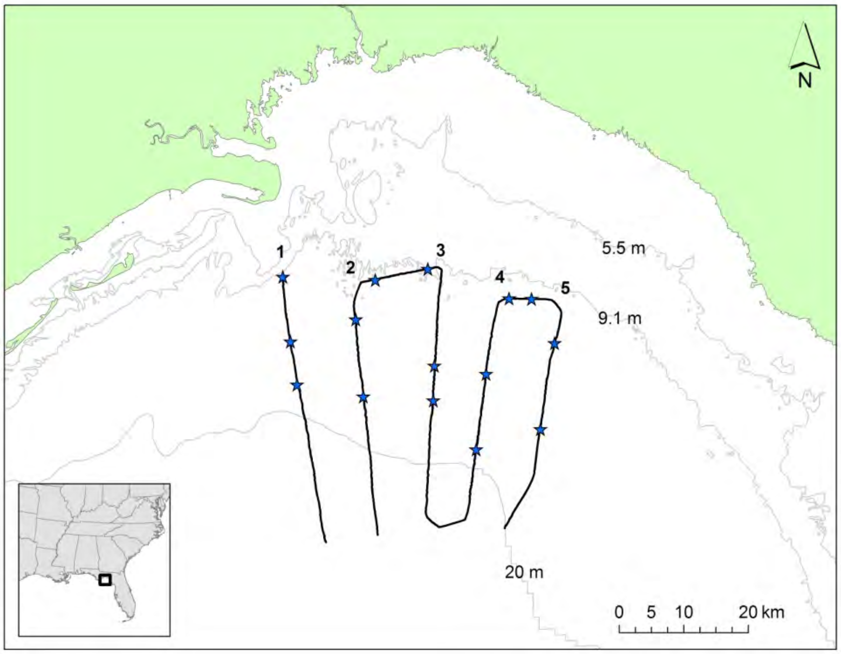

Figure 1. Map of 15 study reefs (stars) on 5 transects (numbers) in three depth intervals (9-12, 13-16, and 17-20 m) in Apalachee Bay of the Northeastern Gulf of Mexico.

Reef Site Selection— Study reefs were selected from a set identified on five sidescan sonar transects conducted by NMFS-Panama City in 2010. We selected 15 reefs of the commonest type, 'low relief—scattered high density rocky outcrops', within three depth zones, 9-12, 13-16, 17-20 m (Fig. 1). *To determine the two dimensional extent of the selected reefs we used our sidescan unit (Hummingbird 997c) to run a series of 400 x 400 m parallel and overlapping swaths north - south, then east – west over the same area and centered on NMFS coordinates for that reef according to the recommendations of* Kendall et al. 2005. Once we defined the spatial extent of the site, a marker buoy was deployed at the center of the reef which served as a reference point at the surface for our boat and on the bottom for divers establishing survey transects.

Sidescan data were processed in the following sequence. Data were first developed as an eXtended Triton Format (xtf) file, then manipulated with SonarWiz.Map software to produce geotiff images. These images were imported into ERDAS Imagine to develop georeferenced mosaic maps of each site. The resulting mosaics were interpreted and then categorized as to geomorphology using both the sidescan imagery, bottom videos, and *in situ* measurements.

Sampling

Transects— At each of the 15 study reefs divers surveyed reef characteristics (geomorphology, sediment depth, rugosity), sessile invertebrates and motile and cryptic fishes along two 30 m transects which originated at the mooring-marked center of the reef. Randomized compass headings were used to determine the direction of each transect from the mooring. If a heading lead off the reef, subsequent random headings were chosen until two 30 m transect could be run.

Reef characteristics – We defined our study reefs by type: rocky outcrops, rough pavement, smooth pavement, and pavement with a veneer of sand, and by relief (very low = <5cm, low = 6-25cm, medium

= 26-50cm and high = >51cm); Newton and Stefanon 1975, Cochrane and Lafferty 2002, Kendall et al. 2005. Further reef characteristics measured were: rugosity, sediment depth, outcrop relief, and relief of sessile organisms.

Rugosity was measured by draping a 3 m weighted line over the bottom, allowing it to follow the peaks and valleys of the bottom along a straight-line path. Then, relative rugosity was calculated by dividing 3m by the strait-line distance between the ends of the line as it followed the contours of the bottom. Rugosity was measured at 3-m intervals along each of two 30-m transect (total of 5 measurements each x 2 = 10). Rugosity classes were defined as: very low (1-1.24 cm), low (1.25-1.49 cm) and moderate (1.5-1.74 cm).

Sediment depth, rock height, and height of sessile invertebrates were measured at 1.5 m intervals for 15 m (total of 10 measurements) at the start of each transect using a fiberglass measuring rod (Prada et al. 2008, Rivera et al. 2006.) Sediment depths were also broken down into classes: none (no sediment), dusting (< 1 cm), thin (1-5 cm), thick (> 5 cm) (Greene et al. 1999). Classes of rock relief were defined as: very low (<5 cm), low (6-25 cm), moderate (26-50 cm) and high (>51 cm). Percent cover of each class was calculated for each site.

Sessile invertebrate diversity and percent cover—Photographic transects were used to estimate species diversity and percent cover of sessile invertebrates. For each reef, six sites were randomly chosen along each of the two 30 m transects (N = 12 sites). We used a ¼ m^2 pyramid frame and took down-looking photos with a Canon S90 digital camera. We tested a series of quadrat sizes to determine which was the most efficient in terms of estimating species abundance, diversity and percent cover. We settled on 1 m^2 as having the least variation, but arranged the ¼ m images in a line so that the quadrat would be a rectangle(½ m x 2 m), assuming that rectangular would cut across multiple habitat patches and thus increase precision (Krebs 1999).

Percent cover was determined by placing a 10 x 10 unit grid over each down-looking photograph and counting each unit in the grid as one percent of the total area. Sessile invertebrates were indentified down to the lowest taxa practicable and percent cover was calculated for each taxon.

Fish assemblages— Fish assemblages were quantified by counting all fish on two 30 m-long and 4 m-wide belt transects. Two divers swam side by side covering a 4 m swath; one diver documented fish species and abundance with a video camera over a 2 m swath while the other diver, swimming alongside, counted all large motile fishes and small cryptic fishes over a 2 m swath.

Sediments— Sediment samples were collected from five reef sites located on the westernmost line/transect in October 2010. Samples were collected by a diver from each site by directly scooping sediment into new acid-washed glass collection jars. Two samples were collected at each site: one from the anchor point and a second at the end of the second transect. Sediment samples were put on ice in the field, then frozen upon returning to the lab until analysis. Sediment samples were also collected following the same method at all reef sites visited in February 2011. Only the samples collected during the fall were analyzed for oil contamination by extraction with a mixture of dichloromethane and methanol (Venosa et al. 1997) and analysis of extracted oil components with a Shimadzu gas chromatograph (Medinavera 1996).

Statistical analysis

Sessile invertebrate assemblage—Response variables for the sessile invertebrate assemblages were species richness (total number of species observed per reef) and two types of percent cover (percent cover of taxa within each quadrat and the percent cover of taxa among the total area covered by invertebrates.) We used a fixed-effect linear model ANOVA (Quinn and Keough 2004) to determine the relationship between depth interval of the reef (9-12m, 13-16m, 17-20m), west to east location (1, 2, 3, 4, 5, resp.), rugosity (very low, low, medium, high) and maximum relief (low, medium, high) and the response variables of species richness and percent cover.

Mean coral and sponge percent cover, and other measures, were compared with depth interval, east-west position, rugosity class and rock relief class using a fixed effect linear model.

Fish assemblages— Response variables for the fish assemblages were species richness (total number of species observed per reef transects) and abundance (total number of individuals observed per reef transects). Species richness was standardized to a constant sample size using rarefaction methods (Krebs 1999). Each response variable was tested using ANOVA for categorical variables or linear regression for continuous variables. Independent variables were depth (continuous and by depth interval), location (transect number), and reef characteristics (mean rugosity, rugosity class, relief, mean height of sessile invertebrates, and percent cover of sessile invertebrates.

RESULTS

Geomorphology.—Although the more powerful Marine Sonic system (NMFS-Panama City Lab) provided clearer imagery (Appendix A), our Humminbird sidescan system was useful for determining the extent of the reefs identified in NMFS' transects (Figure 2). There was no significant relationship (P>0.05) between size of reef and population densities of fishes and invertebrates.

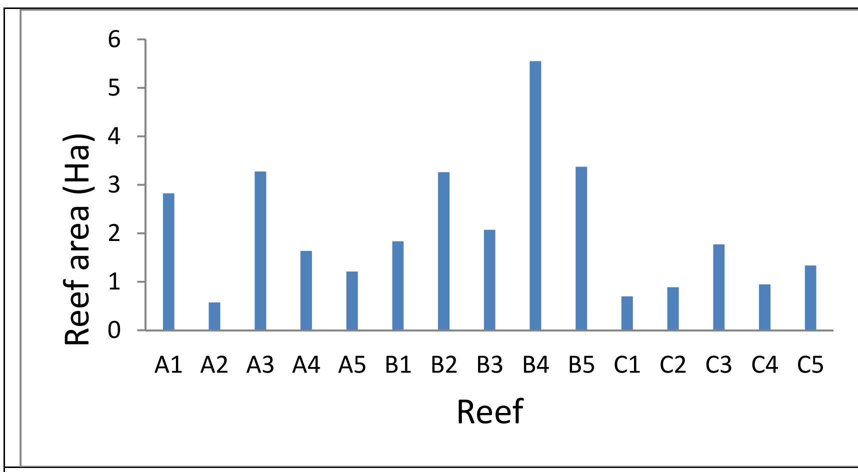

Figure 2. Area in hectares of study reefs in Apalachee Bay in the northeastern Gulf of Mexico. Letters refer to depth interval (A = 9-12 m, B = 13-16 m, and C = 17-20 m). Numbers respresent reef west-east position (1=furthest west, 5=furthest east).

We found no significant relationship (P>0.05) among geomorphological characteristics (sediment depth, rugosity, percent rock cover). Mean depth of sediment for all sites was 5.14 cm (n=301; Fig. 3). Sediment depth class varied greatly among reefs (Fig. 4). Mean rugosity was low (class 1.0-1.25) with little variation (Figure 5), and maximum rugosity was only slightly more variable (Table 1) for all study reefs. Percent area (cover) of exposed rock varied greatly among reefs with reef A4 and C4 being lowest in percent cover and B3 the highest (Figure 6).

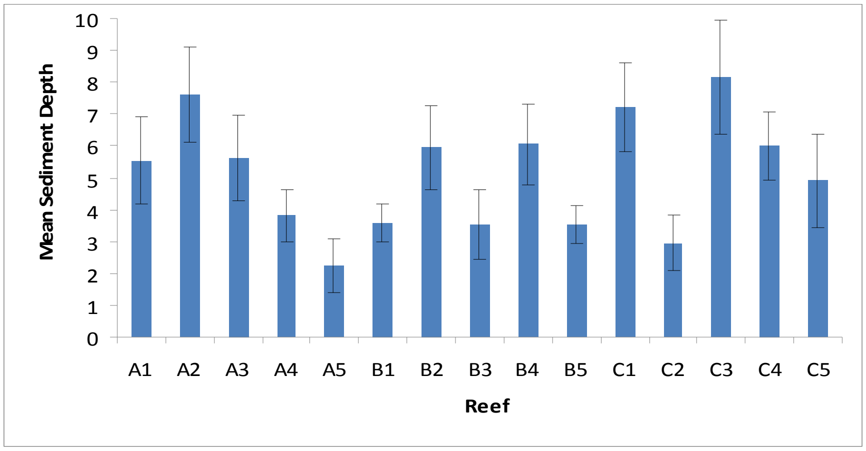

Figure 3. Average sediment depth associated with reefs in Apalachee Bay in the northeastern Gulf of Mexico. Letters represent depth intervals (A = 9-12 m, B = 13-16 m, and C = 17-20 m) and numbers respresent reef east-west position (1=furthest west, 5=furthest east). Error bars represent standard error.

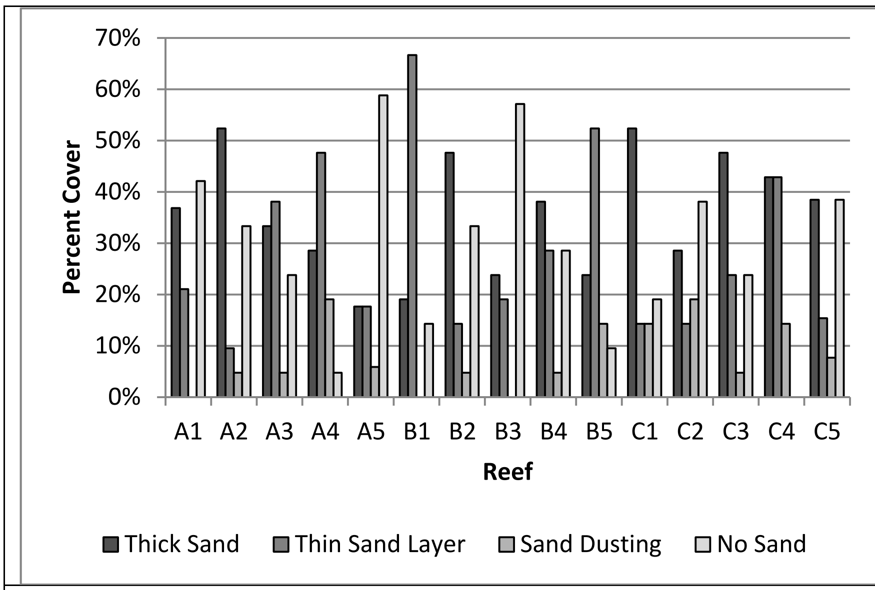

Figure 4. Percent cover of each sediment class at each site. White, no sand present; light grey, dusting = 1 cm or less sand depth; dark grey, thin = 1-5 cm sand depth; black, thick = > 5 cm sand depth (following Greene et al. 1999). Letters represent depth intervals (A = 9-12 m, B = 13-16 m, and C = 17-20 m) and numbers respresent reef west-east position (1=furthest west, 5=furthest east).

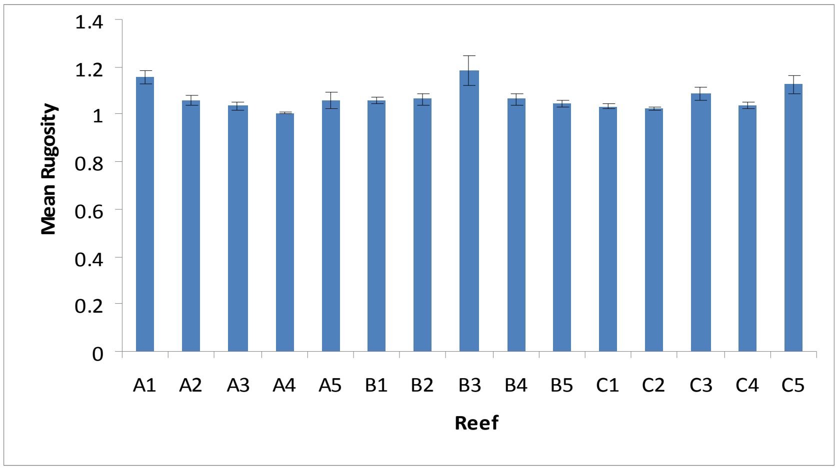

Figure 5. Mean rugosity at each study reef. Zero rugosity equals 1.0. Letters represent depth intervals (A = 9-12 m, B = 13-16 m, and C = 17-20 m) and numbers respresent reef west-east position (1=furthest west, 5=furthest east). Error bars are standard error.

Table 1. Reef habitat characteristics. Relief (maximum rock height): Very low = 0-4.9 cm, Low 5-24.9 cm, Medium = 25-49.9 cm, High = 50-74.9 cm. Rugosity (metrics of Greene et al. 2007): Very low = 1-1.24, Low = 1.25-1.49, Moderate = 1.5-1.75. Letters represesent reef depth intervals (A = 9-12 m, B = 13-16 m, and C = 17-20 m). Numbers respresent reef west-east position (1=furthest west, 5=furthest east).

Reef	**Depth (m)**	**Relief**	**Geomorphological Description**	**Max. Rugosity**	**Rugosity Class**
A1	14.0	very low	Very low relief rocky outcrops surrounded by deep sediment. Low mean rugosity; percent cover of sessile invertebrates high, sponges dominate.	1.304	low
A2	11.9	medium	Very low relief rocky outcrops surrounded by deep sediment; low mean rugosity; percent cover of sessile invertebrates high, colonial tunicates and hard corals dominate.	1.200	very low
A3	9.4	low	Fifty percent hardbottom with thin veneer of sand, exposed rock, thick sediment forming a spur and groove pattern with surrounding sediment; exposed low relief rock; very low rugosity; low cover of sessile invertebrates; sponges dominate.	1.154	very low
A4	11.3	very low	Rough pavement with thin sediment veneer. Very low relief; low rugosity; low cover of sessile invertebrates; brown algae and *Halimeda* sp. algae dominant cover.	1.017	very low
A5	11.3	very low	Exposed flat pavement with very low relief; very low rugosity; low cover of sessile invertebrates; hard corals and sponges dominate.	1.200	very low
B1	18.0	low	Rocky outcrop with a thin veneer of sand and some rough pavement; low rugosity; low cover of sessile invertebrates; sponges dominate.	1.154	very low
B2	14.3	very low	Rough pavement; very low relief exposed pavement surrounded by deep sediment; very low rugosity; moderate cover of sessile invertebrate; hard corals and sponges dominate.	1.200	very low
B3	15.8	high	High relief exposed rocks with moderate rugosity that form a spur and groove pattern; moderate rugosity; high cover of sessile invertebrates; *Sargassum* sp. algae is the dominant cover.	1.667	moderate
B4	16.2	medium	Similar proportions of thick and thin sediment veneer on spur and groove pattern of moderate relief rocky outcrops; low rugosity; moderate cover of sessile invertebrates; *Sargassum* sp. algae is the dominant cover.	1.200	very low
B5	13.4	low	Flat pavement with thin veneer of sediment surrounded by thick sediment and a few low relief exposed rocks; very low rugosity; low cover of sessile invertebrates; diverse sessile invertebrate assemblage.	1.111	very low
C1	19.8	low	Thick sediment with some low relief rocky outcrops; low rugosity; low cover of sessile invertebrates; diverse sessile invertebrate assemblage without any one group dominating.	1.091	very low
C2	18.9	low	Equal portions of exposed low relief rocks, thick sediment, and thinly covered pavement; very low rugosity; moderate cover of sessile invertebrates; sponges dominate.	1.071	very low
C3	16.8	very low	Exposed very low relief rocks with a thin sediment veneer and rocky outcrops forming a spur and groove structure; low rugosity; high cover of sessile invertebrates; hard corals and *Sargassum* sp. algae dominant.	1.333	low
C4	19.8	very low	Very low relief rocks with few sessile invertebrates.	1.111	very low
C5	16.5	low	Low relief rocky outcrops and thick sediment between; low rugosity; low cover of sessile invertebrates; hard corals and *Sargassum* sp. algae dominate.	1.250	low

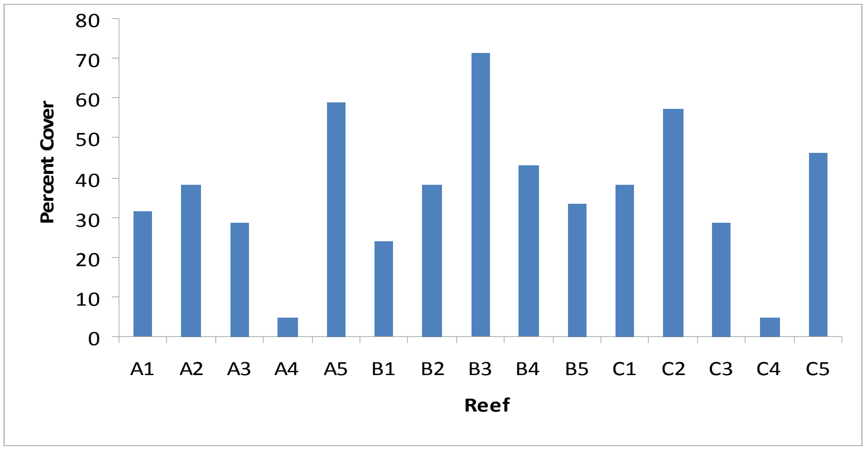

Figure 6. Percent cover (area) of exposed rock at each study reef. Letters represesent reef depth intervals (A = 9-12 m, B = 13-16 m, and C = 17-20 m). Numbers respresent reef east-west position (1=furthest west, 5=furthest east).

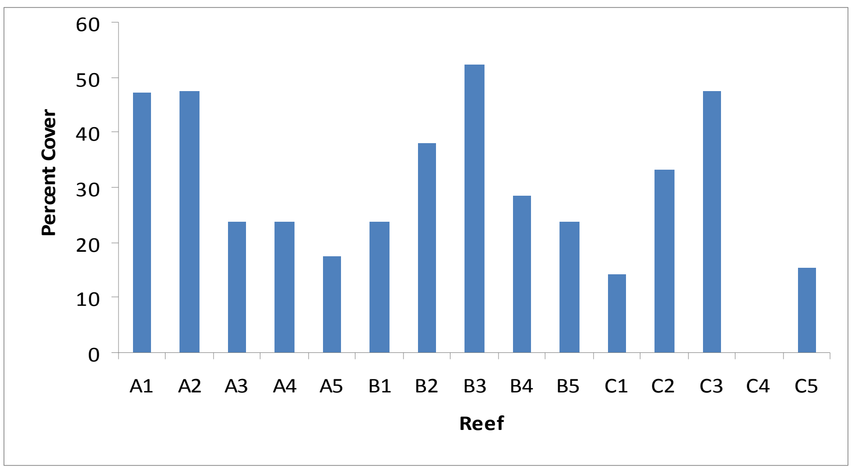

Figure 7. Percent cover of sessile invertebrates at each study reef. Letters represesent reef depth intervals (A = 9-12 m, B = 13-16 m, and C = 17-20 m). Numbers respresent reef west-east position (1=furthest west, 5=furthest east).

Sessile invertebrate percent cover— Percent cover of sessile invertebrates was highly variable across the study reefs with little to no cover on reef C4 and over 50 percent cover on reef B3 (Figure 7). The number of macro-invertebrate taxa was negatively correlated with depth ($P<0.05$). Sponges and corals dominated in terms of percent cover on all study reefs, but percent cover of sponges increased on reefs from east to west; conversely, percent cover of corals increased on reefs from west to east. Percent cover of other sessile invertebrate species showed no clear pattern of variation (Figure 8).

Cladocora sp. (tube coral) was dominant among coral taxa on all study reefs. *Cliona* sp. (CLI) was the dominate sponge on all reefs, except on the reefs in transect 2, where *Ircinia* sp. (IR) was dominant. *Haliclona* sp. (BL) was the second most important sponge in terms of percent cover on transect one. The bryozoan, *Schizoporella violacea* (SV), was dominant among the “other’ category of sessile invertebrates on all reefs (Figure 9).

The depth of the reef appeared to have little effect on percent cover of sessile invertebrates. Percent cover of sponges increased slightly with increasing depth (Figure 10). *Cliona* sp. was the dominant taxon among deep reefs, but was present in all other depth intervals. *Ircinia* sp. (IR) and *Haliclona* sp. (BL) were dominant in depth intervals A and B, and the bryozoan, *S. violacea* (SV), was present at all depths (Figure 11). The tube coral, *Cladocora* sp., was dominant on all reefs except on the shallowest reefs where the coral, *Siderastrea* sp., was dominant.

Mean coral cover was highest on very low rugosity and low relief reefs, but lower on reefs that had low to moderate levels of rugosity and relief. Conversely, mean sponge cover was highest on reefs with high rugosity and high relief and low on reefs with low to moderate rugosity and relief. Tube coral (*Cladocora* sp.) was dominant among the corals and *Cliona* sp. (CLI) was dominant among sponges regardless of rugosity or relief. The percent cover of all other sessile invertebrates, besides corals and sponges, were low regardless of rugosity or relief. *S. violacea* (SV), were equally low among all reefs. (Figures 12, 13, 14 and 15).

Sessile invertebrate diversity—Sessile invertebrate species richness values ranged from 9 to 30 species per reef. A total of 69 species were found across the study area including 7 coral, 56 sponge and 6 other species (mostly bryozoans and tunicates). No significant relationship was found between species richness or percent cover and depth interval, east-west position, rugosity, or relief ($P>0.05$). However, there was a significant relationship between mean coral cover and west-east position ($p<0.01$) and an interaction between depth interval and west-east position ($p<0.05$). There were also significant relationships between mean sponge cover and depth interval ($p<0.05$) and west-east postion ($p<0.01$). We also found a significant interaction between depth interval and rugosity class ($p<0.05$).

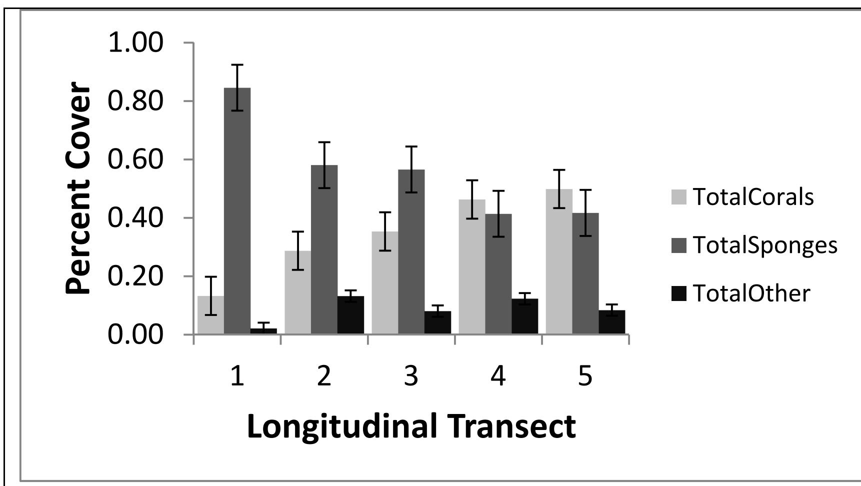

Figure 8. Mean percent cover of sessile invertebrate taxa (corals, sponges, other) across west to east transects 1 to 5, resp. Error bars are standard errors.

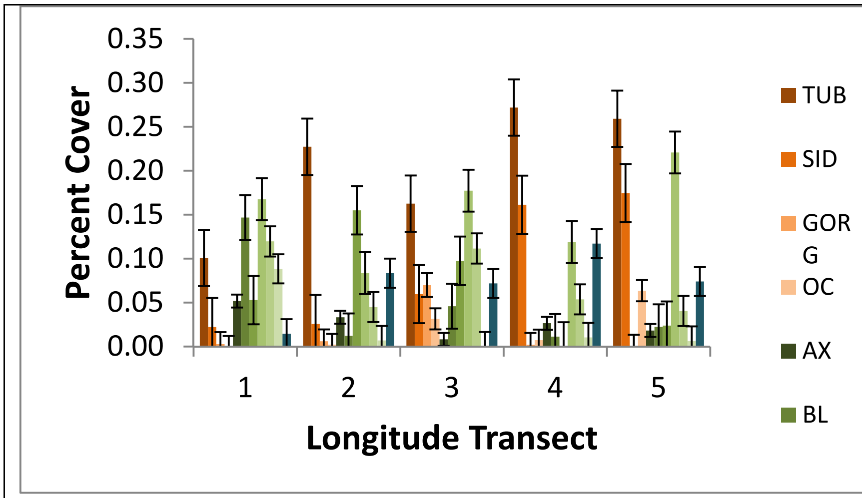

Figure 9. Mean percent cover of sessile invertebrate species across west to east transects 1 to 5, resp. Error bars are standard errors.

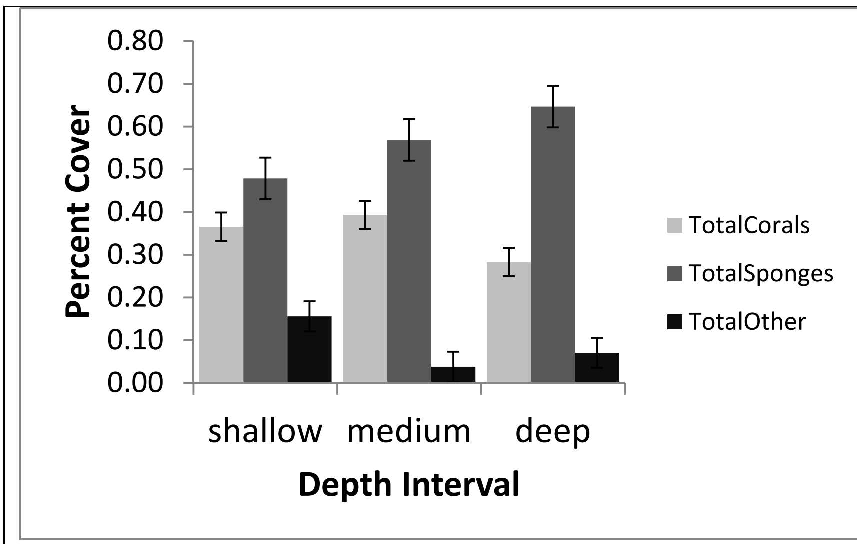

Figure 10. Mean percent cover of sessile invertebrate taxa (corals, sponges, other) across three depth intervals (shallow = 9-12 m, medium = 13-16 m, deep = 17-20 m.) Error bars are standard errors.

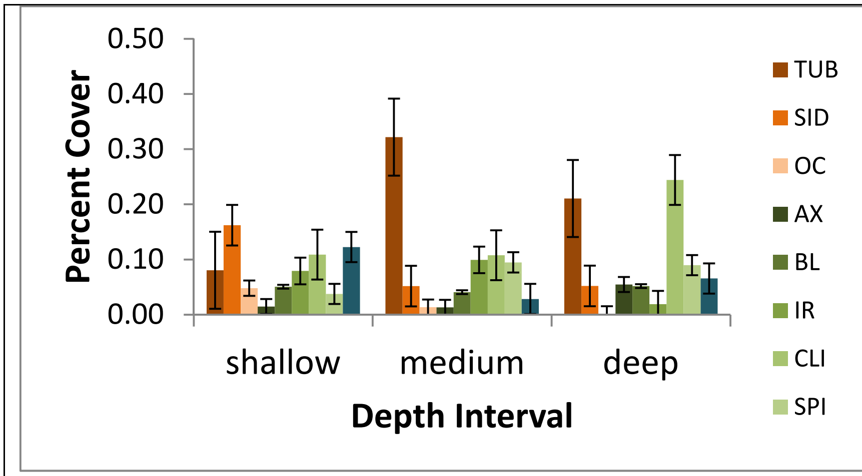

Figure 11. Mean percent cover of sessile invertebrate taxa across three depth intervals (shallow = 9-12 m, medium = 13-16 m, deep = 17-20 m.) Error bars are standard errors.

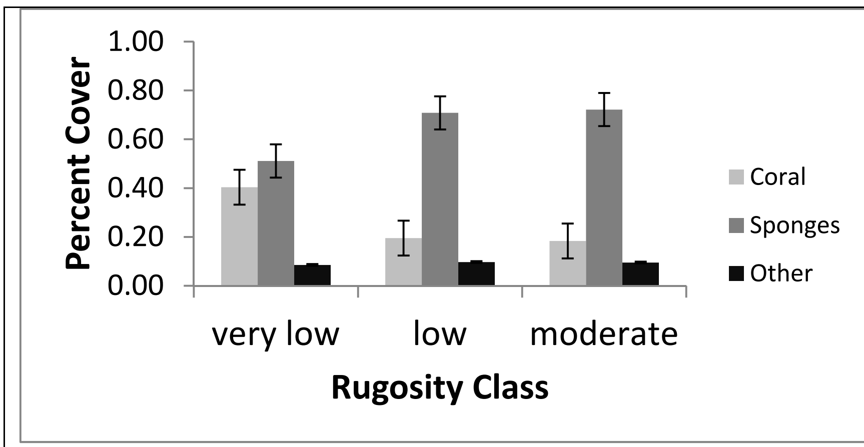

Figure 12. Mean percent cover of sessile invertebrate taxa (corals, sponges, other) across three rugosity classes (very low=1-1.24 cm, low=1.25-1.49 cm, moderate=1.5-1.74 cm). Error bars are standard errors.

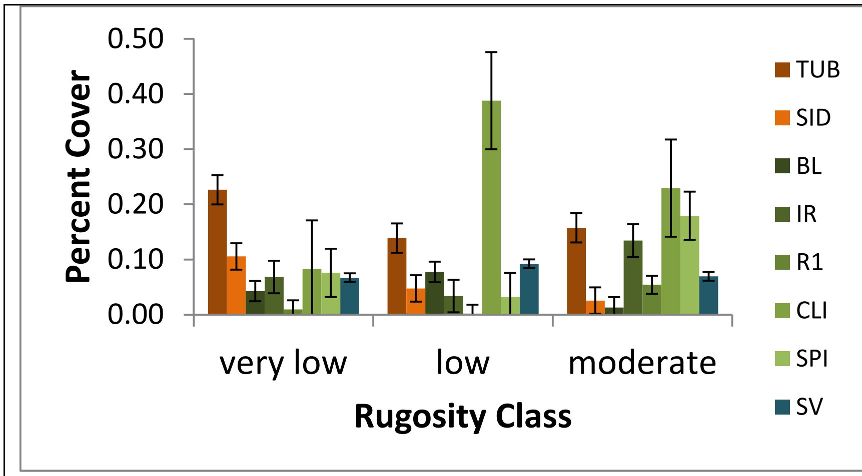

Figure 13. Mean percent cover of sessile invertebrate species across three rugosity classes (very low=1-1.24 cm, low=1.25-1.49 cm, moderate=1.5-1.74 cm). Error bars are standard errors.

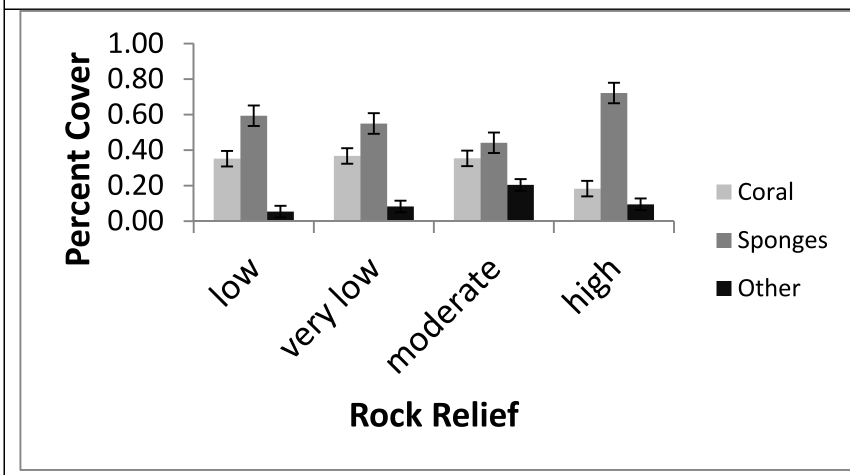

Figure 14. Mean percent cover of sessile invertebrate taxa (corals, sponges, other) across four reef relief classes (very low=1-1.24 cm, low=1.25-1.49 cm, moderate=1.5-1.74 cm). Error bars are standard errors.

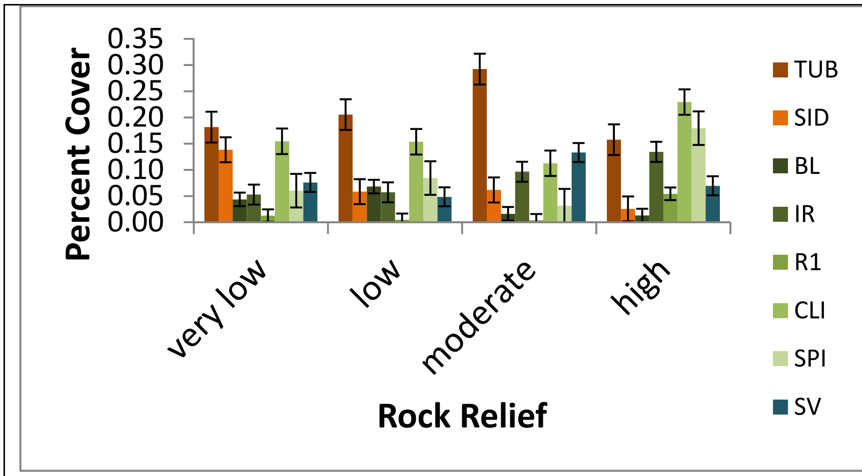

Figure 15. Mean percent cover of sessile invertebrate species across four reef relief classes (very low= <5 cm, low=6-25 cm, moderate=26-50 cm, high= >51 cm). Error bars are standard errors.

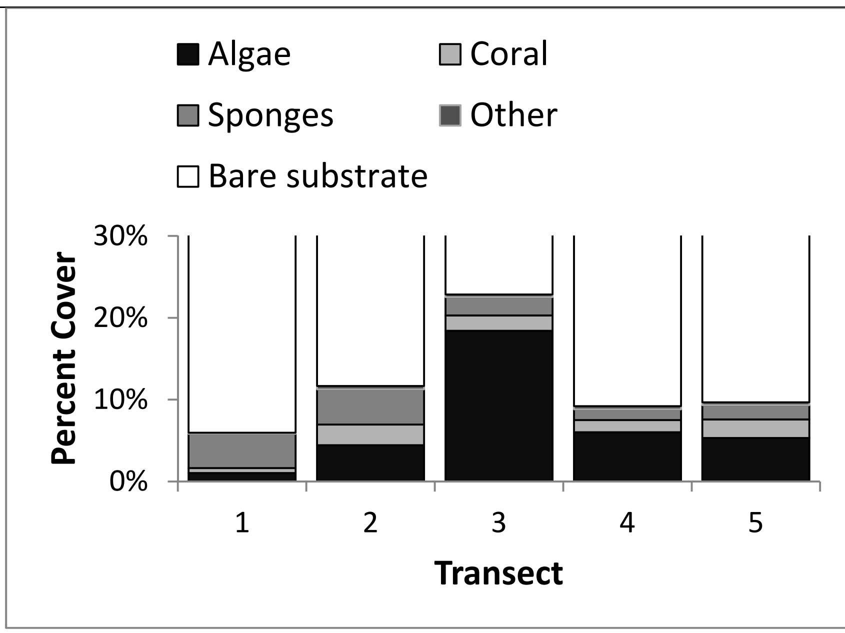

Figure 16. Mean percent cover of sessile invertebrate taxa (corals, sponges, other; includes other cnidarians, bryozoans and tunicates), algae and bare substrate across west to east transects 1 to 5, resp.

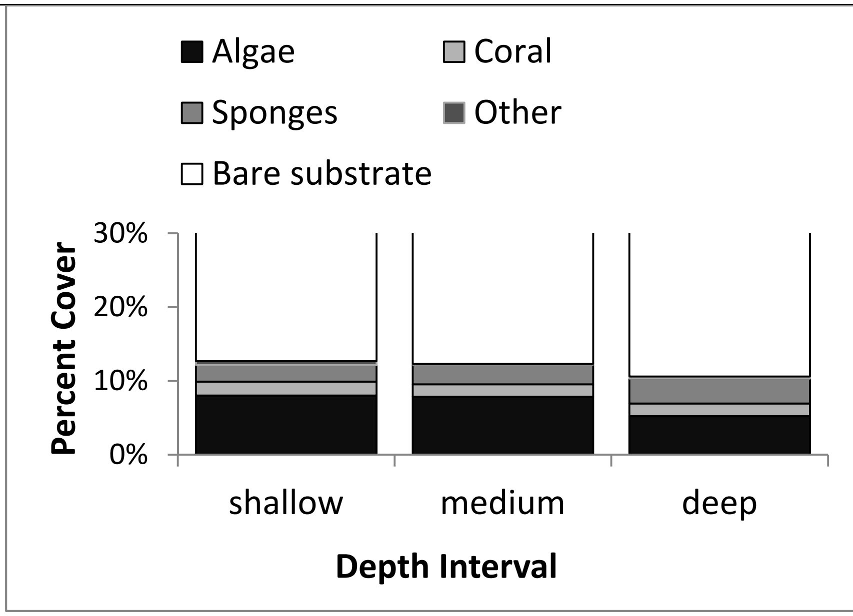

Figure 17. Average percent cover of sessile invertebrate taxa (corals, sponges, other: includes other cnidarians, bryozoans and tunicates), algae and bare substrate across three depth intervals (shallow = 9-12 m, medium = 13-16 m, deep = 17-20 m).

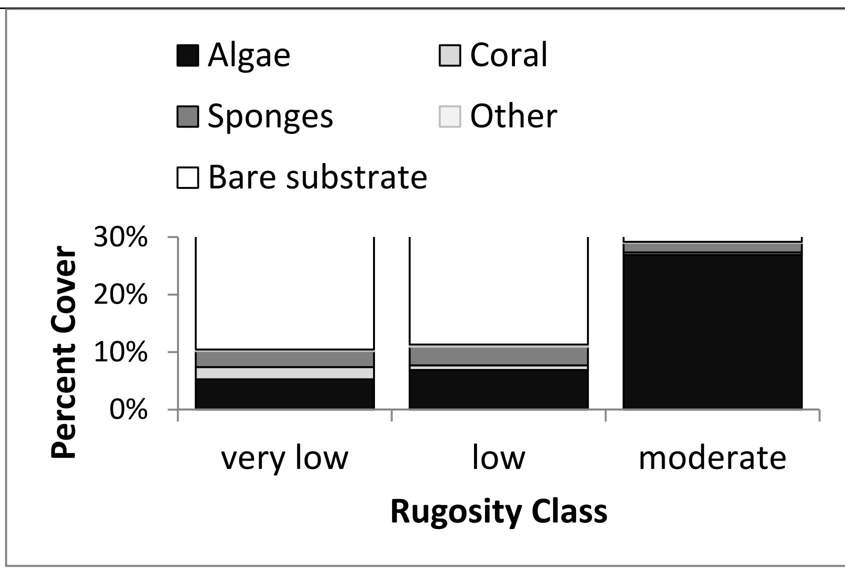

Figure 18. Mean percent cover of sessile invertebrate taxa (corals, sponges, other: includes other cnidarians, bryozoans and tunicates), algae and bare substrate across three rugosity classes (very low=1-1.24 cm, low=1.25-1.49 cm, moderate=1.5-1.74 cm).

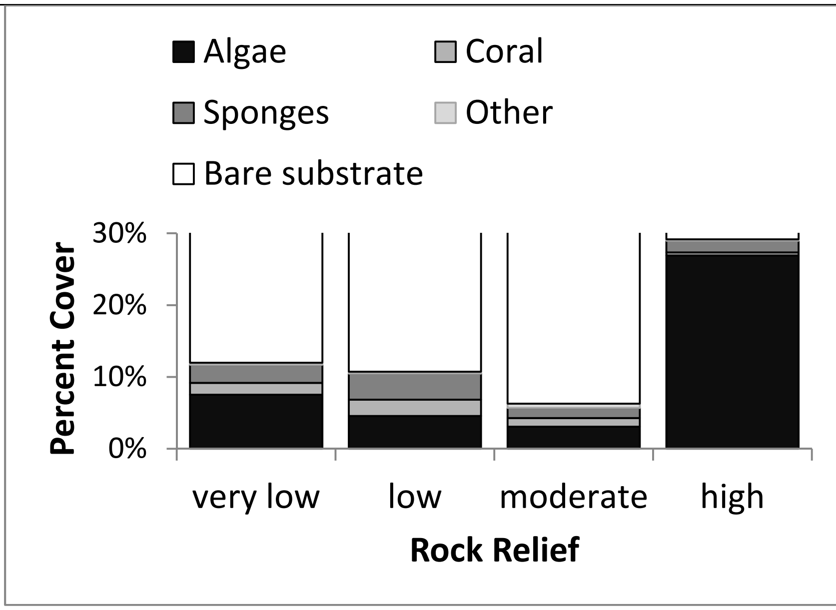

Figure 19. Mean percent cover of sessile invertebrate taxa (corals, sponges, other: includes other cnidarians, bryozoans and tunicates), algae and bare substrate across four reef relief classes (very low= <5 cm, low=6-25 cm, moderate=26-50 cm, high= >51 cm).

Table 2. List of sessile invertebrate species found on shallow (9 – 20 m deep) rocky reefs of Apalachee Bay in the northeastern Gulf of Mexico.

Category	Species	Abbreviation
Corals		
	Cladocora sp	TUB
	Siderastrea sp	SID
	Solenastrea sp	SOL
	Gorgonian	GORG
	Oculina sp	OC
	Cup coral	CupCoral
	Scolymia lacera	MUSH
Sponges		
	Axinella sp	AX
		Sme
	Orange encrusting	ORG1
	Haliclona sp	BL
	Ircinia sp	IR
	Red unknown	RI
	Cliona sp	CLI
	Dark red	DRK
	Spirastrella coccinea	SPI
	Blue unknown	BLU

	Gray black unknown	GIB
	Orange rope unknown	OrgRope
	Orange 3	O3
	Little Log	LittleLog
	Aplysina sp	APL
	Red unknown 3	R3
Other		
	Tunicate 1	Y2
	Colonial tunicate 1	CT
	Bryozoan *Schizoporella violacea*	SV
	Bryozoan *Eudistoma* sp.	EUD
	Cnidarian 1	CNI

Fish abundance— Two belt transects were surveyed at each of 15 study reefs in February 2011; video and visual counts provided both a visual and written records of the fish assemblages. A total of 28 fish species were recorded from all reefs across all transects (Table 3). Four species were observed at 14 out of the 15 reefs (black sea bass, *Centropristis striata*; white grunt, *Haemulon plumieri*; seaweed blenny, *Parablennius marmoreus*; belted sandfish, *Serranus subligaris*), one species (slippery dick, *Halichoeres bivittatus*) was observed at 13 of 15 reefs, all others were observed on fewer than 60% of reefs surveyed (Fig. 20).

Species density and total abundance were both significantly correlated with depth (Figures 21 and 22). Rarified richness was not significantly correlated with depth (Figure 23). When depth was considered by zone (shallow, <12 m; mid, 13-17m; deep, >18m), species density and total fish abundance both showed significant differences between zones (Figures 24 and 25). Pairwise comparisons of depth zones showed the same pattern for both species density and total fish abundance: shallow and deep zones were significantly different from each other but not from the mid zone (Figs. 24 and 25).

None of the response variables showed a significant relationship with any of the geomorphological characteristics tested ($p>0.05$).

Individuals of the five most commonly observed fishes were collected from reefs in transect 1 (furthest west). Collected specimens were frozen in the field and remain in frozen storage at the FSUCML for future analysis.

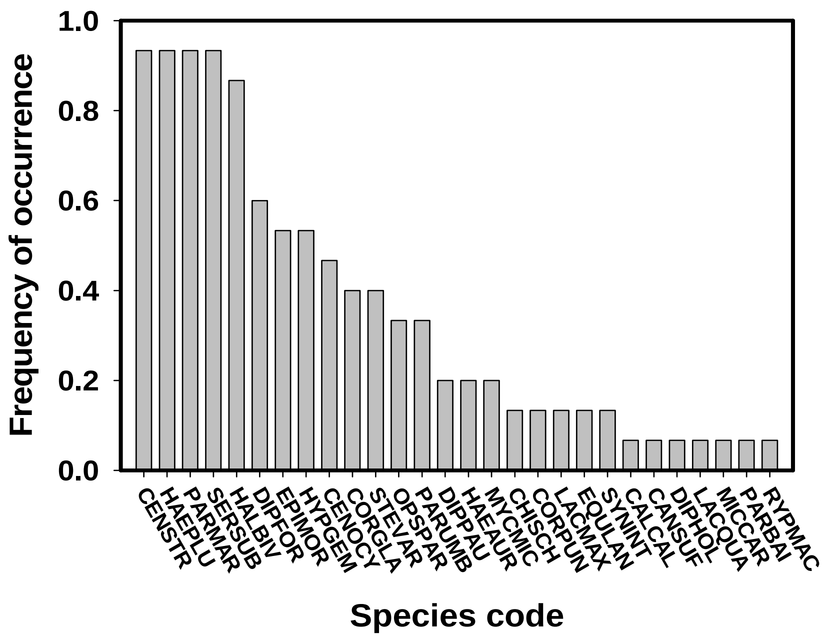

Figure 20. Frequency of occurrence for all fishes observed during visual surveys of Apalachee Bay study reefs conducted February 2011. Species and common names for codes are given in Table 3.

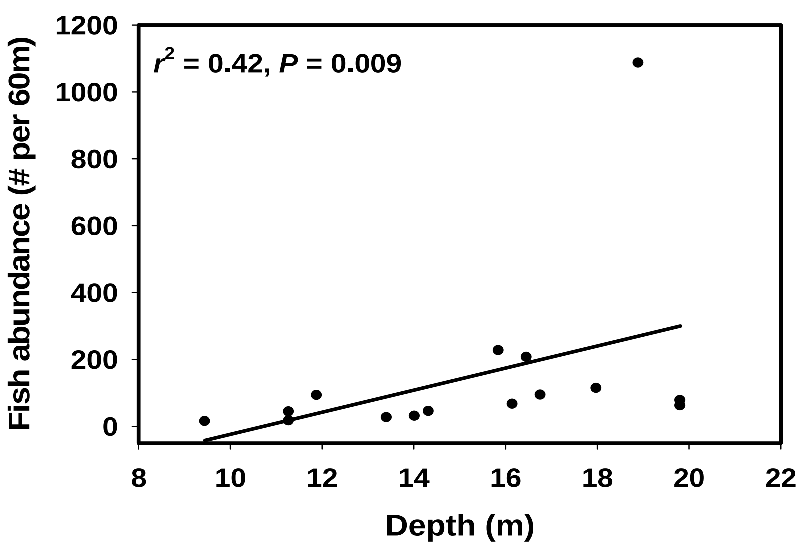

Figure 21. Relationship between total fish abundance from two 30m transects conducted at each site and depth. Raw data are plotted but statistical analyses proceeded with log transformed data. The single outlier was driven primarily by high abundances of juvenile tomtates.

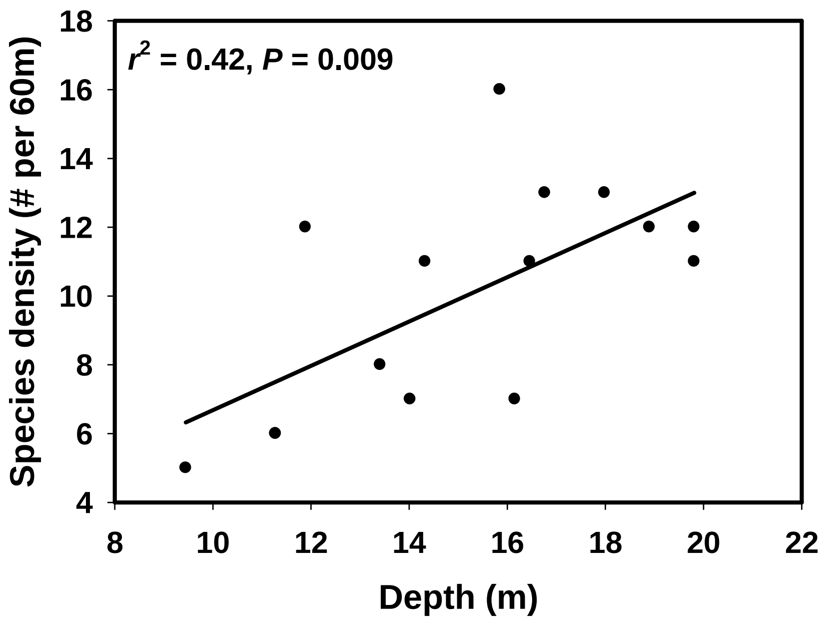

Figure 22. Relationship between species density (total number of species observed from two 30m transects) at each site across different depths.

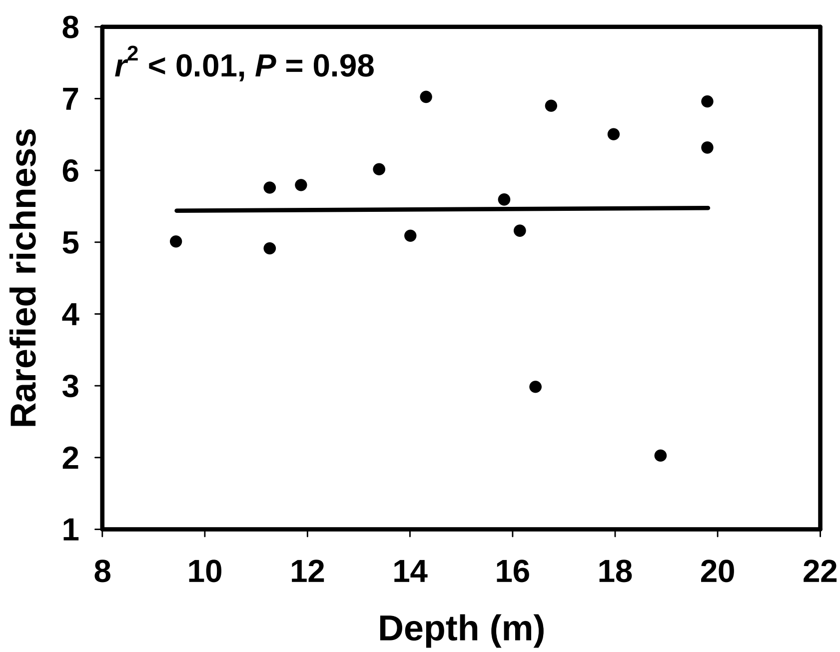

Figure 23. Relationship between rarefied fish species richness and depth.

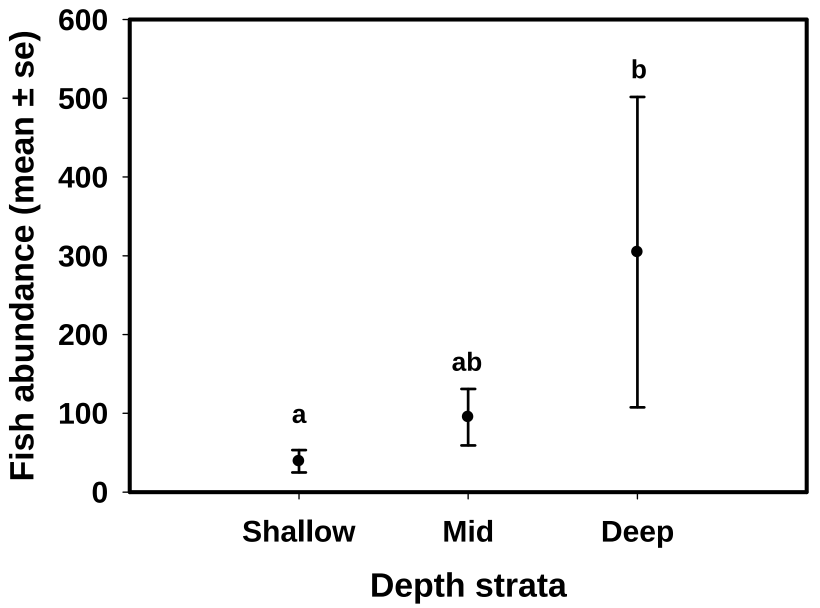

Figure 24. Mean (±se) fish abundance observed across three depth intervals (shallow = 9-12m , mid = 13-16m, deep = 17-20m).

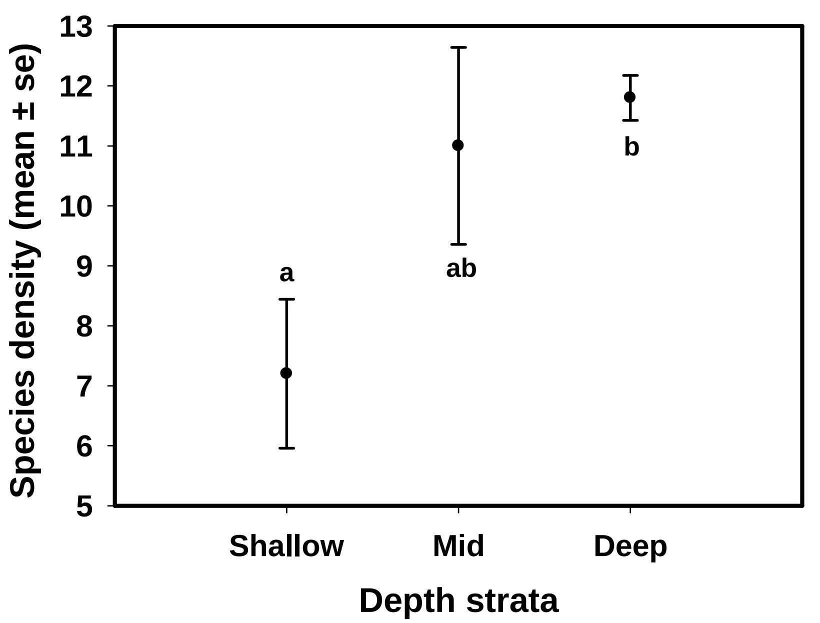

Figure 25. Mean (±se) species density of fishes observed across three depth intervals (shallow = 9-12m, mid = 13-16m, deep = 17-20m).

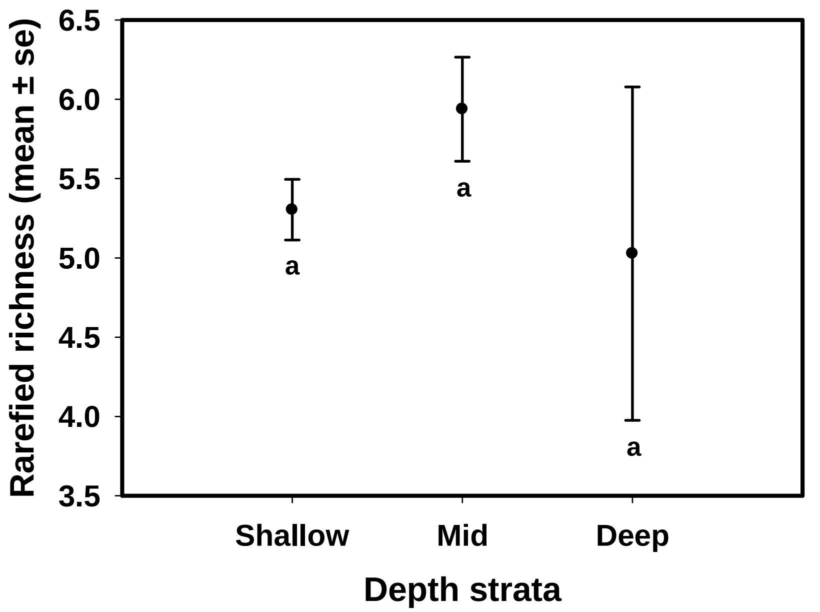

Figure 26. Mean (±se) rarefied richness of fishes observed across three depth intervals (shallow = 9-12 , mid = 13-16, deep = 17-20).

Table 3. Species of fishes observed during visual surveys conducted February 2011.

Family	**Species**	**Common name**	**Code**
Balistidae			
	Canthidermis sufflamen	ocean triggerfish	CANSUF
Batrachoididae			
	Opsanus pardus	leopard toadfish	OPSPAR
Blenniidae			
	Hypleurochilus geminatus	crested blenny	HYPGEM
	Parablennius marmoreus	seaweed blenny	PARMAR
Callionymidae			
	Diplogrammus pauciradiatus	spotted dragonet	DIPPAU
	Paradiplogrammus bairdi	lancer dragonet	PARBAI
Diodontidae			
	Chilomycterus schoepfii	striped burrfish	CHISCH
Gobiidae			
	Coryphopterus glaucofraenum	bridled goby	CORGLA
	Coryphopterus punctipectophorus	spotted goby	CORPUN
	Microgobius carri	seminole goby	MICCAR
Haemulidae			
	Haemulon aurolineatum	tomtate	HAEAUR
	Haemulon plumierii	white grunt	HAEPLU
Labridae			
	Halichoeres bivittatus	slippery dick	HALBIV

	Lachnolaimus maximus	hogfish	LACMAX
Ostraciidae			
	Lactophrys quadricornis	scrawled cowfish	LACQUA
Pomacentridae			
	Stegastes variabilis	cocoa damselfish	STEVAR
Sciaenidae			
	Equetus lanceolatus	jacknife fish	EQULAN
	Pareques umbrosus	cubbyu	PARUMB
Serranidae			
	Centropristis ocyurus	bank seabass	CENOCY
	Centropristis striata	black seabass	CENSTR
	Diplectrum formosum	sand perch	DIPFOR
	Epinephelus morio	red grouper	EPIMOR
	Mycteroperca microlepis	gag	MYCMIC
	Rypticus maculatus	whitespotted soapfish	RYPMAC
	Serranus subligaris	belted sandfish	SERSUB
Sparidae			
	Calamus calamus	saucereye porgy	CALCAL
	Diplodus holbrookii	spottail pinfish	DIPHOL
Synodontidae			
	Synodus intermedius	sand diver	SYNINT

Oil contamination—Results of the oil contamination analysis revealed oil contamination at all five reef sites tested (Table 4); eight of the ten tested samples had measurable oil contamination. Sediments, fish, and invertebrates collected during the spring sampling were not tested for oil contamination due to budgetary constraints.

Table 4. Oil contamination results from sediment samples collected from reef sites located along the westernmost NMFS survey transect collected in fall 2010.

Fall reef	Corresponding Spring reef	Lat	Long	Sample	Date Sampled	Total Petroleum Hydrocarbons (mg/Kg)
WS4	A1	84.333	29.782	B	10/13/2010	3.3
WS4	A1			E	10/13/2010	2.4
WS5	A1	84.333	29.784	B	10/12/2010	3.9
WS5	A1			E	10/12/2010	12.0
WM2	B1	84.324	29.701	B	10/12/2010	6.0
WM2	B1			E	10/12/2010	7.4
WD7	C1	84.302	29.589	B	10/13/2010	0.0
WD7	C1			E	10/13/2010	4.6
WD11	C1	84.303	29.595	B	10/13/2010	0.0
WD11	C1			E	10/13/2010	4.7

DISCUSSION

Reef habitat characteristics— Overall, habitat characteristics in our study area of Apalachee Bay vary greatly among reefs and this heterogeneity may explain the high biodiversity we encountered. Although characteristics such as rugosity and relief were somewhat similar among reefs, other characteristics such as sediment depth and cover, percent cover of rock, and reef area varied greatly among sites. We also demonstrated the utility of using a relatively inexpensive sidescan unit, the Humminbird, for mapping shallow marine reefs. Using the area calculation and a wide variety of additional quantitative metrics, we were able to characterize 15 reef sites with this instrument. These preliminary steps in characterizing the nearshore reefs of Apalachee Bay provide important baseline data and will benefit future studies in the area.

Sessile invertebrates—Some distinct patterns emerged from our shallow reef sessile invertebrate data . We found that sponges were more prevalent in the east and coral species were more prevalent in the west within our study area in Apalachee Bay. This pattern may be due to environmental conditions, such as nutrient or light availability. For instance, *Cliona sp*, a dominate sponge on our study reefs in terms of percent cover, is known to increase in abundance with increasing nutrient concentrations (Holmes 2000). Higher nutrient levels in the water may encourage planktonic algal growth, which in turn impedes light penetration thereby reducing photosynthesis of coral algal symbionts (called zooxanthelli). The nutrition of corals depends to a large extent on photosynthesis of these zooxanthelli, so resuced light penetration could possibly reduce coral growth and survival. Although it is not clear from our data, nutrient levels may be higher (lower light penetration) in the eastern part of our study area where sponges prevail and lower (more light penetration) in western part where corals prevail.

We also observed an increase in the percent cover of sponges with increasing depth. Again, *Cliona sp* was the prevalent species at the greater depths. The success of this species may be in part due to an increase of nutrient concentrations at deeper reefs. It may also be that corals are reduced in abundance at greater depths because of lower light penetration. These environmental relationships need further study.

Substrate relief and rugosity may have also played a role in percent cover of sponges. Sponges were prevalent on reefs with higher rugosity and relief, but corals were not. Sponges depend on filtration for food, which may be confounded by increased sedimentation rates. But, higher relief and greater rugosity, characteristics apparently preferred by sponges, may result from reduced sedimentation rates. *Cliona* sp., the dominant sponge of the area, because of its low profile, may require rocky substrate above shifting sediments, as on rocky prominences. Further supporting this hypothesis is the observation that sponges appear to grow larger on elevated ledges. Conversely, coral cover is higher in areas of low relief and very low rugosity. The most prevalent coral in this area, *C. arbuscula* (tube coral), may be more successful in these low relief reefs, closer to the sediment, because of their high profile. That is, sediment movement would not have as great an effect on them because of their greater distance above it than *Cliona* sp.

Fishes—The only significant factor that was found to explain the abundance and species density of fishes on the study reefs was depth (Figs. 21, 22, 24 & 25); no other measured variable was significantly correlated with either fish abundance or fish species density. Both the observed fish abundance per reef and the species density (total number of species observed per 2-30m transects) increased with depth. However, the relationship between rarefied richness and depth was not significant (Figs. 23 & 26), indicating that the pattern was driven by abundance. Pair-wise comparisons of depth zones showed the same pattern for both species density and total fish abundance: shallow and deep zones were significantly different from each other but not from the mid zone (Figs. 24 & 25).

The observed pattern of increased abundance and species density with increasing depth is interesting, but not surprising. Many fish species are known to leave shallow seagrass habitats in the fall and occupy near-shore reefs. Many other fish species are known to migrate offshore to spawn in the winter and spring months. Thus, we should expect to observe a seasonal pattern of fish abundance with depth that is negatively correlated in the summer and fall (as new individuals enter the reefs from the seagrass) and is positively correlated in the winter and spring (as older individuals migrate to deeper water). Further research is necessary to determine if the observed pattern (increasing abundance with depth) reflects seasonal dynamics or if it holds all year long.

Given that the reefs studied were standardized for complexity, it is not surprising that there was no correlation between observed patterns of fish abundance and diversity and geomorphological characteristics. Future research should include more variability in reef formation to determine if the abundance of fishes on these shallow reefs is correlated with reef complexity.

Oil contamination—Measurable oil was observed in samples collected in October 2010 at five reefs along the westernmost NMFS transect (transect #1). The reefs that were sampled in the fall, although not the same reefs visited in the spring of 2011, were in the general area and should be considered representitive samples (the fall reefs were standardized to the same geomorphological characteristics as the spring reefs). In general, the degree of contamination of the sediments in the fall samples was low and indicates that it may be that some very small amount of Gulf spill oil reached the sampled reefs but the data don't show a clear case of contamination.

None of the sediment samples analyzed in this project showed oil or oil component concentrations that were likely to directly harm the shallow reef environment or human health. All total hydrocarbon concentrations, polyaromatic hydrocarbon concentrations and concentrations of volatile and semi-volatile hydrocarbons were near or below the detection limit. Thus, any effects of these concentrations on the grouper, the associated faunal community or humans consuming grouper from this area can be excluded.

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Simpson EH. 1949. Measurement of diversity. Nature 163: 688.

13. Outreach activities:

N/A

14. Peer Reviewed Articles:

Not available yet.

15. Non-refereed articles and reports for this project:

Not available yet.

16. List conference presentations and poster presentations for this project.

Huettel, M., Kostka, J.E., Green, S., Prakash, O., Kaba, J., Canion, A. (2010). Rates and mechanisms controlling the microbial degradation of crude oil from the MC252 spill in Gulf of Mexico beach sands. Deepwater Horizon Oil Spill Conference, St. Petersburg, FL, October 5-6, 2010

Ruddy, B.M., McKenna, A. M., Podgorski, D.C., Rodgers, R.P., Huettel, M., Marshall, A. G. (2011). Compositional Analysis of BP Deepwater Horizon Oil Contaminated Pensacola Beach Sand by Ultrahigh-Resolution FT-ICR-MS., 59th ASMS Conference on Mass Spectrometry and Allied Topics, Denver, Colorado, June 5 - 9, 2011

Invited presentations, public lectures and seminars:

Huettel, M., Kostka, J.E., Green, S., Prakash, O., Kaba, J., Canion, A. (2010). Deepwater Horizon Oil in Gulf Beach Sands, " Long-term monitoring of Coastal Ecosystem Responses to the Deepwater Horizon Oil Spill" -- September 10-12 2010, Turnbull Conference Center, Florida State University

Huettel, M., Kostka, J.E., Green, S., Prakash, O., Kaba, J., Canion, A. (2010). The Deepwater Horizon Oil in Gulf Beach Sands. Florida State University, Public Lecture, 25 July 2010.

Huettel, M., Kostka, (2011). Crude oil in the Gulf of Mexico, oil spills, and the fate of the oil in the beach environment. Florida A&M University, March 4, 2011

17. Has anyone from this project been hired by NOAA during this reporting period?

No

10-BP_GRI-FSU-01 (Task 3b): Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge - Subproject: Potential for crude oil pollutants to concentrate in shelf-edge habitat engineered by fishery species

1. **NGI Project File Number:** 10-BP_GRI-FSU-01 (Task 3b)

2. **Project Title**:

Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge - Subproject: Potential for crude oil pollutants to concentrate in shelf-edge habitat engineered by fishery species

3. **Project Lead (PIs and Co-PIs):**

Name	Project Lead or Co-PI?	Affiliation	Email
Eric P. Chassignet	Lead	Florida State University	echassignet@coaps.fsu.edu
Felicia Coleman	Lead	Florida State University	coleman@bio.fsu.edu

4. **All Non-Student Personnel funded by this project:**

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Eric P. Chassignet	Lead	PhD	0	no
Felicia Coleman	Lead	PhD	0	no
Chris Koenig	Subproject PI	PhD	11	no
Markus Huettel	Subproject Co-PI	PhD	0	no

*If yes, list NOAA lab

5. All Students funded by this project:

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree Sought	% Salary funded from this project	Is individual located at a NOAA Lab?*
Bob Ellis	M. Sc.	Ph. D.	38	no
John Kaba	BS	BS	29	no
Lindsay Chipman	B. Sc.	Ph. D	10	No
Ian Hunter	High School	B. Sc.	0.4	No
Emily Hutchinson	B. Sc.	none	2	no
Chris Hagan	B. Sc.	BS	10	no
Brian Wells	B. Sc.	M. Sc.	3	no
Alan Fields	High School	B. Sc.	2	no

*If yes, list NOAA lab

6. Project Abstract:

This project investigated whether dispersed or particulate crude oil from the Deepwater Horizon oil spill reached the large sediment pits that are excavated by red grouper (*Epinephelus morio*). These pits, excavated and maintained by red grouper (Coleman et al. 2010), act as natural sediment traps and thus could also accumulate crude oil particles that settle out from the water column or are transported by currents along the sea bed. The continuous excavating activities of red grouper would mix the oil that accumulates in the pit into the sediments as the grouper moves sediments from the center of the pit to the rim. Sediment samples from grouper pits on the West Florida Shelf were retrieved on 26 July 2010 with the Johnson-Sea-Link II (JSL II) manned submersible (Harbor Branch Oceanographic Institute—Florida Atlantic University) from study sites in Steamboat Lumps Marine Reserve (SLMR) within a north (3795 Dive: 28.2044N- 28.2052N) and a south (3796 Dive: 28.2044N- 28.2036N) sampling area in about 70 m depth. Surface sediment samples were retrieved with a grab sampler by scraping the upper layer of the sediment. These sediment samples were analyzed for volatile and semi-volatile hydrocarbons and for a spectrum of polyaromatic hydrocarbons. As an indicator for prior oil contamination, nickel and vanadium were analyzed as these metals occur in relatively high concentrations in crude oil. A second set of samples was analyzed with sediments retrieved from grouper pits in the same area in May 2008, prior to the oil spill. None of the samples that were retrieved from the grouper pits had significantly elevated total petroleum hydrocarbon concentrations. Small amounts (3-5 mg/kg) of petroleum hydrocarbons were detected on the east side of our study area, scattered along the north-south extent of the survey. In one sample in the northern sampling area, trace amounts of polyaromatic hydrocarbons were detected as well. All oil concentrations were close to the detection limit (2.5 mg/kg) and a fingerprinting for the assessment of the origin of the oil, thus, was not possible. Interestingly, nickel and vanadium reflected possible earlier oil contamination, with increased concentrations in the

center and increasing concentrations toward the edge of the pits in the southern part of the study area. In the northern part, elevated nickel and vanadium concentrations were associated with the sample where polyaromatic hydrocarbons were found in trace amounts. These results cannot confirm that DWH oil has been deposited in the grouper pits but suggest that petroleum hydrocarbons may have been collected in the pits as indicated by the nickel/vanadium distributions. The reference samples collected prior to the oil spill contained only small amounts of total petroleum hydrocarbons (<12 mg/kg), however, while in 2008 only one surface sediment sample contained oil (2.8 mg/kg), 8 out of 10 samples in July 2010 contained total petroleum hydrocarbons (2.4-12 mg/kg) suggesting that small amounts of DWH oil may have reached this area.

7. Key Scientific Questions/Technical Issues:

The scientific questions addressed whether DWH oil accumulated in grouper pits on the West Florida Shelf and how it affected sediment biogeochemical properties. Specifically, the project addressed the following questions:

- Was Deepwater Horizon oil deposited in grouper pits and how much total petroleum hydrocarbons were mixed into the sediment by the fish?
- Can toxic polyaromatic hydrocarbons originating from the DWH oil be detected in the pits and would these concentrations be sufficient to cause harm to the diverse life in the pits?
- Did the deposited oil change the sediment characteristics and biogeochemistry in the grouper pits?
- Which factors determined the distribution of petroleum hydrocarbons and metals in the grouper pits area?
- Could measurable amounts of DWH oil reach the West Florida Shelf?

8. Collaborators/Partners:

Name of collaborating organization

Florida Department of Environmental Protection, Bureau of Laboratories

Date collaborating established

9/8/201

Does partner provide monetary support to project? Amount of support?

No

Does partner provide non-monetary (in-kind) support?

Yes

Short description of collaboration/partnership relationship.

FLDEP, Bureau of Laboratories, supported this project by student training on GC/MS and sharing information on protocols and procedures used for PAH analysis in oil-contaminated samples.

9. Project Duration: Start: July 15, 2010 End: December 31, 2010

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

The subsurface transport of oil and its deposition on the sea floor can have significant environmental and economical consequences. Red grouper (*Epinephelus morio*) pits on the West Florida Shelf represent natural sediment traps at about 70 to 100 m water depth and they are biodiversity hot spots and thus sensitive areas for oil contamination. Red grouper is a species of very high economic importance but is threatened by overfishing in certain parts of its range. Thus, deposition of crude oil in grouper pits could have severe ecologic and economic consequences. This project investigated whether these sensitive habitats were threatened by the DWH oil and whether any oil could be detected.

A comprehensive damage assessment of the BP disaster requires quantitative data from subsurface environments and data on the distribution and degradation of crude oil components. In this project, red grouper sites were targeted that are now considered beyond significant oil contamination. Results of this project indicate, however, that small amounts of DWH oil may have reached the area. This project also contributed to the education and training of graduate and undergraduate students.

NOAA Strategic Goal #1: Protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management

Red grouper is one of the most important reef fishes for Florida's commercial and recreational fisheries and is also threatened in parts of its range by overfishing. This project provides data on the oil deposition in red grouper pits and in a reference area and possible effects of oil contamination. These data are important for the assessment of potential oil impacts on the grouper population on the West Florida Shelf.

NGI Theme #4: Coastal hazards and resiliency

Due to extensive oil exploration in the Gulf, habitats in the eastern Gulf may be threatened by possible oil spills. This project provides data showing whether spills in the Mississippi region can influence sensitive habitats on the West Florida Shelf. The indicator metal analysis suggested that oil reached these habitats but had degraded by the time of sampling.

Gulf of Mexico Alliance Priority: Ecosystem Integration and Assessment

We are just beginning to understand the ecological importance of red grouper pits to the associated benthic community. These initial results and the studies of others (Coleman et al. 2010) indicate that these pits are key habitats and diversity hot spots. The destruction of this habitat thus can potentially have far reaching consequences. A thorough understanding of the processes that can affect these ecosystems is critical for their protection.

Gulf of Mexico Research Initiative Themes: Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery

The results of this project show the concentrations of oil that reached sensitive habitats on the West Florida Shelf. Based on this limited data set, any direct negative effects can be excluded, however, the data also suggest that higher oil concentrations may have reached the grouper pit area and degraded prior to sampling as indicated by the elevated Nickel and Vanadium concentrations.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

There is only a very limited amount of data available on red grouper pits and on the effect of DWH crude oil on subsurface habitats on the West Florida Shelf. Therefore, the data produced in this project provide important insights on potential effects of the DWH spill on these areas.

Contributions to BP_GRI goals:

- Spread of the oil and other contaminants and the fate of these components.
- Environmental effects of the oil spill on Gulf of Mexico ecosystems, and ecosystem recovery.
- Technology that could help detect and clean up offshore oil spills, and reduce their impact.
- Potential impact of the oil spill and response on human health

The project directly addressed three of the four BP_GRI goals listed above. The project investigated areas that were not in the direct impact zones of the oil spill and subsurface areas that could have been impacted by the subsurface oil plumes. The project also addressed potential ecological effects on one of the most important fish groups in the gulf and the sensitive ecosystem it generates as an ecosystem engineer. The analyses of PAHs conducted in this project relate directly to potential human health impacts as the grouper is one of the most popular fishes for human consumption in the Gulf region.

11. Milestones accomplished during entire project period:

Sediments sampled from red grouper pits in July 2010

- Sediments analyzed for total petroleum hydrocarbons, volatile and semi-volatile hydrocarbons
- Sediment analyzed for potentially toxic polyaromatic hydrocarbons
- Sediments analyzed for Nickel and Vanadium as indicators for prior oil contamination
- Reference samples analyzed from a 2008 research cruise to the same region prior to the oil spill.

12. Describe all significant research results, protocols developed, and research transitions.

None of the sediment samples analyzed in this project showed oil or oil component concentrations that could directly harm the environment, red grouper or human health. All total hydrocarbon concentrations, polyaromatic hydrocarbon concentrations and concentrations of volatile and semi-volatile hydrocarbons were near or below the detection limit. Thus, any effects of these concentrations on the grouper, the associated faunal community or humans consuming grouper from this area can be excluded. Nonetheless, the data suggest that the grouper pits function as traps for petroleum hydrocarbons and the concentration distributions of nickel and Vanadium support this conclusion. Figure 2, showing the results from the complete sampling transect from the south study area (see map, Fig. 1), indicates that in the center of the transect, vanadium and nickel concentrations reached a maximum and petroleum hydrocarbons were detectable (Fig. 3). Moving away from the center, V and Ni decreased first before the concentrations of both metals increased again towards the edge of the study area. Interestingly, petroleum hydrocarbons were detectable also in the sediments at the edge of the southern study area. V and Ni concentrations in this transect showed a weak positive correlation (R^2 =0.4), this was not the case in the northern study area.

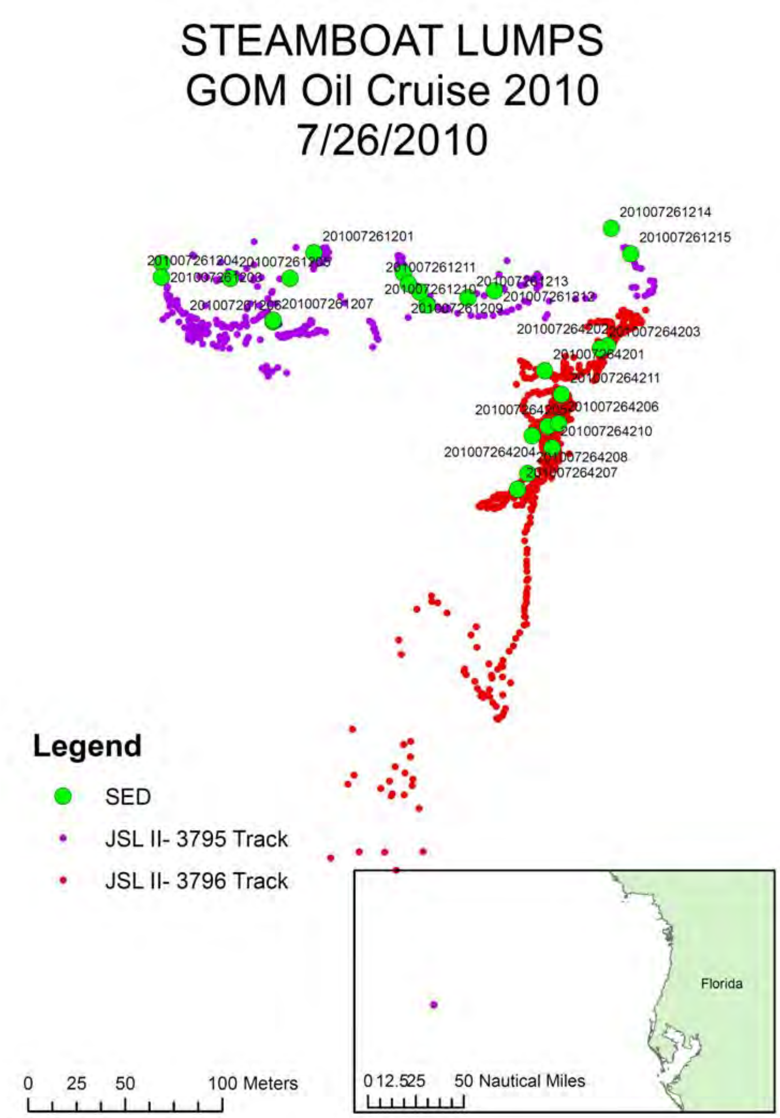

Fig. 1. Sample sites and sample numbers collected on the northern (Dive 3795) and southern (Dive 3796) sampling campaigns.

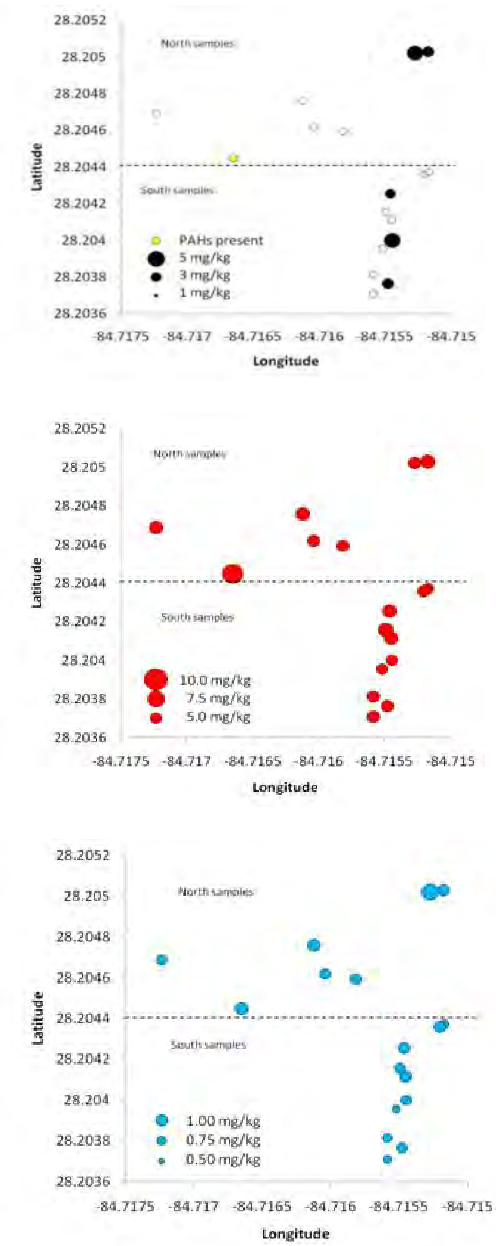

Fig. 2 Petroleum hydrocarbons, PAHs, Vanadium and Nickel distributions in the northern and southern study areas. Top: Petroleum hydrocarbons and PAHs detected in the northern and southern sampling tracks; middle: Vanadium detected in the northern and southern sampling tracks; bottom: Nickel detected in the northern and southern sampling tracks. Dot size reflects conc.

In the latter, oil again was detectable in the samples and also polyaromatic hydrocarbons (Figs. 2, 3). As V and Ni are indicators for crude oil and remain in the environment after the oil has been degraded, these results suggest that the grouper pits accumulated some oil in the past. It may be possible, that small particles of dispersed DWH oil from one of the subsurface plumes reached that area depositing some of these particles in the pits. As these particles were small and biological activity in the pits is relatively high due to the concentrated animal activities, these oil particles may have degraded relatively quickly leaving the V and Ni signatures. However, other oil sources of natural or anthropogenic origin cannot be excluded.

As in all samples retrieved from the grouper pits, total petroleum hydrocarbons were low, close to the detection limit. Nonetheless these samples showed an interesting trend: While in all samples (11) collected in 2008, total petroleum hydrocarbons could not be detected except in one sample (2.4 mg/kg), 8 of the 10 samples collected in October 2010 after the oil spill contained measurable amounts of total petroleum hydrocarbons (Fig. 4). Although fingerprinting could not be conducted due to the small amounts of oil present, this change between 2008 and 2010 suggests that some oil from the DWH accident may have reached the West Florida Shelf. However, there were no clear signs of impact, and red grouper pits had a similar suite of dominant species (Table 1) as we observed prior to the oil spill; published in Coleman et al. 2010.

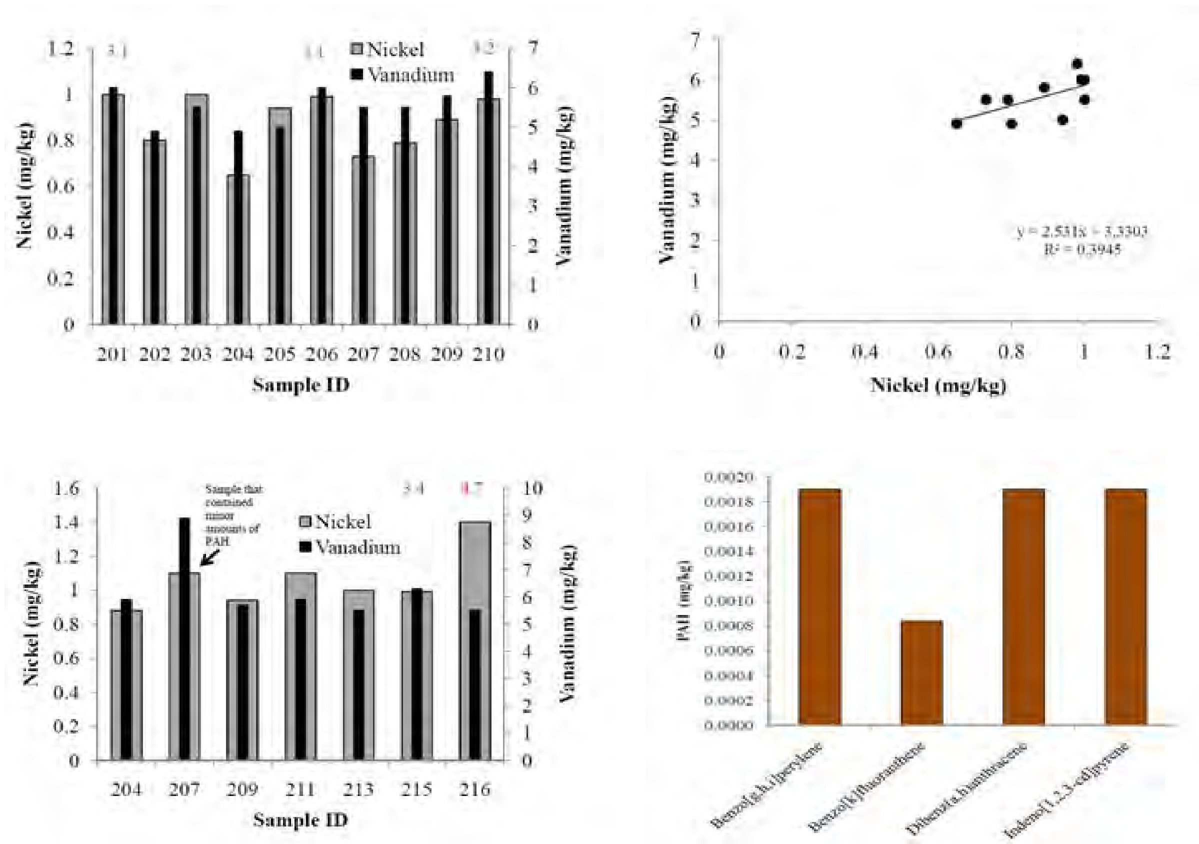

Fig. 3. Results from the sediment analyses. Upper left: Columns show V (black) and Ni (grey) concentrations along southern transect. Red numbers show total petroleum hydrocarbon concentrations. Upper right: Correlation between V and Ni. Lower left: Results from the sediments collected in the northern track. Lower right: Polyaromatic hydrocarbons found in sample 207 of the northern track.

N/A

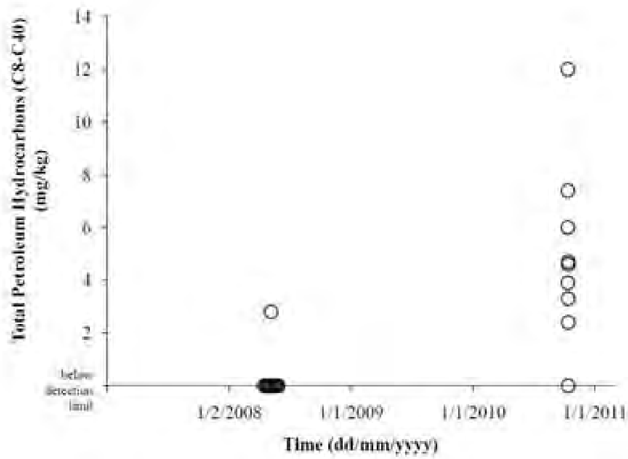

Fig. 4. Results from the total petroleum hydrocarbon analysis of the samples collected in the red grouper pits in 2008 and in October 2010 after the DWH oil spill. 2008 samples were total petroleum hydrocarbons could not be detected were plotted on different days on the X-axis to show the number of samples collected (11).

Table 1. Relative abundance of reef fish associated with 6 red grouper pits.

Common Name	Species	Abundance
Yellowtail Reef fish	*Chromis enchysura*	388
Red Barbier	*Hemanthisa vivanus*	148
Yellowfin Bass	*Anthias nicholsi*	60
Striped Grunt	*Haemulon striatum*	48
Bank Butterflyfish	*Chaetodon aya*	37
Squirrelfish	*Sarocenton bullisi*	36
Bank Seabass	*Centropristis ocyurus*	33
Roughtongue Bass	*Pronotogrammus martinicensis*	29
Two-spot cardinalfish	*Apagon pseudomaculatus*	26
Tattler	*Serranus phoebe*	21
Greenband wrasse	*Halichoeres bathyphilus*	19
Tomtate	*Haemulon aurolineatum*	13
Red Grouper	*Epinephelus morio*	8
Flame fish	*Apogon maculatus*	5
Scamp	*Mycteroperca phenax*	5
Reticulate moray	*Muraena retifera*	3

13. Outreach activities

N/A

14. Peer Reviewed Articles:

Not available yet.

15. Non-refereed articles and reports for this project:

Not available yet.

16. List conference presentations and poster presentations for this project:

Huettel, M., Kostka, J.E., Green, S., Prakash, O., Kaba, J., Canion, A. (2010). Rates and mechanisms controlling the microbial degradation of crude oil from the MC252 spill in Gulf of Mexico beach sands. Deepwater Horizon Oil Spill Conference, St. Petersburg, FL, October 5-6, 2010

Ruddy, B.M., McKenna, A. M., Podgorski, D.C., Rodgers, R.P., Huettel, M., Marshall, A. G. (2011). Compositional Analysis of BP Deepwater Horizon Oil Contaminated Pensacola Beach Sand by Ultrahigh-Resolution FT-ICR-MS., 59th ASMS Conference on Mass Spectrometry and Allied Topics, Denver, Colorado, June 5 - 9, 2011

Invited presentations, public lectures and seminars:

Huettel, M., Kostka, J.E., Green, S., Prakash, O., Kaba, J., Canion, A. (2010). Deepwater Horizon Oil in Gulf Beach Sands, " Long-term monitoring of Coastal Ecosystem Responses to the Deepwater Horizon Oil Spill" -- September 10-12 2010, Turnbull Conference Center, Florida State University

Huettel, M., Kostka, J.E., Green, S., Prakash, O., Kaba, J., Canion, A. (2010). The Deepwater Horizon Oil in Gulf Beach Sands. Florida State University, Public Lecture, 25 July 2010.

Huettel, M., Kostka, (2011). Crude oil in the Gulf of Mexico, oil spills, and the fate of the oil in the beach environment. Florida A&M University, March 4, 2011

17. Has anyone from this project been hired by NOAA during this reporting period? If yes, give date hired and NOAA duty station they were assigned to.

No

Literature Cited:

Coleman, F.C., C.C. Koenig, K.M. Scanlon, S. Heppell, S. Heppell, and M.W. Miller. 2010. Benthic Habitat Modification through Excavation by Red Grouper, *Epinephelus morio*, in the Northeastern Gulf of Mexico. The Open Fish Science Journal. 3:1-15.

10-BP_GRI-FSU-01 (Task 3c): Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge

1. **NGI Project File Number:** NGI file No. 10-BP_GRI-FSU-01 (Task 3c)

2. **Project Title:** "Impact of crude oil on coastal and ocean environments of the West Florida Shelf and Big Bend Region from the shoreline to the continental Shelf Edge "

3. **Project Lead (PIs and Co-PIs):**

Name	Project Lead or Co-PI?	Affiliation	Email
Jeff Chanton	pi	Florida State University	jchanton@fsu.edu
Kevin Craig	Co pi	Florida State University	Kevin.craig@bio.fsu.edu

4. **All Non-Student Personnel funded by this project**:

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Samantha Bosman	technician	BS	35%	No
Alejandra Mickle	Lab assistant	BS	10%	No

*If yes, list NOAA lab

5. **All Students funded by this project:**

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
James Nelson	Phd candidate	PhD	20%	No

*If yes, list NOAA lab

6. **Project Abstract:**

The effects of the oil spill from the Deepwater Horizon accident on the ecology of the Gulf of Mexico are still for the most part still not known. The overall impact is difficult to predict because critical baseline data are lacking to adequately distinguish effects of the oil from normal temporal and spatial variation in species abundances. Additionally, long-term data are generally lacking. The project developed by the Florida State University in response to this spill was an integrated study of the impact of oil on the coastal and ocean marine ecosystem of the northeastern Gulf of Mexico (NEGOM) , including the northern West Florida Shelf (WFS), extending from the Big Bend Region (BBR) west to Louisiana. Specifically this portion of the project as described below was to examine the impact on marine food webs that support fishery production.

The Deepwater Horizon oil spill was a large-scale tracer release. The pulse of carbon from the spill that entered the marine environment provided an opportunity to both better understand the functioning of coastal ecosystems and to investigate the effects of the spill on coastal food webs and fisheries.

- Baseline pre-impact samples have been obtained in Louisiana, Mississippi, Alabama and Florida.
- Post-impact samples have been collected along the Gulf Coast at a variety of sites from the Texas border to the Big Bend region of Florida.
- Offshore samples have been collected across the Gulf in September and in October.

Samples have been processed and 50 have been delivered for radiocarbon analysis but only a few results have been received from the AMS lab. The backlog for samples there is several months. Stable isotope results show clear site fidelity at sites across the region.

7. Key Scientific Questions/Technical Issues

We hypothesized that this pulse of dead carbon would be assimilated into the food web, with potential long-term effects on the capacity of coastal ecosystems to support living resources including fisheries. Our goals were to investigate (1) the effects of the spill on Gulf coast ecosystems with a particular emphasis on the trophic interactions and food web dynamics that support major fisheries in the Gulf. We use the natural abundance ^{14}C (radiocarbon) and ^{13}C, ^{15}N & ^{34}S to trace the fate of the oil, its derivatives, and associated dispersants into and through the coastal and offshore food web. Baseline pre-impact sampling was conducted. Results of post-impact sampling in this region will allow us to characterize the ^{14}C signature of coastal food webs prior to, during, and after oil impact as well as across a spatial gradient in impact severity, thus allowing us to effectively trace its effects through the food web. Our work examines both offshore and coastal communities and sediments.

8. Collaborators/Partners:

Monty Graham, Dauphin Island Sea Lab. Mandy Joye, Marine Sciences University of Georgia. Charlotte Brunner, University of Southern Mississippi, Kevin Dillon, University of Southern Mississippi.

9. Project Duration: List the start and end date of this project:
August 20, 2010 to March 31, 2011.

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

The project has contributed to NOAA's goal #1 "Protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management" and Goal #5. Provide critical support for NOAA's mission.

It is necessary to understand the role of the oil and associated hydrocarbons and their impact on associated food webs and trophic structures in the Gulf regions following this impact. Our work addresses the questions: Does carbon from the oil/dispersant enter the food web via microbial consumption and biomass production from oil/dispersant substrates and subsequent incorporation into the food web (e.g., the microbial loop)? Or through more direct means, perhaps entering via filter and deposit feeding organisms? Our long term objective is to determine the ^{14}C and stable isotopic (C, N, S) content of biomass, particulate organic carbon (POC), and sedimentary organic matter, prior to, during, and following the full impact of petroleum residues across this region. This assessment will aid in the restoration of the ecosystem. The work fits into the NGI themes of ecosystem-based management and effects of coastal hazards and resiliency. In terms of GOMA objectives we fit into objectives # 1, 2 and 3, water quality, habitat restoration and resiliency and ecosystem assessment. Our work is applicable to *Gulf of Mexico Research Initiative Themes of* Chemical evolution and biological degradation of the oil/dispersant systems and subsequent interaction with the marine and coastal ecosystems and Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery.

11. Milestones accomplished during entire project period.

Deliverables for this time period:

a. The radiocarbon composition of organisms, particulate organic carbon and sedimentary organic carbon will be characterized pre-impact along the northern Gulf Coast from both recently collected and archived samples. We have collected and prepared samples of crabs, oysters, shrimp, hermit crabs, snails, fish, sediment, and coquinas.

We have sent ~50 samples to the AMS (accelerator mass spectrometry) facility at the Woods Hole Oceanographic Institution. The backlog for samples there is several months and we don't have results back yet.

b. The stable isotopic composition of organisms, particulate organic carbon and sedimentary organic carbon will be characterized pre-impact along the northern Gulf Coast from both recently collected and archived samples. See below.

c. Early post-impact intrusion of petroleum and methane into the food web will be assessed. Results are pending receipt of analytical data.

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12. Describe all significant research results, protocols developed, and research transitions.

a. We have collected sample of consumer organisms and samples to access dissolved inorganic carbon from 10 coalstal and estuarine sites along the northern Gulf Coast from the Texas border to Apalachicloal Bay in Florida (Figure 1).

b. We have collect core samples from coastal and deepwater areas of the Gulf (Figure 1).

c. We have run stable isotope analysis on selected samples

d. Two students have been trained to prepare sample on the vacuum line for 14C

e. Two students have been trained to prepare and analyze samples for stable isotopic analysis.

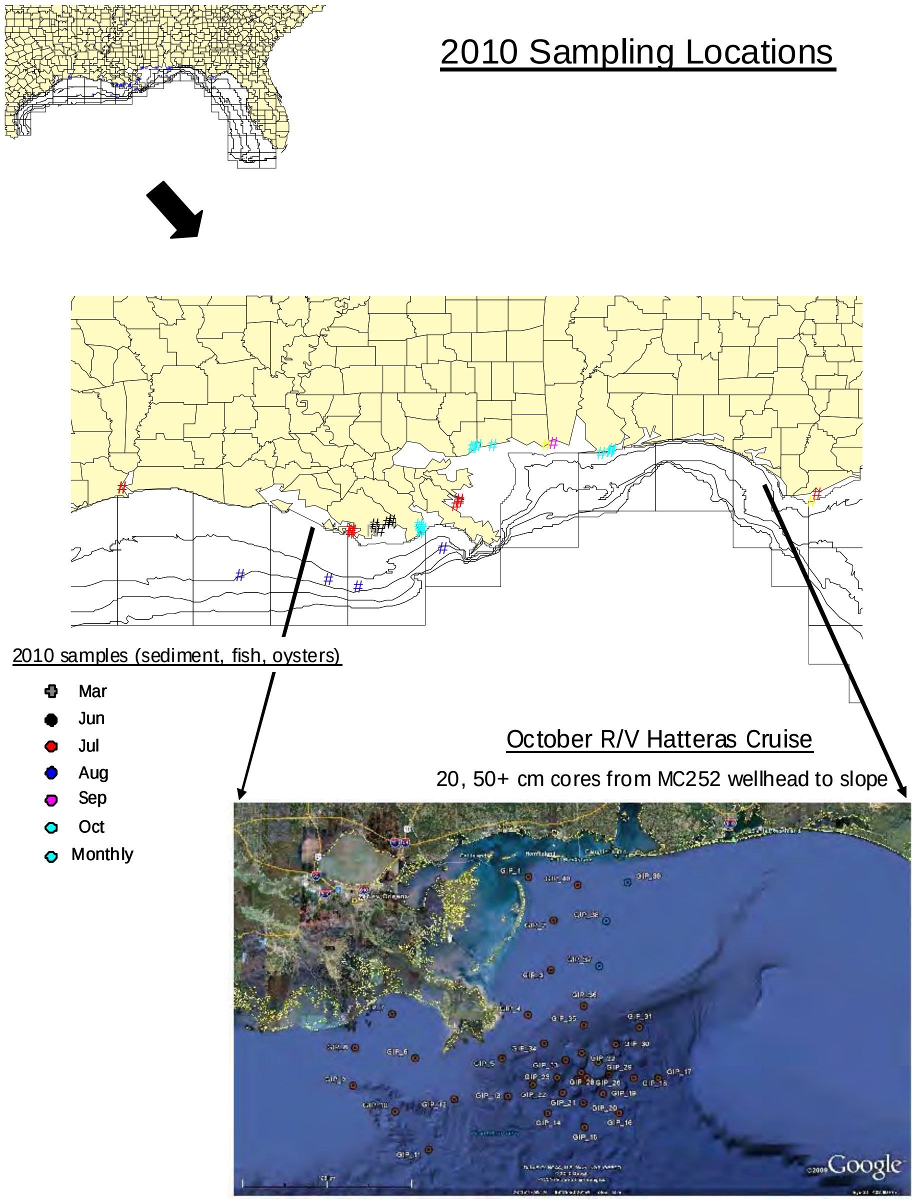


Figure 1. Sample sites where collections were made for this project.

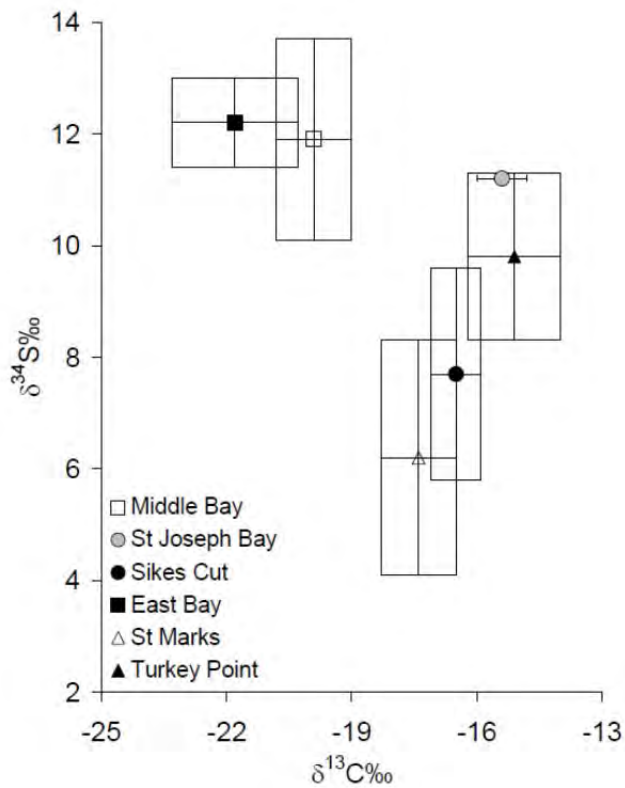


Figure 2. Biplot of flounder (*Paralichthys sp.*). Comparison of isotope values among sites along the Florida northern Gulf coast. Average values are represented by symbols with whiskers outlining one standard deviation in each axis.

Stable isotope results show strong site fidelity indicating that animals collected in an area will reflect the degree of impact to that area.

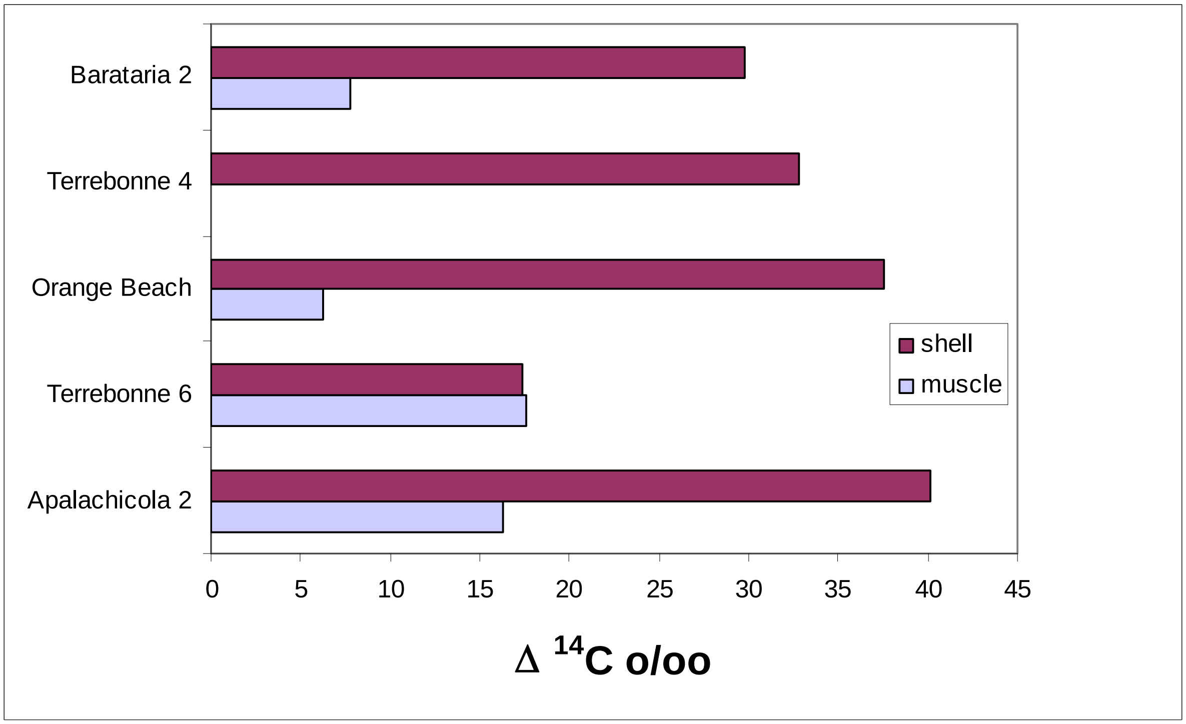


Figure 3. Preliminary radiocarbon results for oysters just received from the AMS lab. Results are reported as $\Delta^{14}C$ values in ‰. These values are all corrected to a common $\delta^{13}C$ value to adjust for isotopic fractionation between organic tissue and inorganic carbonates (shell). Note that organics are depleted in ^{14}C relative to shell material (smaller ^{14}C value indicates less radiocarbon) consistent with the hypothesis that the oysters have ingested some fossil (^{14}C-free) hydrocarbon material. Note that Barataria and Orange Beach have among the lower tissue ^{14}C values and these were the sites most exposed to hydrocarbon. These are results from only a few of the many samples we have collected and prepared for radiocarbon analysis and are offered only to illustrate the type of results we will soon obtain more of. The small number of data presented here are cannot be used to draw any conclusions.

13. Outreach activities:

Outreach. Jeff Chanton has conducted considerable outreach informing the public regarding the Deep Horizon oil spill. He has given public talks at the Dixie Theater in Apalachicola, the Gainesville Public Library, at Cabos Tacos, in Tallahassee, Waterworks in Tallahassee, Native Nurseries, in Tallahassee and at the FSU Panama City Campus. He arranged a major presentation on the oil spill in August for returning FSU undergraduate students and with Ian MacDonald gave a lunch time presentation on the oil spill to FSU faculty. This last effort has been broadcast on public television repeatedly. He plans to continue these efforts and has a public lecture scheduled for the FSU Coastal and Marine lab in January, 2011.

14. **Peer Reviewed Articles:**

None as yet.

15. Non-refereed articles and reports for this project:

None as yet.

16. List conference presentations and poster presentations for this project:

Presentation at NGI conference in May 2011.

17. **Has anyone from this project been hired by NOAA during this reporting period:**

No.

10-BP_GRI-HRI-01: Gulf of Mexico Research and Resource Support Tools (GulfBase, Gulf of Mexico Biodiversity Project, Gulf of Mexico books, etc.)

1. **NGI Project File Number:** 10-BP_GRI-HRI-01

2. **Project Title:**

3. **Project Lead (PIs and Co-PIs):**

Name	Project Lead or Co-PI?	Affiliation	Email
Larry D. McKinney	Project Lead	Harte Research Institute (HRI) for Gulf of Mexico Studies	larry.mckinney@tamucc.edu
John W. Tunnell, Jr.	Co-PI	Harte Research Institute (HRI) for Gulf of Mexico Studies	wes.tunnell@tamucc.edu

4. **All Non-Student Personnel funded by this project:**

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?
Fabio Moretzsohn	Assistant Research Scientist	Ph.D.	23%	no
Patrick Michaud	Programmer	Ph.D.	31%	no
Rosalie Rossi	Webmaster	M.S.	34%	no
Roland Dominguez	IT Research Manager	M.S.	8%	no

5. **All Students funded by this project:**

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?
Luke Eckert	Research Technician	B.S.	58%	no

6. **Project Abstract:**

One of the key goals of the Harte Research Institute (HRI) for Gulf of Mexico Studies since its endowment in 2000 and opening its doors in 2005 was to support and advance the long-term sustainable use and conservation of the Gulf of Mexico (GoMx), through its portal on Gulf of Mexico research resource, GulfBase.org. One of the early HRI projects was the Biodiversity of the Gulf of Mexico Project. HRI sponsored a comprehensive biotic inventory of the GoMx, and 140 taxonomic experts from 15 countries compiled a checklist, listing 15,419 species living in the GoMx. The checklist was then published as a book (Felder and Camp, 2009), by Texas A&M University Press. The book publication was Phase I of the biodiversity project; Phase II, which started before the publication of the book, was the conversion of the checklist into a database to be made freely available online. The distributional data were published through the Ocean Biogeographic Information System (OBIS) and other biodiversity portals, starting in January 2010. A richer database including all of the information from Felder and Camp (2009) had been in preparation. To increase spatial distribution, the Gulf was divided into eight

octants and six depth classes, thus resulting in 48 polygons. Next, each species was restricted, based on distribution, bathymetric range, habitat and biology, to those polygons with potentially suitable habitats within the ranges reported in Felder and Camp (2009).

Besides an updated taxonomy, global and GoMx distribution, the new BioGoMx database provides information on habitat, biology, bathymetric range, conservation status, pertinent scientific references, and endnotes. It also allows queries across taxonomic groups, depth, habitat and other parameters. The results are displayed as a list of species, which can be downloaded as a CSV file (comma-separated value). Clicking on any species on the list links to the species page; each of the over 15,000 species has its own page, with all of the information listed in Felder and Camp (2009). In addition, a map displays the distribution within the GoMx, with the polygons where the species has been recorded highlighted. The database also has links to direct searches on Google, Google Images, the Biodiversity Heritage Library, and the Encyclopedia of Life, and a comment window for users to provide corrections or submit new data, such as new records, or range expansions.

This proposal to NGI made possible the completion of development of the BioGoMx database with analytical tools, and placement on GulfBase to make it widely available to the research community. The new BioGoMx database was launched on March 8, 2011 at: http://gulfbase.org/biogomx. The database may prove useful for ongoing studies on the environmental impacts of the Deepwater Horizon oil spill on the rich fauna and flora of the affected region, including those from the deep Gulf. The book and database represent a pre-oil spill baseline. As results from studies on the impact of the oil spill become available, they can also be incorporated into the database, and flagged as post-spill data.

7. Key Scientific Questions/Technical Issues:

The key scientific questions of this project are: 1) What are the patterns of biodiversity in the GoMx?; 2) Where are the most at-risk species distributed in the Gulf of Mexico, i.e., are there geographic or taxonomic patterns of distribution of endangered or threatened species in the GoMx?; 3) What species lived near the site of the Deepwater Horizon's Macondo well before the oil spill?; 4) How were the different taxa affected by the Deepwater Horizon oil spill?; 5) How will the different species affected by the oil spill recover from the oil spill?

The main technical issues included: 1) How to make the information on GoMx biodiversity from Felder and Camp (2009) publicly available to maximize its usefulness to researchers?; 2) How can researchers studying the impact of the Deepwater Horizon oil spill use BioGoMx as a pre-oil spill baseline?; and 3) How to correct errors, updates, and incorporate new data stemming from new research as they become available?

8. Collaborators/Partners:

The original biotic inventory of the Gulf of Mexico, published as a book (Felder and Camp, 2009) had 140 authors as collaborating partners between 2004 and 2007. An estimated US$2 million of in-kind support were provided by the authors' institutions, and HRI provided over $500,000.

Then, the database was developed with several funding partners:

- Fernando Álvarez and Gema Armendáriz, UNAM, Mexico, and four authors of the book chapters (in-kind help in converting crustacean chapters into Excel, 2008);
- NOAA (funding of $24,000 in 2008 for checklist conversion);
- USGS/NBII/HARC (funding of $15,000 in 2008 for development of an online mapping tool);
- Sloan Foundation (funding of $45,000 in 2008 for checklist conversion; $100,000 in 2011 for development of additional analytical tools);
- Texas Research Development Fund ($36,868 in 2009 for database development);
- OBIS-USA (in-kind support, in 2009 for database development).

Felder, D.L. and D. K. Camp (eds.) 2009. Gulf of Mexico–Origins, Waters, and Biota. Volume 1, Biodiversity. Texas A&M University Press, College Station, Texas. 1393 pp.

9. Project Duration:

July 2, 2010 to March 31, 2011 (no cost extension)

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

The BioGoMx database and GulfBase.org contribute to NOAA's goal of protecting, restoring and managing the use of coastal and ocean resources through an ecosystem approach to management by making information about the Gulf of Mexico biodiversity and the distribution of marine species readily available to researchers and managers.

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

Gulfbase.org is a portal on Gulf of Mexico research. It functions as a social network for GoMx researchers, allowing them to find and connect with their peers, as well as information about scientific conferences and workshops related to the GoMx, regional environmental issues, bays, estuaries, reefs, etc. Although GulfBase is open to the public, it is primarily aimed at the scientific community. The new BioGoMx database now makes expert-vetted information about the marine biodiversity available to the researchers and natural resources managers. It is particularly pertinent to the region because it represents a biodiversity baseline prior to the Deepwater Horizon oil spill in 2010. Specific stakeholders interested in the BioGoMx include scientists performing studies on the environmental impact of the oil spill and monitoring, such as several researchers at NGI, NOAA and other institutions.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

Felder and Camp (2009), along with a cadre of 140 taxonomists, produced a comprehensive biotic inventory of the GoMx, with sound, expert-vetted and updated information and taxonomy. This inventory has narrowed many gaps in regional and taxonomic knowledge, and exposed others that need addressing, such as more research along the Mexican coast, especially in the southwestern quadrant, and several taxa (e.g. nematodes, aplacophorans, and priapulids, to name a few). Although the BioGoMx database is based entirely on Felder and Camp (2009), it considerably expands the book's usefulness because it allows for queries across taxa, including complex queries (e.g. which species of endangered species live between the depths of 20 and 60 m in the eastern Gulf of Mexico?). Queries like the latter are very difficult to answer with a paper checklist, but can be quickly answered with a database. Additionally, by making the entire database freely-accessible on GulfBase, it opens access to everyone interested in the GoMx, including researchers without access to the book. Even for those with access to the book may prefer to use the electronic version, instead of the massive, 7.5-pound book.

Another advantage of an electronic database is the possibility to correct errors, update information, and add new data as they become available, for example, from the extensive on-going collecting effort in response to the Deepwater Horizon oil spill, which is likely to generate more in-depth knowledge on the biota of the affected areas.

Contributions to BP_GRI goals:

This project contributes to the BP_GRI goals of listing all of the biodiversity in the GoMx, including the species found in coastal water, as well as those which inhabit the deep Gulf. This will contribute to the science of ecosystem recovery and monitoring studies, as well as natural resources management.

11. Milestones accomplished during entire project period:

The main milestones accomplished in the project include the completion of the BioGoMx database development and its placement on GulfBase. The final launching of the database occurred on Mar. 8, 2011, a little behind the proposed schedule, but it is currently fully operational. It already has analytical tools, which allow users to conduct complex queries across the entire database, and the representation of species distribution in the GoMx. Currently, new analytical tools are being developed, with financial support of the Alfred P. Sloan Foundation, including the mapping of species richness based on a query. The database homepage is located at: http://www.gulfbase.org/biogomx/.

12. Describe all significant research results, protocols developed, and research transitions:

The BioGoMx database is entirely based on the comprehensive biotic inventory of the Gulf of Mexico, compiled by 140 taxonomists and edited by Felder and Camp (2009). It lists 15,419 species, arranged in 79 chapters, and covers all biodiversity. Despite the editors tremendous efforts to make all chapters and checklists as standard as possible, the nature of individual taxa demanded some departures from the norm, for example, to include hosts for parasitic species, and exclude depths for marine birds. Also, each taxon has unique biological traits, or lives in unique habitats. Therefore, the conversion from the original manuscripts in MS Word to MS Excel required that each chapter be converted individually, and then combined into a "master spreadsheet" in MS Excel.

To increase spatial resolution of the data, the Gulf was divided into eight octants and six depth classes, thus resulting in 48 polygons. The species entries in MS Excel were then updated to restrict each species to the polygons with potentially suitable habitats within the species' bathymetric and geographic range. This "master spreadsheet" was then exported in CSV format to be processed by a set of custom PHP scripts running on the GulfBase server. One script is used to process the raw spreadsheet data into data files that are structured and indexed for rapid search and retrieval. During this processing, checks are performed to identify potential inconsistencies or errors in the spreadsheet so they can be investigated and corrected. Other PHP scripts then provide the web interface to the database, including full text and per-field searches, display of species information, generation of maps, and data export.

It should be pointed out that the distribution reported in the database DOES NOT correspond to individual specimens or observations, but rather represents the probable distribution of the species in the GoMx as judged by the expert. In an attempt to refine the resolution of distribution, the GoMx distribution was divided in eight octants and six depth classes. Jorge Brenner, formerly at HRI and now at The Nature Conservancy, developed the set of 48 polygons (8 octants x 6 depth classes) in a GIS, based on the bathymetry of the GoMx, and an arbitrary point, approximately the centroid of each polygon, was assigned to represent each polygon. Potential caveats of this approach include an overestimation of the species true distribution when the GoMx distribution was reported (in the book) as occurring in all four quadrants, and in all depth classes spanned by the depth range. Expert advice is requested from taxonomists to correct and minimize species distribution overestimation; corrections should be submitted via the comments window at the bottom of each species page in BioGoMx.

To query the BioGoMx database, the user fills out the desired search terms in the search form at the database's homepage (http://gulfbase.org/biogomx/) (Figure 1 below). At the top of the search form is a free-form field that queries the entire database; it can even search through the references and endnotes. Below the free-form field is a series of drop-down menus for some of the more widely used taxonomic levels, then one for habitat and biology descriptors, the eight GoMx octants, and finally depth range.

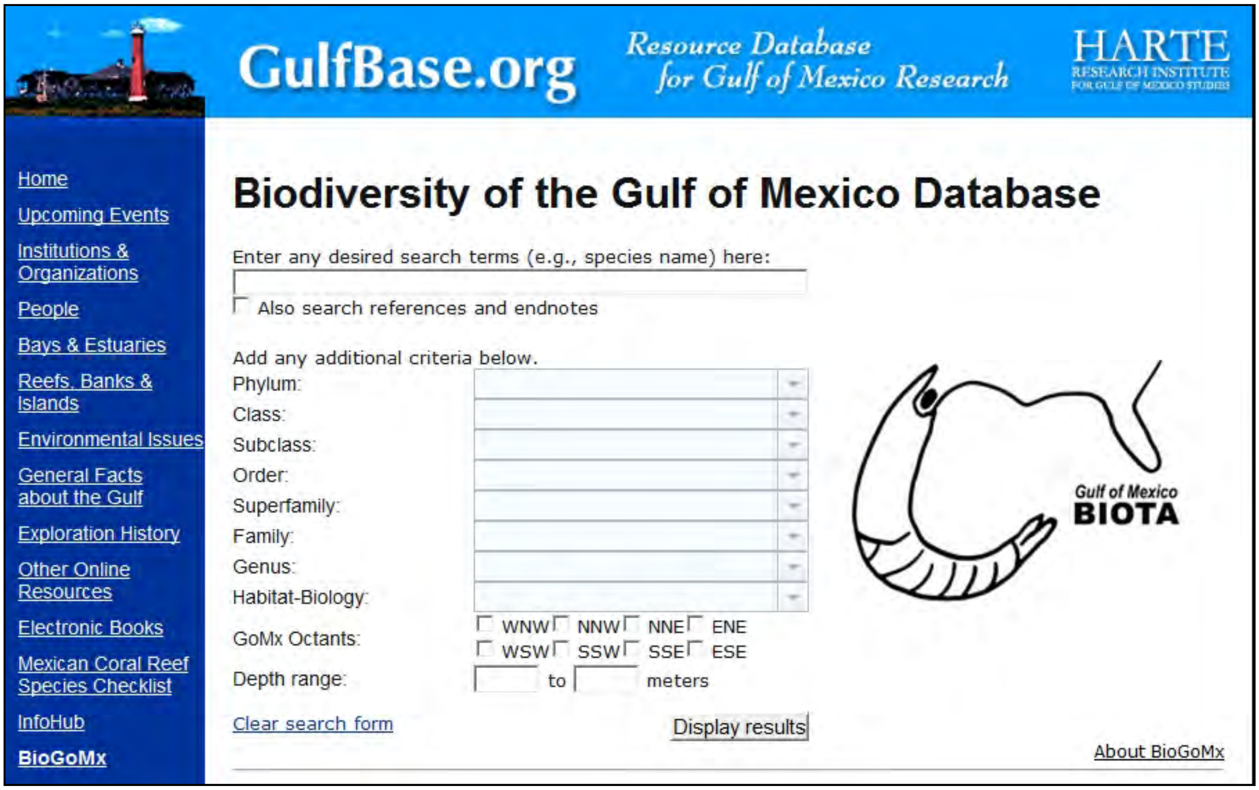
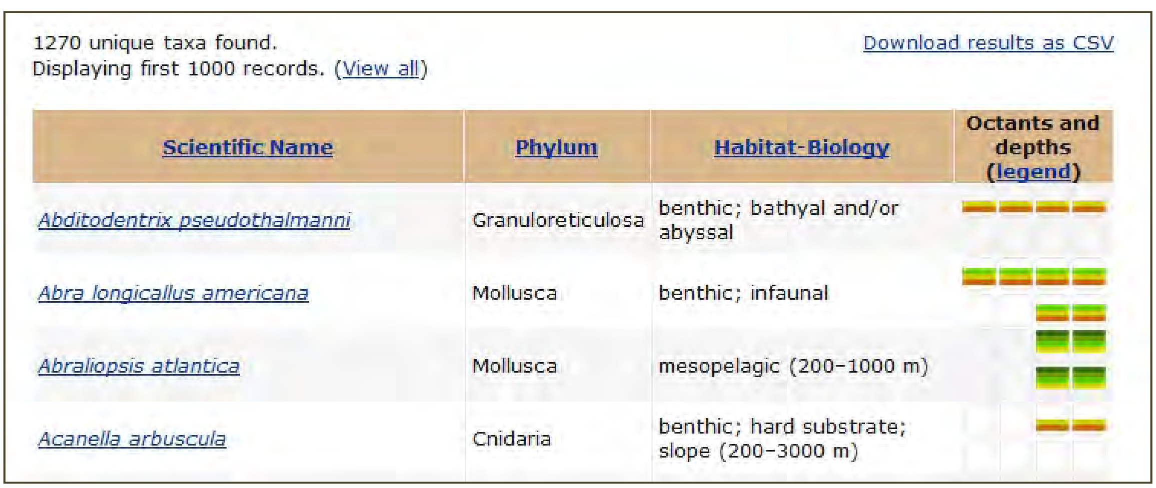


Figure 1. BioGoMx search form.

Once a query is performed, the database lists the results below the search form. At the top of the result list it provides the number of records found that correspond to the query. Next, there is a list of all species found, with the phylum, habitat-biology, and a graphic representation of each species distribution in the eight GoMx octants and depth range, illustrated by colored bars (Figure 2). The results are displayed in alphabetical order by species name by default, but can be re-sorted by phylum or habitat-biology. The results can be downloaded as a CSV (comma-separated values) file.



1270 unique taxa found.
Displaying first 1000 records. (View all)

Download results as CSV

Scientific Name	Phylum	Habitat-Biology	Octants and depths (legend)
Abditodentrix pseudothalmanni	Granuloreticulosa	benthic; bathyal and/or abyssal	
Abra longicallus americana	Mollusca	benthic; infaunal	
Abraliopsis atlantica	Mollusca	mesopelagic (200–1000 m)	
Acanella arbuscula	Cnidaria	benthic; hard substrate; slope (200–3000 m)	

Figure 2. Search results list.

Each species in the database has its own webpage, with all of the data from the book (Felder and Camp, 2009). In addition, there is a graphical representation, on a map, of its distribution in the GoMx, in octants and depth classes, with all of the polygons (out of the possible 48) with suitable habitat highlighted (Figure 3). The species page notes any changes from data in the book, a citation of the book chapter, and database citation. It also provides links to direct searches on the species in question on Google, Google Images, Encyclopedia of Life, World Register of Marine Species, and OBIS. Finally, there is a listing of a complete taxonomy, and a window for user comments or corrections for that species (Figure 4). For more information on the database and tutorials on how to use it, please refer to "About the database" page at: http://gulfbase.org/biogomx/about.php.

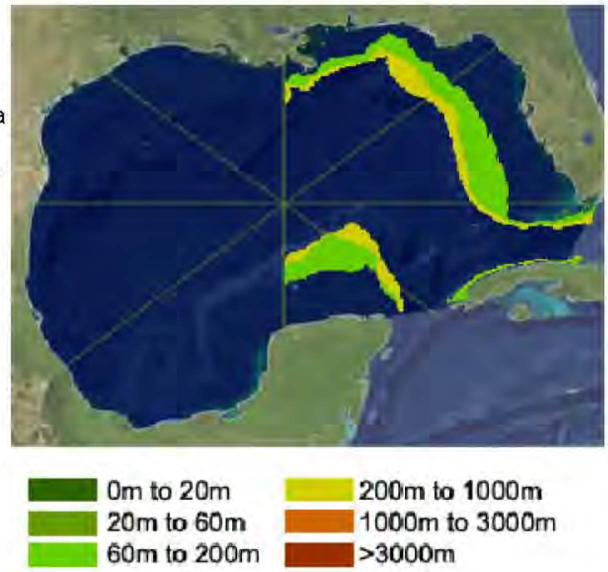
Some of the results obtained from querying the database include the following: 1) The most diverse (in species richness) GoMx quadrant was the NE (with 8897 species), followed by SE (7524 species), NW (5594 species) and SW (5209 species). 2) A total of 8295 species where found in the NNE octant prior to the oil spill (the second most diverse octant in the GoMx overall); of those, the depth class between 1000-3000 m, which included the Macondo well, had the highest species richness in the GoMx, with 1270 species (the octant with the second highest species richness at that depth class was ENE, with 1240 species).

Biodiversity of the Gulf of Mexico Database (BioGoMx)
About the database Another search

Celleporaria advena (Smitt, 1873)

Taxonomy

Phylum	Bryozoa
Class	Gymnolaemata
Order	Cheilostomatida
Superfamily	Lepralielloidea
Family	Celleporariidae
Genus	*Celleporaria*
Species	*advena*
Author	Smitt, 1873



Distribution, Habitat, and Biology

GoMx range	ne, se
Min depth (m)	73
Max depth (m)	212
Overall geographic range	Gulf of Mexico
Habitat-Biology	epibenthic encrusting; endemic to Gulf of Mexico

References

Smitt, F. A. 1873. Floridan Bryozoa, collected by Count L.F. de Pourtales, Part II. Kongliga Svenska Vetenskaps-Akademiens Handlingar 11, no. 4: 3–83.

Winston, J. E. 2005. Re-description and revision of Smitt's "Floridan Bryozoa" in the collection of the Museum of Comparative Zoology, Harvard University. Virginia Museum of Natural History Memoir 7: 1–152.

Endnotes

FSBC I 066875. EJ66455 / Hourglass Sta. E / 27°37'N, 84°13'W / depth: 73.2m.

Changes from the book

Added keyword "endemic to Gulf of Mexico"

Data from: Winston, J. E. and F. J. Maturo Jr. 2009. Bryozoans (Ectoprocta) of the Gulf of Mexico, Pp. 1147–1164 in Felder, D.L. and D.K. Camp (eds.), Gulf of Mexico–Origins, Waters, and Biota. Biodiversity. Texas A&M Press, College Station, Texas.

BioGoMx citation: Moretzsohn, F., J. Brenner, P. Michaud, J.W. Tunnell, and T. Shirley. 2010–2011. Biodiversity of the Gulf of Mexico Database (BioGoMx). Version 1.0. Harte Research Institute for Gulf of Mexico Studies, Texas A&M University-Corpus Christi, Corpus Christi, Texas.

Figure 3. Species page for *Celleporaria advena*.

Links to external resources

Search for "*Celleporaria advena*" in:

- Google
- Google Images
- Encyclopedia of Life
- World Register of Marine Species (WoRMS)
- OBIS mapper

Complete taxonomy

Kingdom	Animalia
Phylum	Bryozoa
Class	Gymnolaemata
Order	Cheilostomatida
Suborder	Ascophorina
Infraorder	Umbonulomorpha
Superfamily	Lepralielloidea
Family	Celleporariidae
Genus	*Celleporaria*
Species	*advena*
Author	Smitt, 1873

Comments about *Celleporaria advena* (Smitt, 1873) (Spp-68-0173)

This record currently has 0 comments.

Add a new comment:

Your email address: Submit comment

gulfbase.org/biogomx/biospecies.php?... 2/2

Figure 4. Continuation of the species page for *Celleporaria advena*.

13. Outreach activities:

This project was announced to the Gulf of Mexico science and management community, as well as the public, on March 8, 2011 via HRI News Winter 2011 (the HRI electronic newsletter). There were not any other specific outreach activities associated with the project.

14. Peer Reviewed Articles:

Fautin, D., Dalton, P., Incze, L. S., Leong, J.A. C., Pautzke, C., Rosenberg, A., Sandifier, P., Sedberry, G., Tunnell, J. W., Jr., Abbott, I., Brainard, R. E., Brodeur, M., Eldredge, L. G., Feldman, M., Moretzsohn, F., Vroom, P. S., Wainstein, M., and N. Wolff. 2010. An overview of marine biodiversity in United States waters. PLOS One 5(8): e11914. doi:10.1371/journal.pone.0011914.

15. Non-refereed articles and reports for this project: List all other articles about this project:

Brenner, J., Moretzsohn, F., Tunnell, J. W., Jr., and T. Shirley. 2010. Gulf's biodiversity online. HRI News, Winter 2010.

Moretzsohn, F. and P. Michaud. 2011. Biodiversity of the Gulf of Mexico Database debuts on GulfBase.org. HRI News, Winter 2011.

Moretzsohn, F., J. Brenner, P. Michaud, J.W. Tunnell, and T. Shirley. 2011. Biodiversity of the Gulf of Mexico Database (BioGoMx). Version 1.0. Harte Research Institute for Gulf of Mexico Studies (HRI), Texas A&M University-Corpus Christi (TAMUCC), Corpus Christi, Texas. http://gulfbase.org/biogomx/

16. List conference presentations and poster presentations for this project:

Tunnell, J. W., Jr. 2010. Biodiversity status of the Gulf of Mexico region. Integrated assessment and management of the Gulf of Mexico large marine ecosystem. Workshop: Invasive species and other drivers of biodiversity change in the Gulf of Mexico. CONABIO, Mexico City, Mexico, Sept. 8, 2010. [oral presentation by T.C. Shirley]

Tunnell, J. W., Jr., Moretzsohn, F., Felder, D. L. and D. K. Camp. 2010. Comprehensive regional assessment of known biodiversity in a large marine ecosystem: the Gulf of Mexico effort. The J. Frederick Grassle Science Symposium on the Census of Marine Life, The Royal Society, London, U.K., Oct. 5–6, 2010. [poster]

Moretzsohn, F., Michaud, P., and J. W. Tunnell, Jr. 2010. GulfBase.org: a resource database for Gulf of Mexico Research. Gulf and Estuarine Research Society Meeting, University of Texas Marine Science Institute, Port Aransas, Texas, Nov. 3–4, 2010. [oral presentation]

Moretzsohn, F., Tunnell, J. W., Jr., Brenner, J., Shirley, T. C., and P. Michaud. 2010. Pre-BP oil spill biotic benchmark: the Biodiversity of the Gulf of Mexico Database. Gulf and Estuarine Research Society Meeting, University of Texas Marine Science Institute, Port Aransas, Texas, Nov. 3–4, 2010. [poster]

Moretzsohn, F., Tunnell, J. W., Jr., Brenner, J., Shirley, T. C., and P. Michaud. 2011. Using the Biodiversity of the Gulf of Mexico Database as a tool for conservation of marine species. 2nd International Marine Conservation Congress, Victoria, Canada, May 14-18, 2011. [oral presentation]

Additionally, McKinney and Tunnell have mentioned the BioGoMx database and GulfBase in their numerous presentations at conferences, workshops and focus groups, although they have not given any presentations dedicated to the project.

17. Has anyone from this project been hired by NOAA during this reporting period?

No

10-BP_GRI_LSU-01 (Task 1): Impact of the Deepwater Horizon Oil Spill on the Louisiana Coastal Environments - Subtask: Water Quality in Barataria and Lake Pontchartrain)

1. NGI Project File Number: 10-BP_GRI_LSU-01 (Task 1)

2. Project title (exactly as submitted in proposal): Impact of the Deepwater Horizon Oil Spill on the Louisiana Coastal Environments - Subtask: Water Quality in Barataria and Lake Pontchartrain)

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI?	Affiliation	Email
R. Eugene Turner	Project Lead	LSU	euturne@lsu.edu
Nancy N. Rabalais	Co-PI	LUMCON	nrabalais@lumcon.edu

4. All Non-Student Personnel funded by this project (including those listed above):

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
JM Lee	Research Assoc.	M.S.	1.5 mo	No
EM Swenson	Research Assoc.	M.S.	1 mo	No
CM Milan	Research Assoc.	M.S.	1 mo	No
W Morrison	Research Assoc.	M.S.	1 mo	No
R. Eugene Turner	Project Lead	Ph.D	0	No
Nancy N. Rabalais	Co-PI	Ph.D	0	No
Danielle Richardi	Research Assoc.	M.S.	1 mo	No

*If yes, list NOAA lab

5. All Students funded by this project (including those listed above):

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
none				

*If yes, list NOAA lab

6. Project Abstract (500 words or less):

We collected monthly samples from the Barataria and Lake Pontchartrain estuaries and one offshore station, from July 2010 to December, 2011 to (a) make comparisons with the long-term data record (+10 years), (b) assess if the Deepwater Horizon oil 'spill' significantly affected water quality, and (c) address the health of the ecosystem(s). Our primary focus is on dissolved nutrients, phytoplankton, microbes, and oil; importantly, we also collect water samples for others as time and space allows – thus continuing our indirect participation with others.

7. Key Scientific Questions/Technical Issues: (500 words or less):

The point of this data collection is to assess if water quality changed as a result of the Macondo BP oil spill in Lake Pontchartrain and Barataria Bay. We have made monthly sample collections stations in the Barataria watershed at 37 stations sampled since 1994 and eight stations since 1999. Seven stations on the Causeway over Lake Pontchartrain have been sampled since 1996. These two time-series measurements. They provide excellent baseline data for what is recognized as an essential component of modern environmental science. There is no way to re-assemble a missed opportunity. The technical issues are to maintain the sampling grid and to have a long-enough time series to test for differences. The scientific questions include documenting how much oil is present, whether it is from the Macondo 252 block (from the spill), and whether ancillary oil-spill response measures like the opening of the Davis Pond diversion, affects our interpretation of changes.

8. Collaborators/Partners: NA

9. Project Duration: List the start and end date of this project (if applicable, include only *approved* No Cost Extension end date) 1 July 2010, through 15 May 2011.

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

Water quality changes, or lack thereof, are being documented. The dispersion of the oil and the background concentrations before and after the oil spill are documented.

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

The effects of 2010 oil spill concern the entire GOM community. This is self-evident by the billions of dollars in fines that are in discussion through the NRDA process.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

We are able to demonstrate (preliminary conclusions) that the introduction of the oil to the estuary had minimal levels of impact on the water quality parameters measured, and that the amount of oil dissolved in the water are small relative to the background values. The changes to the microbial community are harder to discern, and we are awaiting the results of sampling from jan. to june, 2011 to come to a conclusion about this. The opening of the Davis Pond Diversion during the oil spill appears to have had a measurable effect on salinity and water quality in Barataria estuary.

Contributions to BP_GRI goals:

We responded with appropriate analyses measuring impacts from the oil spill on water quality.

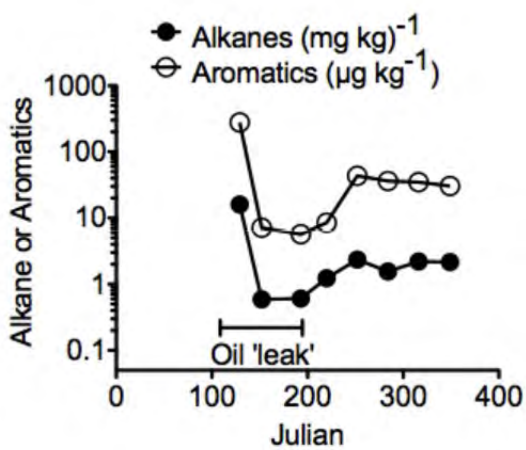
11. Milestones accomplished during entire project period. List major milestones completed (in terms of the project proposal).

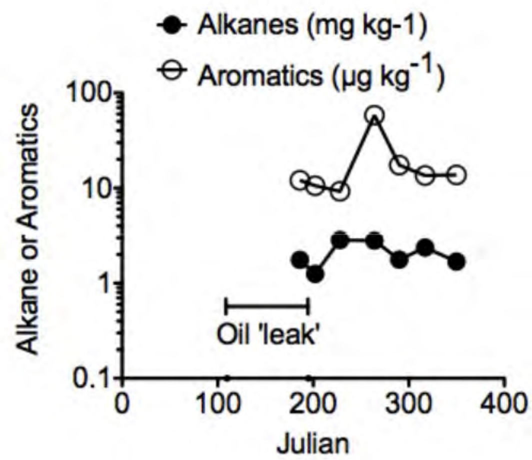
All monthly field sampling took places for each of the 6 months, at the locations identified in the proposal. Data on nutrients, pigments, oil and phytoplankton composition were analyzed at the end of the contract (extended by several months). Everything is done, but more time is needed to incorporate the data now being collected for January to June, 2011 (funded separately).

12. Describe all significant research results, protocols developed, and research transitions.

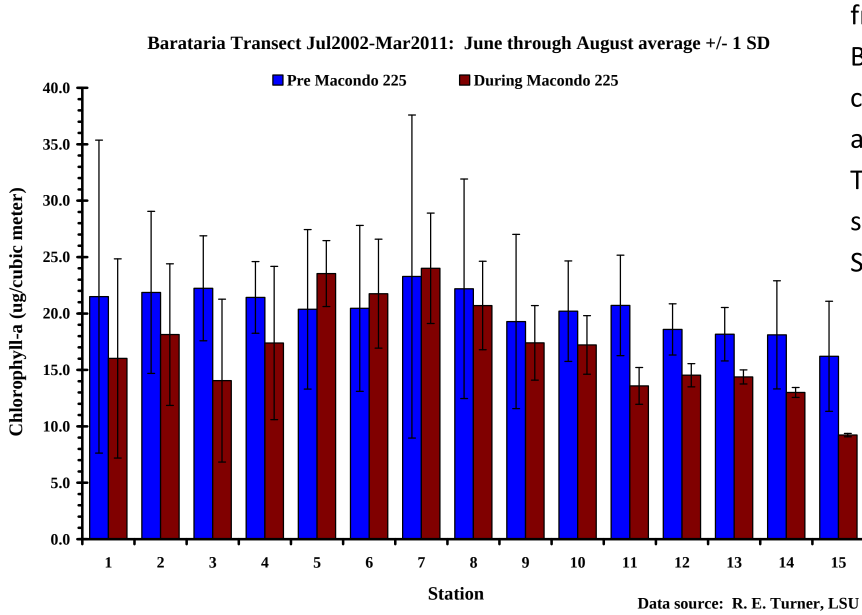
The proposed sampling was completed as originally proposed. Some examples are provided below. These data will be combined with the results from the January through June Phase 2 sampling currently underway.

a. Water Quality Comparisons in Barataria Bay and Lake Pontchartrain

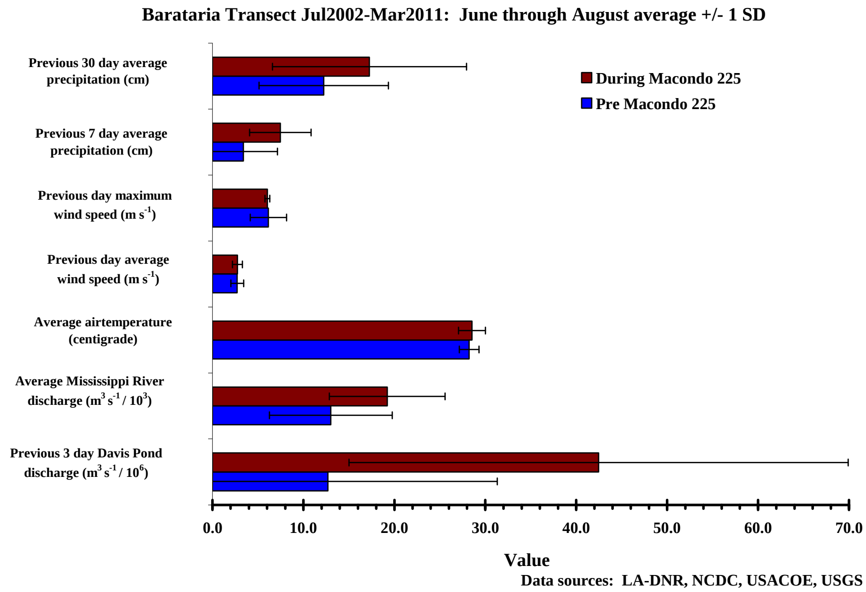




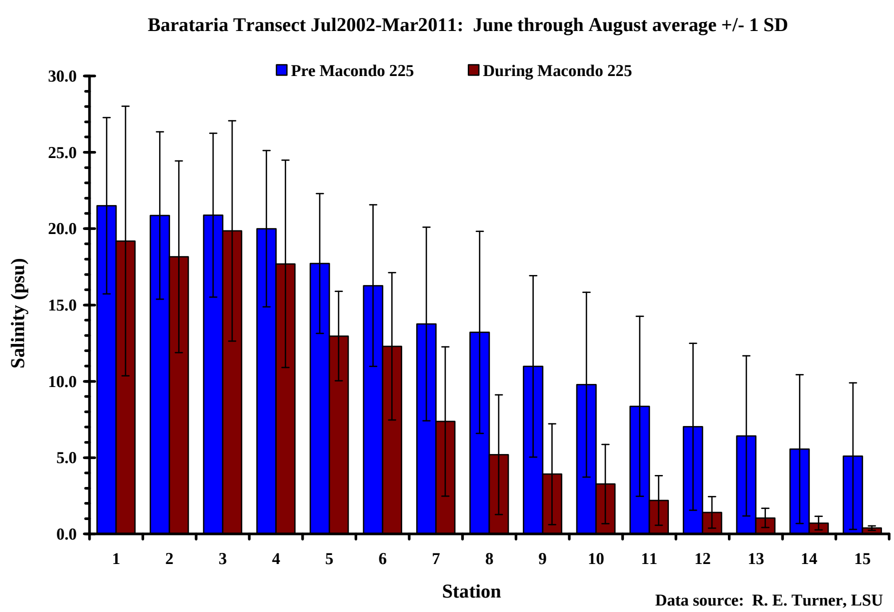
The average concentrations of alkanes and aromatics in the middle of lower Barataria Bay (left panel) and Lake Pontchartrain (right panel). The fingerprinting of oil sources is provisional. The X axis is the Julian Day.



The average Chl concentration from June through August in Barataria Bay (purple bar) compared to the long-term average conditions (blue). There is no difference among stations. The error bar is ± 1 Std. dev.



The average conditions in physical factors from June through August in Barataria Bay (purple bar) compared to the long-term average conditions (blue). The error bar is ± 1 Std. dev. There is a significant difference in the discharge of the Davis Pond diversion, but not in Mississippi River discharge, temperature, wind speed, or precipitation.



The average salinity from June through August in Barataria Bay (purple bar) compared to the long-term average conditions (blue). There is no difference among stations in the lower bay (stations 1-8), but there is in the upper bay (stations 11-15). The error bar is ± 1 Std. dev.

b. Microscopic examination of water samples for phytoplankton assemblage and abundance

Samples were collected in the field by filling a clean sample bottle with surface water and then pouring into labeled 125 ml polypropylene screw cap bottles. They are immediately preserved with 0.5 % gluteraldehyde and chilled in an ice chest until return to the lab where they are refrigerated. A known sample volume was filtered onto 25mm 8 µm polycarbonate filters (in order to concentrate cells) that were then mounted onto glass slides for microscopic analysis of phytoplankton species or groups.

When collection of Barataria Basin samples first began in the late 1990's, abbreviated phytoplankton counts looking at only HAB or potential HAB species were performed and this convention was maintained in subsequent years. Thus the data represented in this report only detail a subset of the phytoplankton community. Data generated from these early years of sampling were organized in an informal manner and routine housing of data in a searchable database was not begun until 2004. Thus data utilized for this report ranges from 2004 to 2010. Further, since post oil spill sampling did not begin until July 2010, only historic data from the months of July through December were analyzed. Because of time constraints and increased workload for the Phytoplankton Group in 2010, only samples for those stations most likely to have received oil (lower estuary stations) were analyzed.

HPLC comparisons

The HPLC data have been compiled for the pre-bp Deepwater Horizon spill period. Complications with the HPLC, maintenance, calibration, and logistical problems at LUMCON regarding HVAC, have delayed the HPLC analyses. These are due to be completed. These data will be combined with the 2011 analyses for the final report of the two projects.

Figure 1. Phytoplankton species or groups detected in samples at station BT2. Samples were not collected in December 2005 and only August and September samples were collected in 2009.

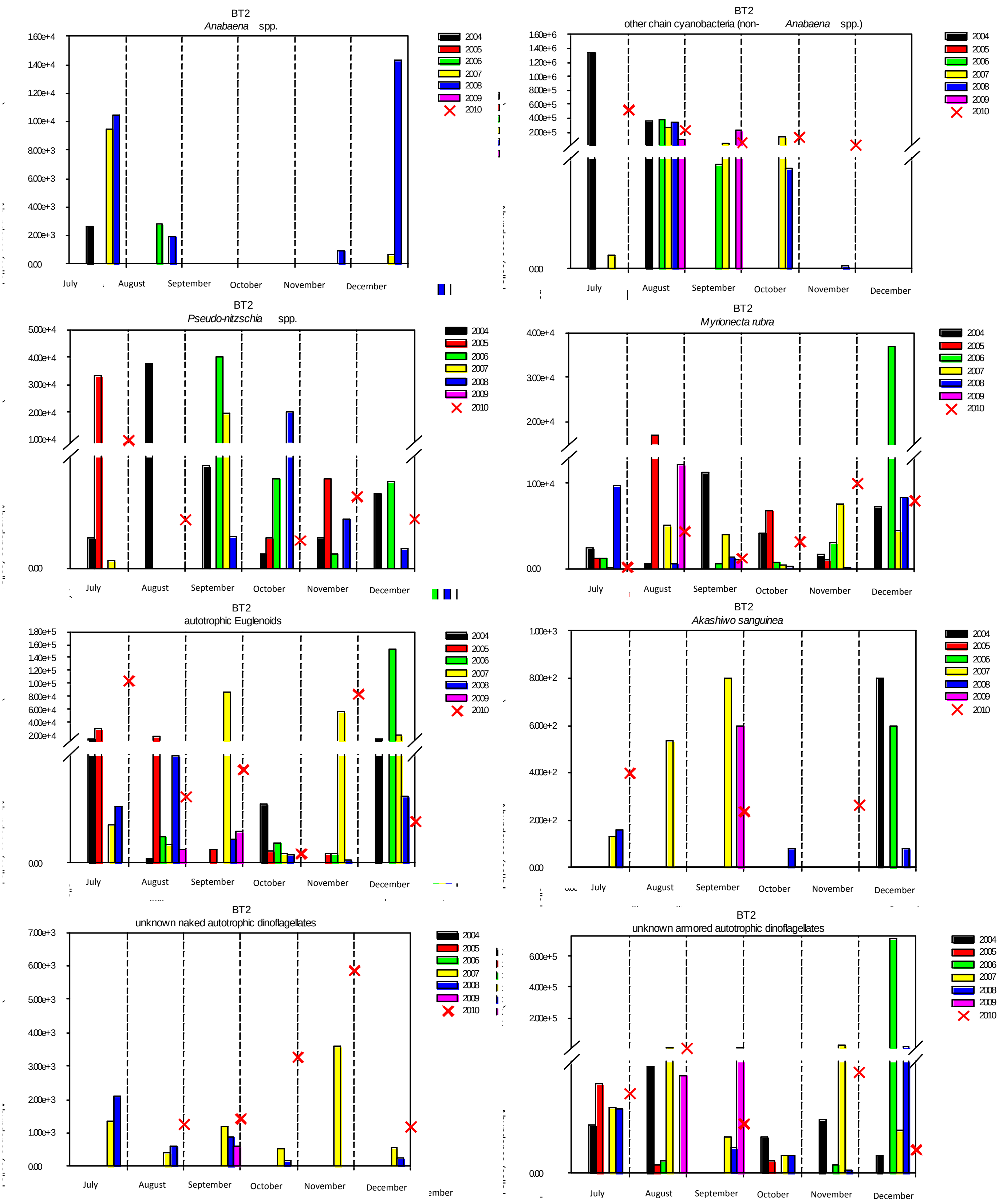


Figure 1, continued. Phytoplankton species or groups detected in samples at station BT2. Samples were not collected in December 2005 and only August and September samples were collected in 2009.

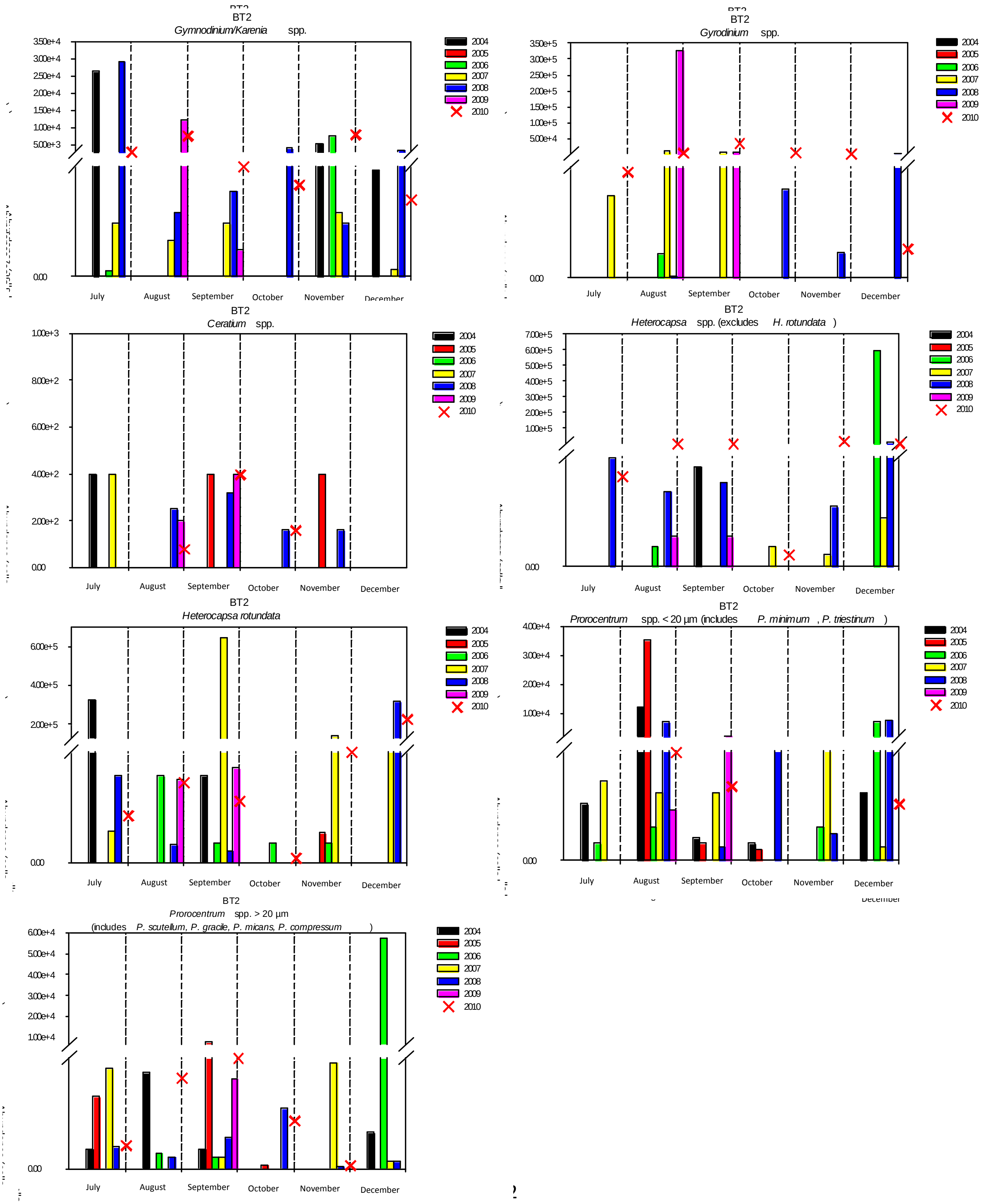


Figure 2. Phytoplankton species or groups detected in samples at station BT8. Samples were not collected in December 2005 and September 2007 and only August and September samples were collected in 2009

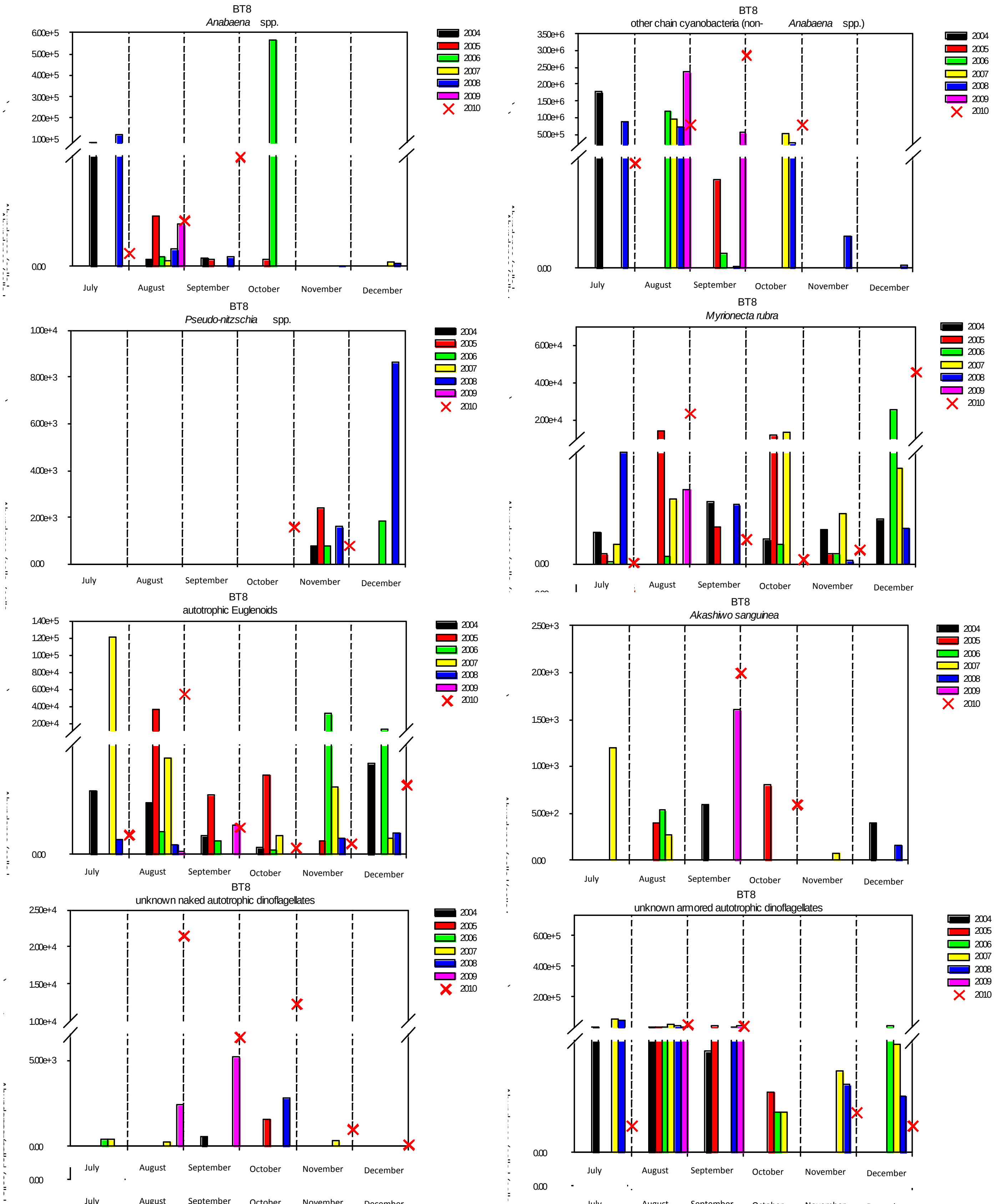
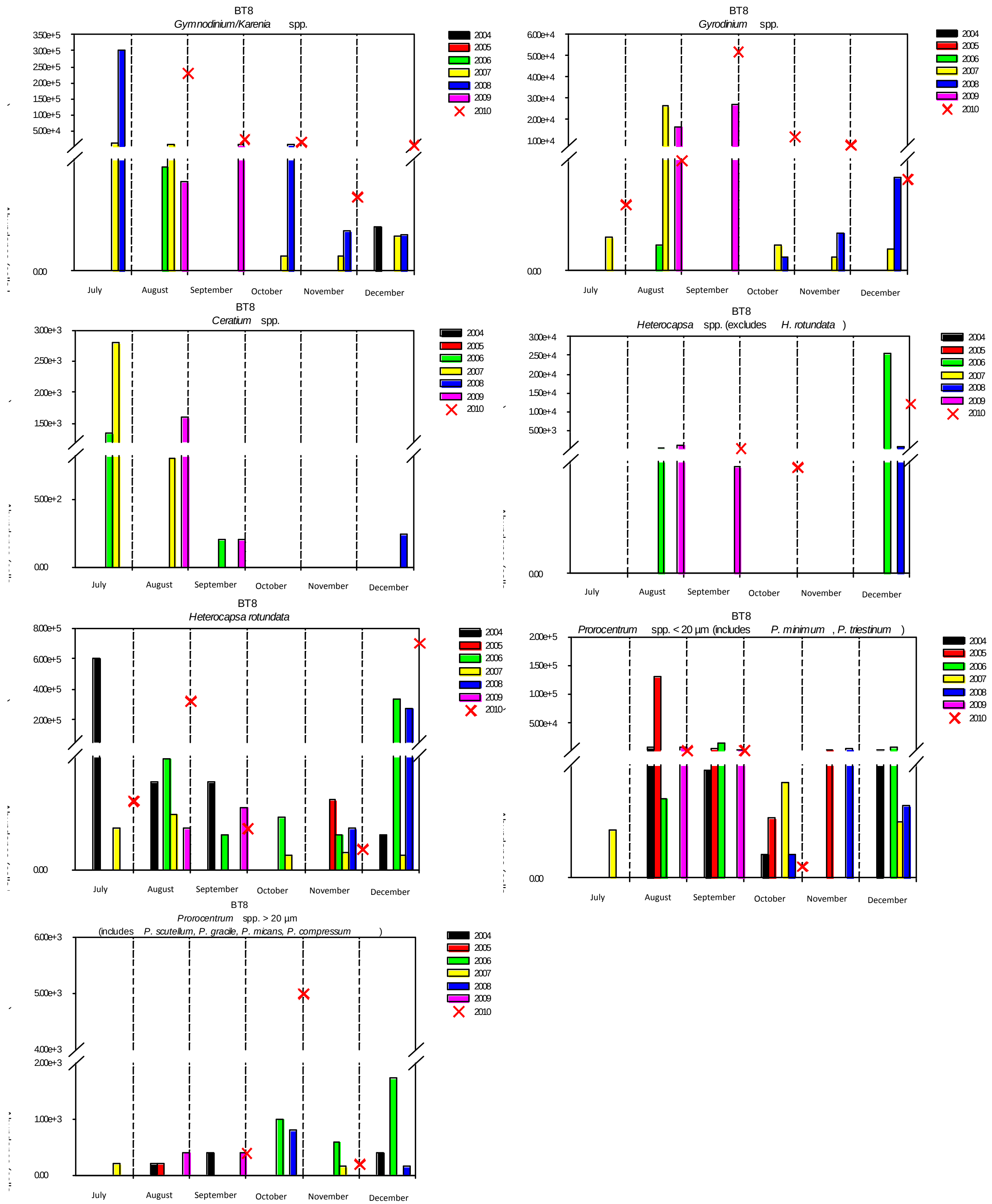


Figure 2, continued. Phytoplankton species or groups detected in samples at station BT8. Samples were not collected in December 2005 and September 2007 and only August and September samples were collected in 2009.



13. Outreach activities

Our primary scientific objective is to produce high quality scientific results (i.e., peer-reviewed contributions) that meet the test of relevancy for the program needs. Turner participated in a Tulane Law School course this fall (BP Oil Spill Lecture Series; Invited Talk: ”The Gulf Ecosystems: Diversity and Threats” Tulane Law School. 13 September 2010) and held discussions of this issue in a scientist/artist webinar (http://www.ghostnets.com/). A presentation and discussion of the data was made: “Louisiana: What monitoring have they been doing and what is their long-term vision for coordinated monitoring?” National Water Quality Monitoring Council, New Orleans; 4 May 2011.

14. Peer Reviewed Articles: List peer reviewed articles about this project published during this period of reporting. If this is the final report for the project, list all peer reviewed articles published about this project’s work. Do not include any publications before the start date of this project.

None – way too early, this is a 6 month project

15. Non-refereed articles and reports for this project: List all other articles about this project. Provide full list

None – way too early, this is a 6 month project

16. List conference presentations and poster presentations for this project. Provide full citation including conference name and date. Please include copy, if available.

None – way too early, this is a 6 month project

17. Has anyone from this project been hired by NOAA during this reporting period? If yes, give date hired and NOAA duty station they were assigned to.

No

10-BP_GRI-LSU-01 (Task 2): **Aquatic Primary Productivity and spatial/temporal water quality variations of the Breton Sound Estuary and Impacts of Oil Pollution**

1. NGI Project File Number: 10-BP_GRI-LSU-01 (Task 2)

2. Project title (exactly as submitted in proposal): Aquatic Primary Productivity and spatial/temporal water quality variations of the Breton Sound Estuary and Impacts of Oil Pollution

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI?	Affiliation	Email
John W. Day	Lead	Louisiana State University	*johnday@lsu.edu*
Robert R. Lane	Co-PI	Louisiana State University	*rlane@lsu.edu*

4. All Non-Student Personnel funded by this project (including those listed above):

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
None				

*If yes, list NOAA lab

5. All Students funded by this project (including those listed above):

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Chris Lundberg	MS	PhD	50%	no

*If yes, list NOAA lab

6. Project Abstract (500 words or less):

We measured water chemistry and phytoplankton productivity along transects in the Breton Sound estuary, which receives Mississippi River water from the Caernarvon freshwater diversion, and potentially has been impacted by the Gulf oil spill.

Water quality transects for this study were started shortly after the Macondo Oil Spill in April 2010, and have been carried out monthly since to measure water chemistry and related hydrographic parameters. A flow-through system was used to map suspended sediment, chlorophyll *a*, salinity, and temperature in the major bayous and

water bodies of the estuary. Discrete water samples for nutrient and hydrocarbon analysis were also collected at 16 locations in the estuary. We measured phytoplankton production seasonally for several locations using the light, semi-shaded and dark bottle oxygen technique in a field incubator. The impacts of petroleum hydrocarbons were measured by adding 100 ppm of oil from the spill to a subset of the light-dark bottles. As one would expect, oxygen production decreased with decreasing light availability, though there was little difference between the dark and more heavily shaded bottles. Oxygen production was lower in oil- spiked samples relative to non-spiked samples when light availability was high. However, under low- light conditions, there was little to no difference in oxygen production between oil spiked samples and non-spiked samples.

7. Key Scientific Questions/Technical Issues: (500 words or less):

This study aims to answer the following question: Did the Macondo 252 Oil Spill result in large scale perturbation of aquatic primary production in the Gulf of Mexico, especially in the Breton Sound estuary? The objectives of this study are to 1) continue an ongoing monthly water quality sampling in the Breton Sound estuary that has been carried out almost continuously since 1999, 2) analyze new and historical data to determine spatial and temporal patterns of nutrients, sediments, salinity and chlorophyll *a* in the Breton Sound estuary, 3) correlate factors influencing aquatic primary production, especially light and nutrient concentrations, with special reference to the stoichiometric ratios of inorganic nitrogen, phosphorus and silicate, and 4) determine the impact of different oil concentrations on aquatic primary productivity in the Breton Sound estuary. This work builds on an extensive series of studies summarized in Day et al. (2009), and is a continuation of a very similar study carried out previously in 2007 (www.laseagrant.org, J. Day, PI).

8. Collaborators/Partners: None

Name of collaborating organization
Date collaborating established
Does partner provide monetary support to project? Amount of support?
Does partner provide non-monetary (in-kind) support?
Short description of collaboration/partnership relationship.

9. Project Duration: List the start and end date of this project (if applicable, include only *approved* No Cost Extension end date)

July, 2010 - March 2011

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

This project applies to the NOAA goal of protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

This project provides geospatial data of water quality and phytoplankton productivity of the entire Breton Sound estuary. In addition, the potential impact of oil on phytoplankton productivity has also been examined. This data will be helpful for management of the Caernarvon River diversion, which impacts water quality throughout the basin.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

Contributions to BP_GRI goals:

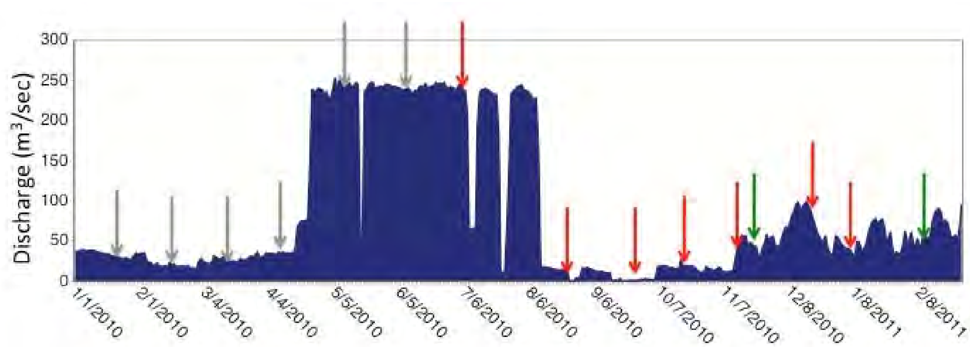
The following BP NGI goals have been addressed by this project: Chemical evolution and biological degradation of the oil/dispersant systems and subsequent interaction with the marine and coastal ecosystems; and Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery

11. Milestones accomplished during entire project period. List major milestones completed (in terms of the project proposal). All tasks of the proposal have been carried out.

12. Describe all significant research results, protocols developed, and research transitions.

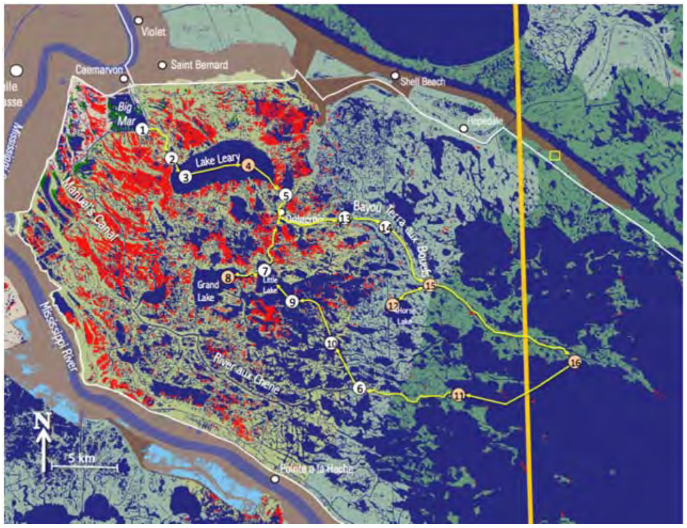
(If you have interesting graphs, photos, maps, etc., please include here or attach to your email. Images not used in previous progress reports are preferred.)

The Caernarvon river diversion structure is located downriver of New Orleans at river mile 81.5 on the east bank of the Mississippi River near Caernarvon, Louisiana in St. Bernard Parish. The water control structure has been in operation since August 1991 and consists of five box culverts with vertical lift gates. The structure has a maximum discharge rate of 226 m^3s^{-1}, which occurred from April to August, 2010, in response to the Deepwater Horizon oil spill.



Discharge from the Caernarvon diversion structure. Red arrows indicate when water quality samples were collected, and green arrows indicate when additional aquatic primary productivity measurements were taken. Grey arrows refer to previous sampling trips.

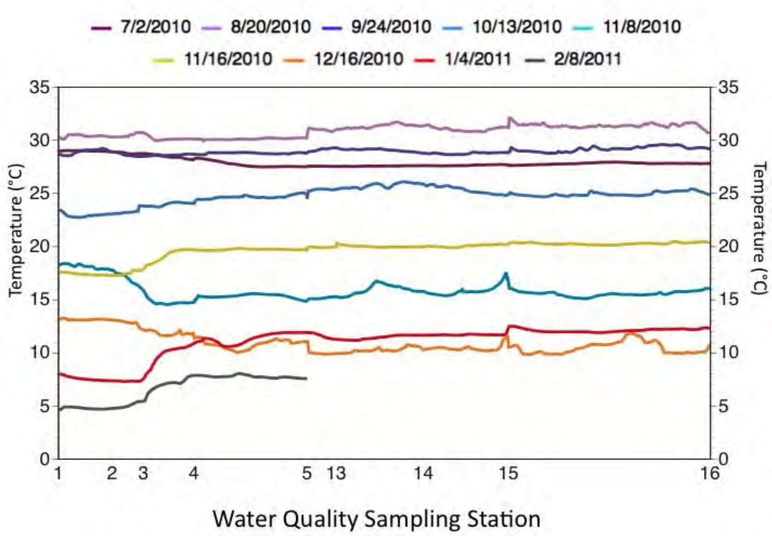
Between the diversion structure and the Gulf of Mexico there are about 1100 km^2 of fresh to brackish and saline wetlands interspersed with water bodies and diverted water travel must travel 30-40 km before reaching open waters of Breton Sound, and an additional 50 km before reaching Gulf waters.



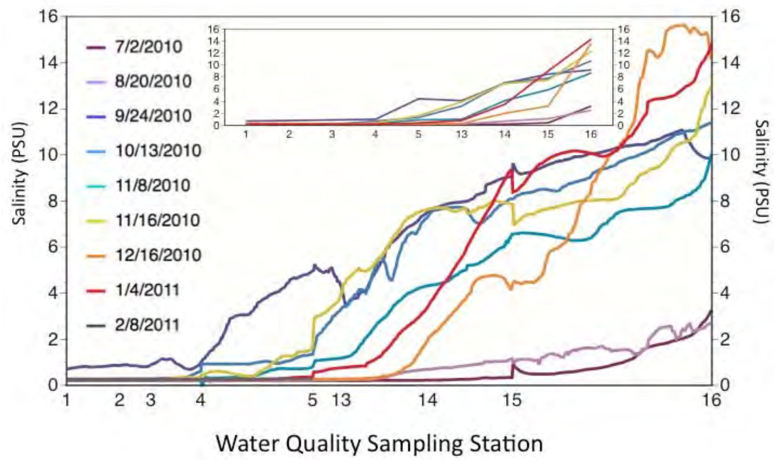
Major lakes and waterways in the Breton Sound estuary. Arrows refer to flow-through transect route and numbers refer to discrete water sampling locations.

Spatial and temporal patterns of water quality

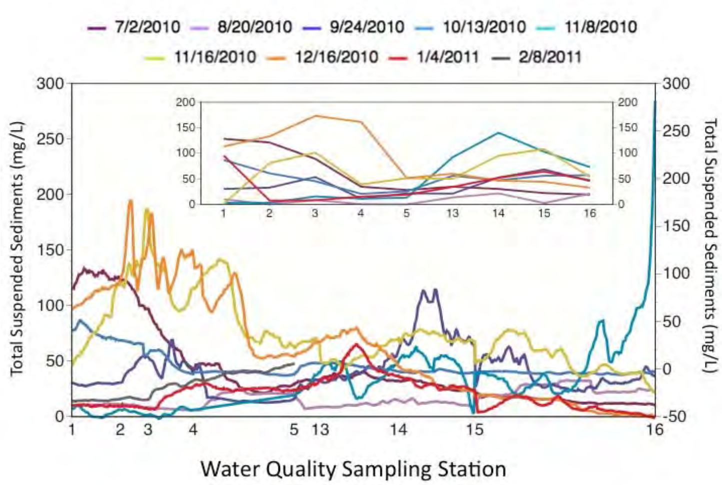
We mapped the distribution of various ecological parameters along a transect run monthly in the Breton Sound estuary. The flow-through system consisted of a 1.5 cm diameter pipe mounted on the transom of a small boat that scoops surface water at planing speed, routes the water past several environmental sensors, and eventually flushes out where it was sub-sampled when necessary. Measurements of fluorescence, turbidity, salinity and temperature were taken using a YSI-6600 probe (www.ysi.com) modified for flow-through measurement. Readings were taken every 5 seconds, with an average boat speed of 50 km hr^{-1}, providing a reading about every 70 meters. During each transect, discrete water samples were taken at about 16 fixed locations and later analyzed for nutrients (NO_x, NH_4, PO_4, TN, TP, & SiO_4), suspended sediment, chlorophyll *a*, and salinity.

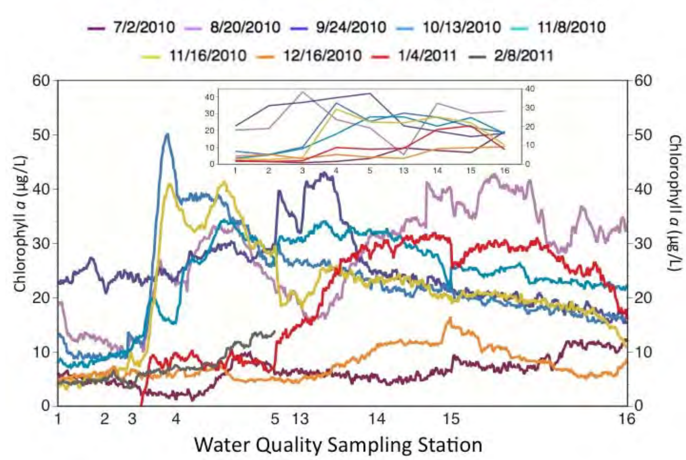


The temperature data reflected the seasonal signal of high summer temperatures (<33°C) transitioning to cooler winter temperature.Salinity in the upper estuary was fresh throughout the study, and increased at the outer estuary up to 16 PSU. Salinities were greatly influenced by discharge from the Caernarvon river diversion structure, which decreased salinity throughout the estuary, but this effect rapidly dissipated once flow decreased.



The Caernarvon diversion effectively delivered suspended sediments to the upper and mid estuary, with resuspension processes dominating in the lower estuary. Total suspended sediment concentrations of Mississippi River water entering the estuary were as high as 142 mg/L, and generally decreased as water flowed through Lake Leary (Stations 3 & 4), often with a turbidity maximum at the lake. There were also elevated and fluctuating TSS concentrations at the southern end of the estuary, likely due to wind resuspension related to storms.



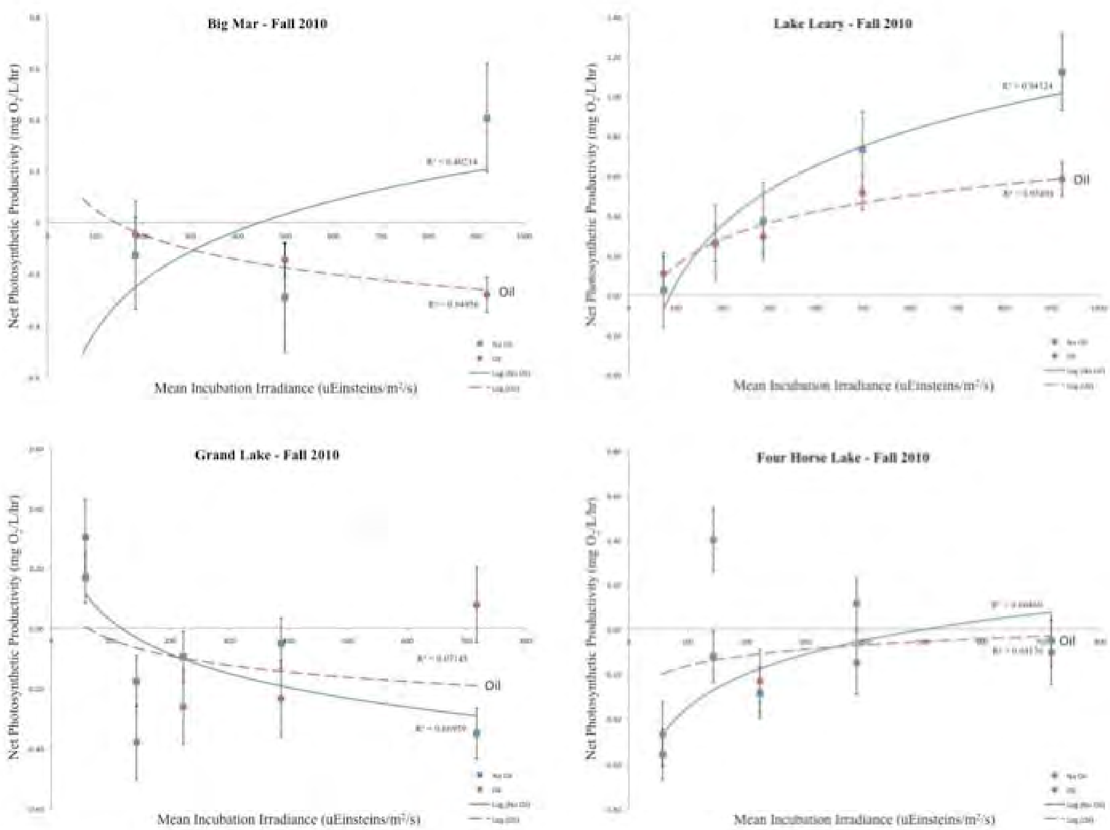


Chlorophyll *a* concentrations were generally less than 20 mg/L in the upper estuary, with concentrations rising in the mid-estuary up to 50 ug/L, and decreasing in the lower estuary. Discharge during the beginning of the study suppressed chlorophyll *a* levels. After discharge decreased, a phytoplankton bloom was observed in the lower estuary. This bloom moved up estuary through the fall sampling.

Aquatic Primary Production

Water samples were collected in 12-L carboys from four locations within Breton Sound: Big Mar, Lake Leary, Grand Lake and Four Horse Lake. These locations were selected to represent a gradient of salinity, turbidity and nutrients.

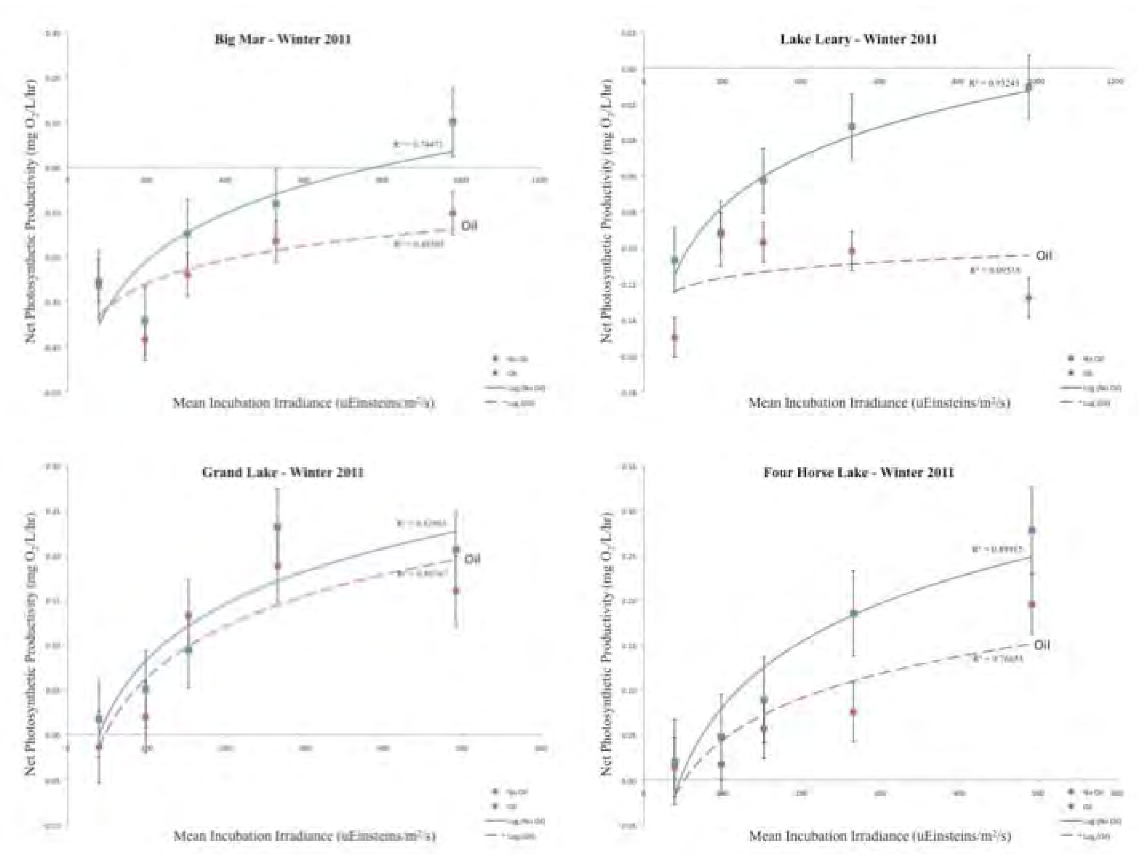
Water column net and gross production and respiration were measured by dissolved oxygen difference in 6 replicate 300 mL light, semi-shaded and dark bottles following the method of Madden and Day (1992). Initial dissolved oxygen (DO) measurements were taken directly from carboys placed on a magnetic stirrer. Water was then transferred to 300 mL BOD bottles and placed in one of six light treatments (full exposure, 1 screens, 2 screens, 3 screens, 4 screens, dark) and one of two oil treatments (oil amended and unamended) resulting in 12 irradiance-oil treatment combinations. Three replicates were placed in each treatment combination. Neutral density screens were used to simulate decreasing light. Representative petroleum hydrocarbons were added at a concentration of 100 ppm to the oil-spiked samples. Bottles were incubated for 3-5 hours under natural light in a water-cooled incubator located dockside maintained at in situ temperature with ambient water pumped from the adjacent bayou. The incubator was large enough to accommodate samples from two sites per day, requiring two days of incubation for all four study sites. Incident photosynthetically active radiation (PAR) was measured above and below the incubator water surface using a LiCor Li-1700 quantum radiometer. Analysis of variance (ANOVA) was applied to determine the effects of season (in the form of quarterly sampling trips), sampling site, light exposure and oil on net primary productivity (NPP). Separate photosynthesis-irradiance (P-I) curves were estimated for oil-spiked and non-spiked samples for each season-location treatment combination. During the fall sampling trip, the dissolved oxygen (DO) meter and the quantum radiometer malfunctioned, resulting in potentially inaccurate DO readings and missing PAR



data for the Grand Lake and Four Horse Lake samples. All NPP results for fall sampling should be considered carefully due to this malfunction. P-I curves created for Grand Lake and Four Horse Lake were created using an estimated 800 uEinsteins/m^2/s, obtained by selecting a value at the lower end of the range observed for the previous day. All malfunctions have since been rectified.

Negative values for NPP occur when respiration exceeds photosynthesis, meaning the system is heterotrophic. The P-I curves indicate that Big Mar is generally heterotrophic except under high irradiance when oil is absent. There was little difference in the range of irradiance experienced by the Big Mar samples during the fall and winter samples. The presence of oil suppressed NPP except at low light levels. The oil-spiked curve in the fall is atypical of most P-I curves, most likely due to malfunctions with the DO meter. The estimated logarithmic curve better fit the winter data for the non-spiked samples (R^2=0.745) than the fall data (R^2=0.402). Due to time constrictions during Fall 2010 sampling, two light treatments (2-screen and 4-screen) were not included for incubation.

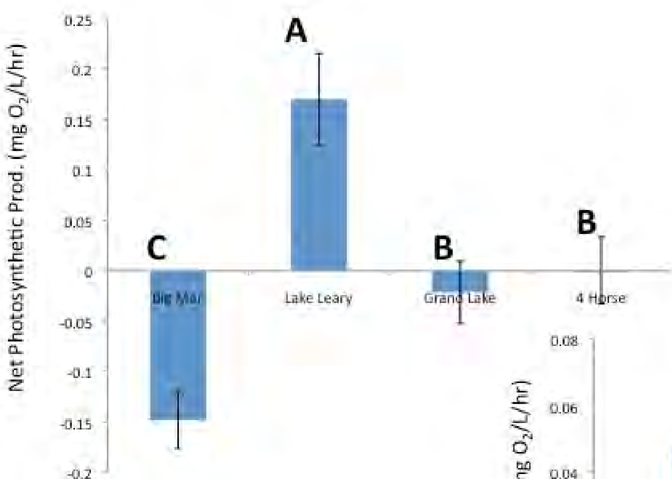
Although there was little variation in the range of irradiance values experienced by the Lake Leary samples during fall and winter sampling, NPP values were drastically different. Lake Leary was autotrophic in the fall and heterotrophic in the winter. NPP for the oil-spiked samples was much lower than non-spiked samples under high irradiance conditions, but little difference was observed under low irradiance conditions. Estimated P-I curves for both the non-spiked and spiked samples fit the observed fall data well (R^2=0.941, R^2=0.955, respectively), whereas the non-spiked curve was a much better fit than the spiked curve for the observed winter data (R^2=0.952, R^2=0.095, respectively).

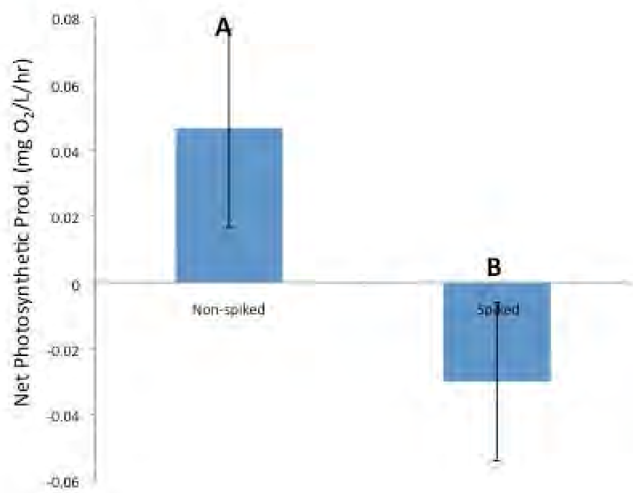


Unlike Lake Leary and Big Mar, Grand Lake appears to be autotrophic during the winter. The estimated curves for Grand Lake depict the expected relationship between NPP and irradiance: a logarithmic increase in NPP with increasing irradiance. Both non-spiked and spiked curves fit the observed winter data well (R^2=0.830, R^2=0.808, respectively). The curves from fall are atypical of the established relationship between NPP and irradiance. The resence of oil appears to have less of an effect on NPP at Grand Lake relative to the two upstream sites, even at high light exposure. The effect of light exposure on NPP is more evident in the winter sampling than the fall, likely due to the aforementioned malfunctions with the DO meter.

Like Grand Lake, Four Horse Lake is generally heterotrophic in fall and autotrophic in winter. As with the other sites, estimated non-spiked and spiked curves fit observed winter data (R^2=0.899, R^2=0.767, respectively) better than fall data (R^2=0.665, R^2=0.042, respectively). As the other curves have indicated, NPP is suppressed by the presence of oil under high irradiance.

An ANOVA with a 2x2x4x5 treatment arrangement, with season, oil, site and light as treatments, was significant (F=12.44, p<0.0001). When averaged across site, light and oil treatments, no difference in NPP was found between fall and winter sampling (F=2.46, p=0.1191).





Among sites, Lake Leary had the highest average NPP and Big Mar had the lowest. Grand Lake and Four Horse Lake were intermediate (F=52.82, p<0.0001). NPP was greatest at high light exposure (full sun and 1 screen) and lowest at low light (2, 3 and 4 screens; F=13.47, p<0.0001). NPP was greater among non-spiked samples relative to oil-spiked samples (F=17.41, p<0.0001).

13. Outreach activities N/A

14. Peer Reviewed Articles: List peer reviewed articles about this project published during this period of reporting. If this is the final report for the project, list all peer reviewed articles published about this project's work. Do not include any publications before the start date of this project.

Provide the full citation and include copy, if available.

15. Non-refereed articles and reports for this project: List all other articles about this project. Provide full citation and include copy, if available.

16. List conference presentations and poster presentations for this project. Provide full citation including conference name and date. Please include copy, if available.

17. Has anyone from this project been hired by NOAA during this reporting period? No.

If yes, give date hired and NOAA duty station they were assigned to. No.

10-BP_GRI-LSU-01 (Task 3): **Impact of DH Oil Spill on the Louisiana Coastal Environments**

1. NGI Project File Number: 10-BP_GRI-LSU-01 (Task 3)

2. Project title (exactly as submitted in proposal): Impact of DH Oil Spill on the Louisiana Coastal Environments

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI?	Affiliation	Email
Malinda Sutor		LSU	Msutor1@lsu.edu

4. All Non-Student Personnel funded by this project (including those listed above):

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Alvaro Armas	Research Associate	MS	50	No

*If yes, list NOAA lab

5. All Students funded by this project (including those listed above):

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
None				

*If yes, list NOAA lab

6. Project Abstract (500 words or less):

Plankton are the base of the estuarine foodweb and are important primary and secondary producers and consumers. Plankton also have relatively short generation times and live in the water column and so have the potential to be affected by oil and dispersant advected into the estuary on relatively short time scales. We have collected monthly plankton samples from September 2007 to April 2009 in both the Barataria Bay and Breton Sound estuaries. We propose to resume this sampling to determine potential changes in the plankton community in response to oil and dispersant entering the estuary. We will collect samples to determine the abundance and community composition of phytoplankton, microzooplankton, and mesozooplankton at six stations evenly spaced along the Barataria and Breton transects. We will utilize an imaging microscope and semi-automated software techniques to rapidly analyze the samples we have collected.

7. Key Scientific Questions/Technical Issues: (500 words or less):

Plankton are the base of the estuarine foodweb and are important primary and secondary producers and consumers. Plankton also have relatively short generation times and live in the water column and so have the potential to be affected by oil and dispersant advected into the estuary on relatively short time scales. By estimating the abundance and community composition of the plankton in these areas, we can monitor changes over the course of the study and compare the data to our past data to determine what changes have occurred and if they appear to be independent of coincidently measured environmental variables. This information can be used to determine how the dynamics of the base of the food web were affected and potentially explain changes observed at higher trophic levels.

8. Collaborators/Partners:

Name of collaborating organization
Date collaborating established
Does partner provide monetary support to project? Amount of support?
Does partner provide non-monetary (in-kind) support?
Short description of collaboration/partnership relationship.

NO COLLABORATIONS

9. Project Duration: List the start and end date of this project (if applicable, include only *approved* No Cost Extension end date)

7/2/2010-12/31/2010

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

Our project addresses the ecological function of coastal wetlands and their response to potential stressors, such as an oil spill. A greater understanding of plankton dynamics will help to address several issues specific to the NOAA mission, namely 1) enhance our understanding and management of hazards to cultural, economic and natural resources of coastal regions; and 2) provide information that will increase our understanding of the implications of habitat loss and destruction and better guide ecosystem management and coastal restoration in this important river delta system.

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

Regional Awareness: This project will contribute to the regional awareness of potential impacts and hazards associated with the petroleum industry.

Regional Interest: The ecological functioning of estuarine and coastal environments in southern Louisiana is critical to assess to determine their response to events such as an oil spill and to guide restoration efforts. As many commercial fish species important to the economy of southern Louisiana utilize these areas as critical habitat, we feel there will be great interest in our findings.

Regional Understanding: We have worked to communicate our science through Ocean Commotion, organized by Louisiana Sea Grant.

Regional Acceptance: The results of this research have the potential to greatly enhance our understanding of the ecological function of coastal wetlands and their response to impacts such as an oil spill, particularly as they translate to fisheries issues, and given the importance of these issues to Louisiana, we anticipate our work will be well accepted.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

There is a great need for enhanced knowledge of biogeochemical and energy cycling in coastal ecosystems to improve model prediction of biomass changes over various temporal and spatial scales. The data collected on plankton biomass and taxonomic distributions in these areas will be of great value as there is a relative paucity of these data collected in coastal Louisiana.

Contributions to BP_GRI goals:

This work will help to determine if the estuarine plankton community was impacted by the Deepwater Horizon oil spill and if so, how. By comparing our results to past data, we can potentially make determinations about how those impacts may translate to higher trophic levels and affect the ecosystem in general.

11. Milestones accomplished during entire project period. List major milestones completed (in terms of the project proposal).

We collected samples as planned for the Breton Sound estuary. We collected samples as planned for the Barataria estuary for the first 3 months. For the last 2 months, Dr. Eugene Turner who was lead PI on the portion of the proposal that funded that cooperative field work did not allow us to send a person in the boat citing that he wished to have a different additional person in the boat to collect samples for another project and there was no room. We were therefore not able to collect samples as planned for the last 2 months of the project in the Barataria estuary.

All samples collected were initially analyzed and synthesis with other transect data began in December, but did not continue due to lack of funding in the second phase.

12. Describe all significant research results, protocols developed, and research transitions.

We completed the collection and initial analysis of all of the samples. We did not receive continued funding and so have not had the support to dedicate personnel to the final analysis and interpretation of the data.

(If you have interesting graphs, photos, maps, etc., please include here or attach to your email. Images not used in previous progress reports are preferred.)

13. Outreach activities

General Description
Have you hosted speakers, workshops and/or any training? For each provide:
Type (speaker, workshop, training)
Name of event
Date

Location
Description
Approximate Number of Participants

We have participated in the Sea Grant Ocean Commotion activity for elementary aged school children. We showcased our FlowCAM instrument and showed them pictures of the plankton that are found in local lakes and estuaries and described the ecological role that plankton have in aquatic systems.

14. Peer Reviewed Articles: List peer reviewed articles about this project published during this period of reporting. If this is the final report for the project, list all peer reviewed articles published about this project's work. Do not include any publications before the start date of this project.
Provide the full citation and include copy, if available.

None

15. Non-refereed articles and reports for this project: List all other articles about this project. Provide full citation and include copy, if available.

None

16. List conference presentations and poster presentations for this project. Provide full citation including conference name and date. Please include copy, if available.

None

17. Has anyone from this project been hired by NOAA during this reporting period? If yes, give date hired and NOAA duty station they were assigned to.

None

10-BP_GRI_LSU-01 (Task 4): Oil spill effects on ecosystem respiration for two Louisiana estuaries

1. **NGI Project File Number**: 10-BP_GRI_LSU-01 **(Task 4)**

2. Project title (exactly as submitted in proposal): Oil spill effects on ecosystem respiration for two Louisiana estuaries

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI?	Affiliation	Email
Brian Fry	Co-PI	LSU	bfry@lsu.edu

4. All Non-Student Personnel funded by this project (including those listed above): NONE.

5. All Students funded by this project (including those listed above):

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Philip Riekenberg	BS		25	No

*If yes, list NOAA lab

6. Project Abstract (500 words or less):

Natural abundance radiocarbon ($\Delta^{14}C$) analyses are a sensitive way to trace fates and use of oil in aquatic environments. Oil is an ancient geological substance and natural radioactive decay has removed ^{14}C that was present at the time of oil formation. Consequently, oil has a -1000‰ $\Delta^{14}C$ value and is quite distinct from +10‰ to +40‰ values of carbon circulating in modern estuarine food webs. To test for food web use of oil from the Deepwater Horizon oil spill, barnacles (*Balanus* sp.) and barnacle shells were collected in Barataria Bay, Louisiana, before and after oil from the spill entered the bay and coated many marshes. Radiocarbon analyses showed no uptake of the oil into barnacle tissues or shells, indicating <0.2% overall incorporation of oil into the food web leading to barnacles or into the pool of respired CO_2 naturally present in estuarine waters. Stable carbon isotope ($\delta^{13}C$) analyses of these barnacles and of marsh mussels (*Geukensia demissa*) collected within oiled marshes also showed no evidence of oil incorporation. The surprising lack of oil use is likely due to a combination of several factors, including slow bacterial break-down of oil and high biological production of phytoplankton foods that act to dilute oil signals in estuarine food webs. Elevated respiration rates and altered decomposition dynamics were not detected following oil entry into the Barataria Bay system. Overall, measurements are most consistent with an hypothesis of only very slow respiration of oil in Louisiana estuaries, in spite of elevated summer temperatures.

7. Key Scientific Questions/Technical Issues: (500 words or less):

The main hypothesis tested was that the spilled oil is increasing ecosystem respiration and the heterotrophic status of two estuaries (Breton Sound and Barataria Bay) that are situated near the Deepwater Horizon rig.

8. Collaborators/Partners: None

9. Project Duration: List the start and end date of this project (if applicable, include only *approved* No Cost Extension end date) **July 02, 2010 – March 31, 2011**

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

This work bears directly on assessing effects of the Deepwater Horizon spill on marine ecosystems and so addresses Strategic NOAA goal 1, “Protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management”.

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

Many groups are interested in measured effects of oil on coastal systems. This finding of low impacts is fine on its own, but needs to be considered in the larger context where oil impacts are being documented as strong in other ways. Those impacts are known to the PI (Fry) at the moment only via conversation with other scientists, but include negative effects on fish metabolism, on marsh sustainability, and on abundance of marsh insects. The measurements support Gulf of Mexico Alliance Priority Issues related to 1) Ecosystem Integration and Assessment and 2) Habitat Conservation and Restoration.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

Results of the project surprised the investigator, but could be explained by several factors including relatively low amounts of oil entering Barataria Bay, the likely weathered nature of the oil after being at sea several days before entering the bay, and the natural strong metabolism of the bay that made small oil signals hard to detect. The project focused on oil effects in warm semi-tropical systems where temperatures were 30-32^{O}C, and thus filled a gap in our understanding of oil metabolism that was largely based on work done in colder environments, e.g., Alaskan coasts affected by the Exxon Valdez spill.

Contributions to BP_GRI goals:

The project related to “ Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery”. The project showed little effect of food web effect of oil on barnacles or decomposition dynamics in Barataria Bay.

11. Milestones accomplished during entire project period. List major milestones completed (in terms of the project proposal).

A manuscript describing the results has been submitted to a scientific journal.

12. Describe all significant research results, protocols developed, and research transitions.

We had two main results, summarized below about a) respiration and b) barnacle food webs. A powerpoint talk summarizing these results is also attached to this report submitted in the email. This talk was presented at a regional meeting of the Geological Society of America in New Orleans in March 2011. Results are:

a. We measured respiration in 24 hour incubations in the dark and did not find elevated respiration rates in Barataria Bay that had received oil from the Deepwater Horizon spill. In detail, results were that respiration rates given as average mmol oxygen consumed $m^{-3}d^{-1}$ $\pm$ standard error of the mean (N) were 28$\pm$2 (10) for Barataria late August and 27$\pm$2 (17) for early October, versus 41$\pm$5 (9) for Breton Sound that lacked oil inputs. These respiration rates are within the central median range of respiration rates observed in unpolluted estuarine waters.

b. We tested for low radiocarbon activity that would indicate oil use by the barnacle food web, but found no measurable radiocarbon decline associated with the Deepwater Horizon oil that entered Barataria Bay. In detail, barnacles tissues collected 10 years before the spill in May 2000 and six weeks after the end of the spill in August 2010 showed virtually identical $\Delta^{14}C$ values, as did Barataria barnacle shells collected in 2010 and also barnacle tissues collected in Breton Sound in 2010. Values given as average $\pm$ standard error of the mean (N) were 20$\pm$2‰ (7), 18$\pm$4‰ (17), 16$\pm$4‰ (5) and 16$\pm$6‰ (6) for respectively 2000 Barataria barnacle tissues, 2010 Barataria barnacle tissues, 2010 barnacle shells and 2010 Breton Sound barnacle tissues. None of these values were significantly different ($P>0.05$) from any other value by unpaired t tests, and mixing model calculations using end members of 20 and -1000‰ for respectively oil-free barnacles and oil yielded contributions of oil that were very low at a maximum average of 0.2% and not significantly different than 0.0%. Using reference barnacles collected in 2010 in Breton Sound rather than the May 2000 barnacles gave the same result of 0.0% incorporation of oil into post-spill Barataria barnacles and shells.

13. Outreach activities

General Description
Fry teaches a general education course in Oceanography at LSU, and presented the barnacle results to the class. Students represent a cross-section of Louisiana citizens and were surprised that effects were not stronger. They were also impressed that scientific testing will give you unexpected answers, answers that help mold our thinking and policies.

Have you hosted speakers, workshops and/or any training?
No

14. Peer Reviewed Articles: List peer reviewed articles about this project published during this period of reporting. If this is the final report for the project, list all peer reviewed articles published about this project's work. Do not include any publications before the start date of this project.

No articles have been published, but a manuscript has been submitted. The manuscript title is: Tracing use of Deepwater Horizon oil in estuarine food webs.

15. Non-refereed articles and reports for this project: List all other articles about this project. Provide full citation and include copy, if available. None.

16. List conference presentations and poster presentations for this project. Provide full citation including conference name and date. Please include copy, if available.

We presented two public talks about this work, both entitled "Isotopic evidence for minimal food web use of Deepwater Horizon oil in Louisiana esturine food webs" The presentations were at the Geological Society of America's South-Central Section - 45th Annual Meeting (27–29 March 2011) in New Orleans (and 2) at the annual NGI meeting (17-19 May 2011) in Mobile Alabama.

The abstract for the first talk at GSA in New Orleans was: The 2010 Deepwater Horizon (DWH) well explosion led to the largest accidental oil spill in history. Such substantial oil inputs to the coastal zone might be expected to stimulate bacterial activity and provide a carbon source for estuarine food webs. We investigated uptake of oil into estuarinefood webs of the central Louisiana coast, using natural abundance carbon isotope tracers to study transfer of oil carbon to filter feeding oysters, mussels and barnacles. Where oil entered food webs, consumer isotope values were expected to shift from background values towards those of oil, i.e. from -23‰ background towards -27‰ oil for stable carbon isotopes and from about +25‰ background towards -1000‰ oil for radiocarbon. Perhaps surprisingly, the isotope tracers showed little evidence for oil uptake, <20% uptake using stable isotopes in all filter feeders and <1% uptake using the more sensitive radiocarbon measurements for barnacles. Reasons for low uptake of oil potentially include a relatively long and inefficient food chain from oil-degrading microbes to filter feeders, high natural phytoplankton productivity that dilutes any oil signals, and dilution/mixing of oil within the water column. There was some evidence for 1-2‰ lower stable nitrogen isotope values in oil-exposed marsh biota, so that some very localized food web use of oil may be indicated by isotope studies. Abstract ID#: 186928, Session S1C. Deepwater Horizon Oil Spill: Biotic Responses to the Oil Spill Incident—Microbes to Macrobiota. Authors were Brian Fry, Laurie C. Anderson, P.H. Riekenberg and C.J. Michael.

The abstract for the second talk at NGI in Mobile was: To test for food web use of oil from the Deepwater Horizon oil spill, barnacles (Balanus sp.) and barnacle shells were collected in Barataria Bay, Louisiana, before and after oil from the spill entered the bay and coated many marshes. Radiocarbon analyses showed no uptake of the oil into barnacle tissues or shells. Concurrent session 1, Tuesday May 17, 2-2:30pm. Authors were Brian Fry and Laurie C. Anderson.

17. Has anyone from this project been hired by NOAA during this reporting period?

No.

10-BP_GRI_LSU-01 (Task 5): Examining the biological uptake of highly carcinogenic polycyclic aromatic hydrocarbon - Benzo(a)pyrene - from crude oil polluted environments in the Gulf of Mexico.

1. NGI Project File Number: 10-BP_GRI_LSU-01 (Task 5)

2. Project title (exactly as submitted in proposal):

Examining the biological uptake of highly carcinogenic polycyclic aromatic hydrocarbon - Benzo(a)pyrene - from crude oil polluted environments in the Gulf of Mexico.

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI?	Affiliation	Email
Sibel Bargu	Project Lead	DOCS-LSU	sbargu@lsu.edu

4. All Non-Student Personnel funded by this project (including those listed above):

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
None				

*If yes, list NOAA lab

5. All Students funded by this project (including those listed above):

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Koray Ozhan	MS	PhD	%50	No

*If yes, list NOAA lab

6. Project Abstract (500 words or less):

Benzo(a)pyrene, which is one of polycyclic aromatic hydrocarbons (PAHs) with five benzene rings, is found as one of the highly toxic components of crude oil and introduced into an aquatic system directly with oil spills. The toxicity of benzo(a)pyrene to two native Gulf of Mexico phytoplankton species, a diatom *Ditylum brightwellii* and a dinoflagellate *Heterocapsa triquetra*, was studied by analyzing the growth, abundance and cell viability of cultured species. The degree of benzo(a)pyrene influence on phytoplankton growth varied with exposure concentration, and species of phytoplankton. A decrease in growth rate was observed as concentration of benzo(a)pyrene increased for both species. The organisms tested demonstrated a range of sensitivity to different level of the toxicant from growth inhibition to mortality. There was a progressive decay of growth rate until remarkable cell death occurred at higher level of the toxicant. As for *D. brightwellii*, mortality of cells was observed after 20 ppb benzo(a)pyrene, however the concentration was 50 ppb for *H. triquetra*. IC_{25} and IC_{50} (12.72 ppb and 24.58 ppb, respectively)(concentration that inhibit the growth of 25% and 50% of population, respectively) values of *H. triquetra* were three fold higher than that of *D. brightwellii*. A negative linear relationship between cell size and $IC_{25, 50}$ values were also observed.

7. Key Scientific Questions/Technical Issues: (500 words or less):

This study aimed to evaluate (1) which major taxonomic group of phytoplankton are more tolerable to benzo(a)pyrene?, (2) Is there any relationship between the size of phytoplankton and tolerance to benzo(a)pyrene toxicity?, and (3) Does benzo(a)pyrene show similar effect on phytoplankton that are adapted to different environment?

8. Collaborators/Partners:

None

Name of collaborating organization
Date collaborating established
Does partner provide monetary support to project? Amount of support?
Does partner provide non-monetary (in-kind) support?
Short description of collaboration/partnership relationship.

9. Project Duration: List the start and end date of this project (if applicable, include only *approved* No Cost Extension end date): 07-02-10 – 03-31-11

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

The Mississippi River delta is one of the most impacted coastal ecosystems in the world. The impacts of the Deepwater Horizon oil spill on this area, especially as the oil reaches the sensitive marshlands along the coast is not well known. Phytoplankton community response in the event of an oil spill may be influenced by site/species specific conditions. Petroleum-based hydrocarbons (PH) are toxic to marine life and relatively little is known about the uptake and biomagnification of these compounds at the base of the marine food web.

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

The Deepwater Horizon oil spill (also known as the Gulf of Mexico Oil Spill or the BP Oil Spill) is the largest marine oil spill in history. The negative effects of oil on organisms and ecosystems are studied intensively and well documented. However, studies indicate that toxicity of oil contaminants depends on the species and the environment. Thus, examining the true effects of the Deepwater Horizon oil spill on phytoplankton species can only be properly performed by using native phytoplankton species from the Gulf of Mexico. One of the many groups that make up crude oils is the PAHs, which are produced as a result of natural and anthropogenic processes. Benzo(a)pyrene is one of PAHs with five benzene rings and it is found as one of the highly carcinogenic, teratogenic and mutagenic component of crude oil, and can be introduced into an aquatic system directly with oil spills. Due to high hydrophobicity and low volatile nature of benzo(a)pyrene, its studies are mainly restricted on sediments and less attention have been given to water column. This study quantified the toxicity of benzo(a)pyrene on two different phytoplankton species, a diatom *Ditylum brightwelli* and a dinoflagellate *Heterocapsa triquetra*, by analyzing the effect of different concentrations of this toxic compound on the phytoplankton growth response.

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

There is a critical need to determine the effect of oil on phytoplankton as this carbon pool comprises a vital link to the higher trophic levels in terms of food resources as well as integrity of coastal ecosystem stability. Although a substantial amount of research has established that compounds in crude oil are toxic to marine life, relatively little is known at the base of the marine food web.

This research will help us to comprehend current and possible future changes *at the base of the coastal food webs* (bottom-up-control) when they exposed to oil, and consequently will enhance our understanding for the level of oil contamination impact on higher trophic levels.

Contributions to BP_GRI goals:

11. Milestones accomplished during entire project period. List major milestones completed (in terms of the project proposal).

- Two different taxonomic group were used in this study to compare their tolerance to benzo(a)pyrene. The study results showed that the dinoflagellate more tolerable to same dose of benzo(a)pyrene than the diatom.
- The relationship between the size of phytoplankton and tolerance to benzo(a)pyrene toxicity study showed that there is an linear relation between cell surface area and tolerance to benzo(a)pyrene toxicity.

12. Describe all significant research results, protocols developed, and research transitions.

A static non-renewal toxicity test of benzo(a)pyrene was performed. The concentrations that were used in LC_{50}, LC_{25}, IC_{50} and IC_{25} calculations, represent initial concentrations of the 10 days exposure period (Table 1).

The results of the test benzo(a)pyrene used in six concentrations on *D. brightwellii* and *H. triquetra* growth rates after 10 days of exposure are summarized in Table 2 and Figure 1. The results show that growth inhibition rates had increased with increasing benzo(a)pyrene concentrations for both species (Figure1 and Table 2). However, the lower growth rates data (Table 2) and the lower IC_{50}, IC_{25}, LC_{50}, and LC_{25} values (Table 3) suggest that a diatom *D. brightwellii* are more vulnerable to benzo(a)pyrene exposure. It is reported that relatively smaller sized cells became the dominant species during oil spills and this might be attributed to benzo(a)pyrene, as a component of crude oil. This study underlined the correlation between cell size and IC_{25} and IC_{50} values. As shown from the figure 2, *D. brightwellii* have approximately three times bigger surface area than *H. triquetra*, and almost the same ratio exists between their IC_{25} and IC_{50} values.

Even though *H. triquetra* showed a non-observable effect to one of the concentration, *D. brightwellii* responded with growth inhibition to the lowest dose exposure. While *H. triquetra'*s growth inhibited by about 6% between 0.5 ppb and 5.3 ppb, *D. brightwellii*'s growth inhibited over 40% at similar range of the toxicant dose. There was a progressive decay of growth rate until remarkable cell death occurred at higher level of the toxicant. As for *D. brightwellii*, mortality of cells was observed after 20 ppb benzo(a) pyrene, the number became 50 ppb for *H. triquetra*. Specially, the highest two dose for *D. brightwellii* and highest dose for *H. triquetra* were resulted in catastrophic cell death after 4 days.

Table 1: Concentrations (ppb) of benzo(a)pyrene (B(a)P) for each treatment before and after the experiment.

	B(a)P conc.(ppb) DAY 0	B(a)P conc.(ppb) DAY 10	% Difference

D. brightwellii t6	1.20	0.41	65.70
D. brightwellii t5	4.26	1.64	61.52
D. brightwellii t4	15.40	10.21	33.73
D. brightwellii t3	20.43	17.83	12.72
D. brightwellii t2	48.87	51.68	-5.76
D. brightwellii t1	92.59	90.63	2.11
H. triquetra t6	0.96	0.10	90.02
H. triquetra t5	5.28	0.52	90.20
H. triquetra t4	11.40	4.57	59.92
H. triquetra t3	18.71	10.81	42.25
H. triquetra t2	53.13	42.96	19.15
H. triquetra t1	72.64	66.98	7.80

Table 2: Growth rate and % growth inhibition of each treatment during the course of the experiment are shown. Ctrl stands for control, not containing any benzo(a)pyrene or DCM. And, sol. Ctrl refers to solvent control treatment, containing only DCM. Also, t1-6 represents treatments, containing different dose of benzo(a)pyrene in each experimental flask.

	Growth Rate (cell d^{-1}) ± std error	% Growth inhibition ± std error
D. brightwellii ctrl	0.517±0.003	0.00±0.00
D. brightwellii sol. ctrl	0.521±0.008	-0.61±0.47
D. brightwellii t6	0.471±0.060	8.95±0.21
D. brightwellii t5	0.306±0.024	41.8±1.04
D. brightwellii t4	0.229±0.019	55.74±0.91
D. brightwellii t3	-0.053±0.001	110.27±0.03
D. brightwellii t2	-0.062±0.005	111.88±0.21
D. brightwellii t1	N/A	N/A
H. triquetra ctrl	0.514± 0.008	0.00±0.00
H. triquetra sol. ctrl	0.520±0.032	-0.44±0.89
H. triquetra t6	0.514±0.012	0.05±0.42
H. triquetra t5	0.482±0.144	6.37±0.43
H. triquetra t4	0.406±0.014	21.08±0.53
H. triquetra t3	0.327±0.023	39.16±1.13
H. triquetra t2	-0.143±0.057	163.21±4.36
H. triquetra t1	N/A	N/A

Table 3: The 6 days IC_{50}, IC_{25}, LC_{50}, LC_{25}, NOEC and LOEC values of benzo(a)pyrene with respect to *D. brightwellii* and *H. triquetra*.

	IC_{25}	IC_{50}	NOEC	LOEC	LC_{25}	LC_{50}
Ditylum brightwellii	4.00	8.88	-	1.20	35.25	42.21
Heterocapsa triquetra	12.72	24.58	0.96	5.28	61.85	59.75

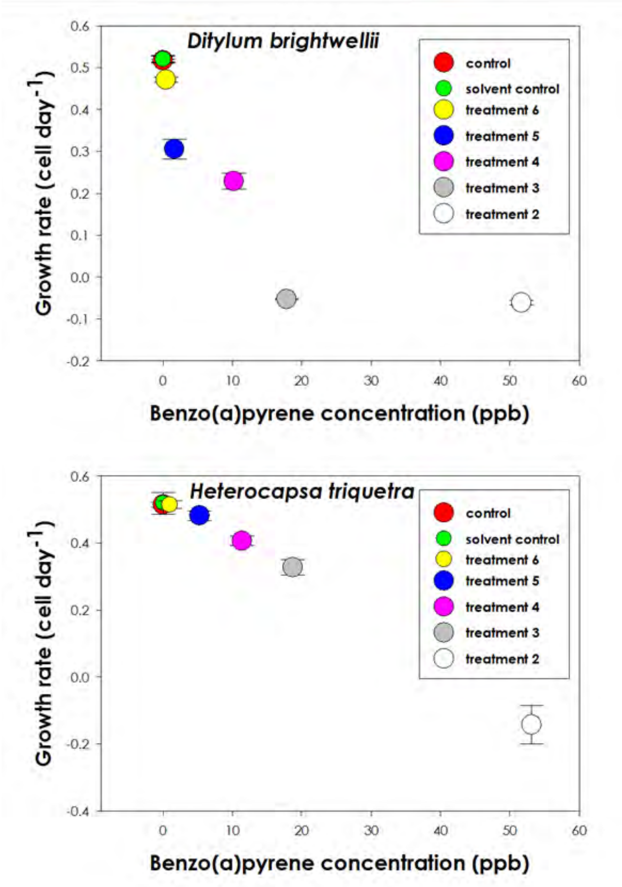


Figure 1: Growth rate responses of different treatments D. brightwellii and H. triquetra. The treatment 1 is not shown since cell growth never reached exponential phase (between day 4-7).

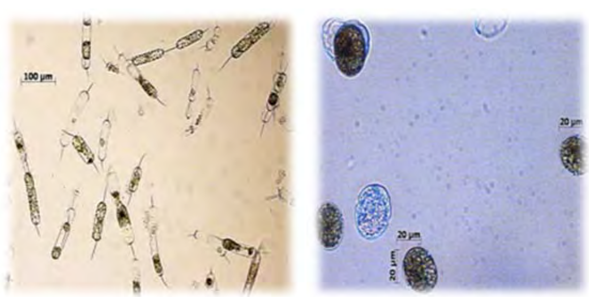


Figure 2.: Photos of the diatom, *Ditylum brightwellii* (left), and the dinoflagellate, *Heterocapsa triquetra* (right). They are two of the native Gulf of Mexico marine phytoplankton, currently used in our research as a representative of two

phytoplankton taxonomic groups.

13. Outreach activities

General Description
Have you hosted speakers, workshops and/or any training? NO
For each provide:
Type (speaker, workshop, training)
Name of event
Date
Location
Description
Approximate Number of Participants

14. Peer Reviewed Articles: List peer reviewed articles about this project published during this period of reporting. If this is the final report for the project, list all peer reviewed articles published about this project's work. Do not include any publications before the start date of this project. None

Provide the full citation and include copy, if available.

15. Non-refereed articles and reports for this project: List all other articles about this project. Provide full citation and include copy, if available. None

16. List conference presentations and poster presentations for this project. Provide full citation including conference name and date. Please include copy, if available.

Ozhan K., Bargu S. Effects of benzo(a)pyrene on marine phytoplankton, Deepwater Horizon Oil Spill Conference, April 2011, Baton Rouge, LA

17. Has anyone from this project been hired by NOAA during this reporting period? If yes, give date hired and NOAA duty station they were assigned to. NO

10-BP_GRI_LSU-01 (Task 6): Impact of the Deepwater Horizon Oil Spill on Vibrios in the Northern Gulf of Mexico

1. NGI Project File Number: 10-BP_GRI_LSU-01 (Task 6)

2. Project title (exactly as submitted in proposal): Impact of the Deepwater Horizon Oil Spill on Vibrios in the Northern Gulf of Mexico

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI?	Affiliation	Email
Aixin Hou	Project Lead	Dept. of Environmental Sciences, Louisiana State University	ahou@lsu.edu

4. All Non-Student Personnel funded by this project (including those listed above):

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Aixin Hou	PI	Ph.D.	8%	No

*If yes, list NOAA lab

5. All Students funded by this project (including those listed above):

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Nabanita Bhattacharyya	BS	MS	50%	No
Spence Colwell	BS	MS	10%	No

*If yes, list NOAA lab

6. Project Abstract (500 words or less):

The Deepwater Horizon oil spill introduced a large amount of petroleum compounds and oil dispersants to the Gulf of Mexico. Adaptation to these organic carbons may result in an increase in some species of vibrios and/or have other impacts on the bacteria. Our study was to determine the impact of the oil spill on the abundance and virulence of *Vibrio vulnificus,* and *V. parahaemolyticus* in Breton Sound and Barataria Bay. Water samples were collected on a monthly basis along two salinity gradients in Breton Sound and Barataria Bay from April 2010 to January 2011. Along with water samples, bottom sediment and shellfish samples were also collected on the stations in Breton Sound. Samples were assayed for total vibrios, and total and pathogenic *V. vulnificus* and *V. parahaemolyticus* by the standard FDA methods, followed by PCR detection of *Vibrio* species. The PCR identification of species targeted the *vvhA* gene for *V. vulnificus* and *tlh* for *V. parahaemolyticus*. Target genes for pathogenic strains were *viuB* for *V. vulnificus* and *tdh*, and *trh* for *V. parahaemolyticus*. Environmental pparameters obtained from the *in situ* measurements included temperature, salinity, and total suspended solids. The 3 to 4-year data sets resulting from our previous NGI project and this project showed that in general, the abundance of

total vibrios, and putative *V. parahaemolyticus* and *V. vulnificus* in Barataria Bay and Breton Sound waters was seasonally dominated by water temperature, but spatially controlled by salinity level. Like that in the waters of Breton Sound, the population of putative *V. parahaemolyticus* and *V. vulnificus* in Breton Sound sediments also followed a similar trend. Significant effects of freshwater diversion on the population of these two species in the coastal waters were observed. The most striking observation was an extremely high population of total vibrios in the surface water samples collected from station 2 in Barataria Bay on May 4, 2010. Station 2 is the most offshore among all the sampling stations in Barataria Bay, and it is the one that is most prone to contamination of the Deepwater Horizon oil spill. However, currently it is unknown whether this outlier of total *Vibrio* population was attributed to the spilled oil or something else. We also carried out a microcosm study to determine oil/dispersant effects on vibrios in a controlled environment with varying concentrations of oil/dispersants. In conclusion, the field study seemed to have shown no significant oil/dispersant impacts on the abundance and virulence of *Vibrio vulnificu* and *V. parahaemolyticus* in Breton Sound and Barataria Bay; however, it indicated a possible increase in total *Vibrio* level in response to the oil/dispersant. The preliminary laboratory results showed that the dispersant might likely enhance the presence of *V. parahaemolyticus.* Further studies will be carried out to confirm this observation. In addition, we successfully developed a multiplex-PCR protocol to simultaneously detect the five target genes (i.e. *vvhA*, *viuB, tlh, tdh*, and *trh*) from isolates collected in this study.

7. Key Scientific Questions/Technical Issues: (500 words or less):

The overall hypothesis of the proposed work was: *adaptation to a large amount of petroleum compounds and oil dispersants that were introduced to the Gulf of Mexico by the Deepwater Horizon oil spill may result in an increase in some species of vibrios and/or have other impacts on the bacteria.*

The specific objectives and related approaches of this project were:

A. To measure the concentrations of total vibrios, *V. vulnificus,* and *V. parahaemolyticus* in water, bottom sediment, and oysters on a monthly basis along two salinity gradients in Breton Sound and Barataria Bay;

B. To measure environmental parameters, in particular salinity, temperature, and turbidity;

C. To compare the concentrations of total vibrios, *V. vulnificus,* and *V. parahaemolyticus* before and after the oil spill.

8. Collaborators/Partners:

This project was coordinated with two other NGI_BP_GRI- Phase I LSU tasks. The two teams had helped collect the monthly samples for this project.

9. Project Duration: List the start and end date of this project (if applicable, include only *approved* No Cost Extension end date)

Start date 7/2/2010
End date 3/31/11 (with no cost extension approved)

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:
Broadly speaking, the Mississippi River delta is one of the most impacted coastal ecosystems in the world including four of the most significant national issues relative to the NOAA mission: 1) climate change and sea level impacts on coastal resources; 2) hazards including hurricane disturbance to cultural, economic and natural resources of coastal regions; 3) habitat loss and ecosystem management including the loss of nearly one-third of the deltaic wetland landscape (4,500 km2) in the last one hundred years; and 4) water quality including the periodic occurrence of one of the largest hypoxic zones among coastal ocean regions.

Contributions to regional problems and priorities:
The Deepwater Horizon oil spill introduced about 170 million gallons of toxic crude oil and over 1.8 million gallons of oil dispersant into the Gulf of Mexico. The impact to the people and the environment of the region has been widespread. One of the major concerns is how such a large amount of petroleum compounds and oil dispersants may alter the *Vibrio* community in coastal waters. Vibrios are ubiquitous in estuarine and marine environments, and some of these bacteria are pathogenic to humans. In the United States, *V. vulnificus* and *V. parahaemolyticus* are the leading causes of seafood-related illnesses. In addition to human disease, vibrios play major roles in the health and ecology of marine animals that include mollusks, fish, and corals. Furthermore, vibrios are the dominant culturable microbes in the ocean. This research has the potential to greatly enhance our understanding of these bacteria, which are fundamental to estuarine and marine systems as well as critical to the public and environmental health. Given the importance of seafood industry to Louisiana and the Gulf, our work may be well accepted. Our connections to advisory committees in Louisiana may facilitate a rapid transfer to the decision makers.

Gaps:
Currently very few information is available about oil/dispersant impacts on *Vibrio* community, in particular *V. vulnificus* and *V. parahaemolyticus,* in coastal and marine environments despite of their extreme importance to the public and environmental heath. With the previous NGI funding and this funding, we were able to study vibrios and water quality in Breton Sound and Barataria Bay from 2007 to 2011 in a systematic way via monthly sampling. The long-term biological data sets that we have produced are invaluable to the assessment of environmental effects of the oil/dispersant system on the coastal waters and more generally, to a better understanding of *Vibrio* ecology and responses of these bacteria to environmental stressors/perturbations such as the freshwater discharges and the Deepwater Horizon oil spill.

Contributions to BP-GRI Goals:
This research is relevant to the BP-GRI Themes "Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery", and "Fundamental scientific research integrating results from the other four themes in the context of public health".

The results help improve the understanding of the northern Gulf ecosystems, in particular understanding of impacts of the Deepwater Horizon spill on vibrios in the Gulf.

11. Milestones accomplished during entire project period. List major milestones completed (in terms of the project proposal).

Water samples were collected on a monthly basis along two salinity gradients in Breton Sound and Barataria Bay from April 2010 to January 2011. Along with water samples, bottom sediment and shellfish samples were also collected on the stations in Breton Sound. Samples were assayed for total vibrios, and total and pathogenic *V. vulnificus* and *V. parahaemolyticus* by the standard FDA methods, followed by PCR detection of *Vibrio* species. The

PCR identification of species targeted the *vvhA* gene for *V. vulnificus* and *tlh* for *V. parahaemolyticus*. Target genes for pathogenic strains were *viuB* for *V. vulnificus* and *tdh*, and *trh* for *V. parahaemolyticus*. Environmental pparameters obtained from the *in situ* measurements included temperature, salinity, and total suspended solids. We have analyzed all the samples that were collected. The data produced have been presented at two international scientific conferences (see section 16). Currently we are preparing manuscripts for peer-reviewed journals.

In addition to accomplishing what we proposed in the project, we developed a multiplex PCR protocol that can simultaneously detect the five target genes (i.e. *vvhA*, *viuB, tlh, tdh*, and *trh*) from isolates collected during this study.

We also carried out a microcosm study to determine oil/dispersant effects on vibrios in a controlled environment with varying concentrations of oil/dispersants (i.e. 0, 10, 100, and 1000 ppm oil with (a ratio of 1 dispersant: 50 oil) and without dispersant, respectively).

12. Describe all significant research results, protocols developed, and research transitions.

The 3-year data sets resulting from our previous NGI project and this project have shown that in general, the abundance of putative *V. parahaemolyticus* and *V. vulnificus* in Barataria Bay (Figure 1) and Breton Sound (Figure 2) waters was seasonally dominated by water temperature, but spatially controlled by salinity level. Like that in the waters of Breton Sound, the population of putative *V. parahaemolyticus* and *V. vulnificus* in Breton Sound sediments also followed a trend. Freshwater diversion was observed to lower the population of these bacteria in the coastal waters, in particular in Breton Sound.

The most striking observation was an extremely high population of total vibrios in the surface water samples collected from station 2 in Barataria Bay on May 4, 2010, about 2 weeks after the Deepwater Horizon oil spill (Figure 1). Station 2 is the most offshore among all the sampling stations in Barataria Bay, and it is the one that is most prone to contamination of the Deepwater Horizon oil spill. However, currently it is unknown whether this outlier of total *Vibrio* population was attributed to the spilled oil or something else. PCR identification of the *Vibrio* isolates showed no presence of *V. parahaemolyticus* and *V. vulnificu* in the 2010 May Station 2 samples, indicating some other *Vibrio* species were dominating in these samples.

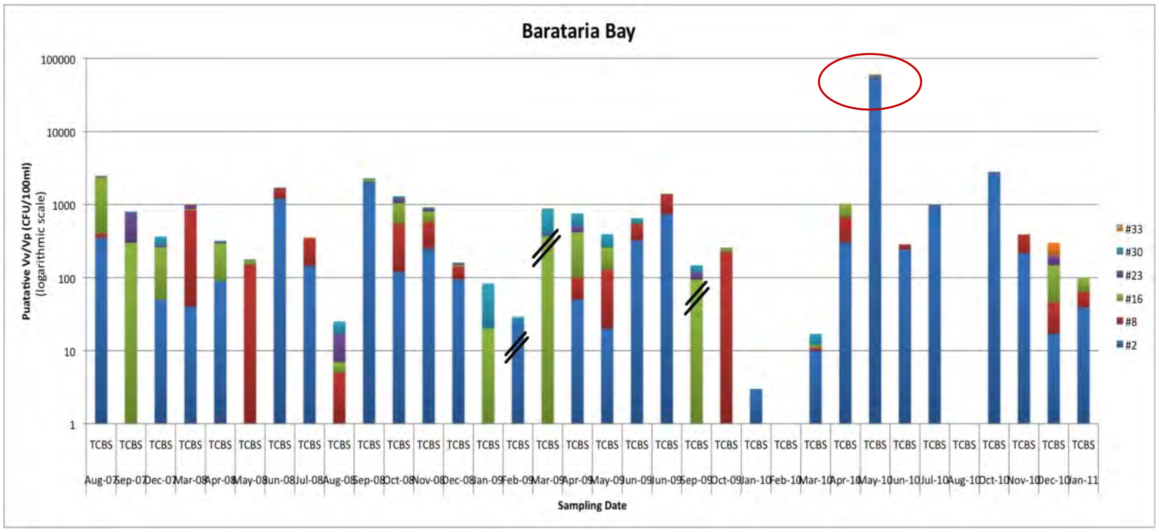


Figure 1. Seasonal populations of putative *V. vulnificus* and *V. parahaemolyticus* as grown on TCBS at six stations along a salinity gradient in Barataria Bay waters; "//" indicates one or multiple sites had too many colonies to count on the TCBS plate

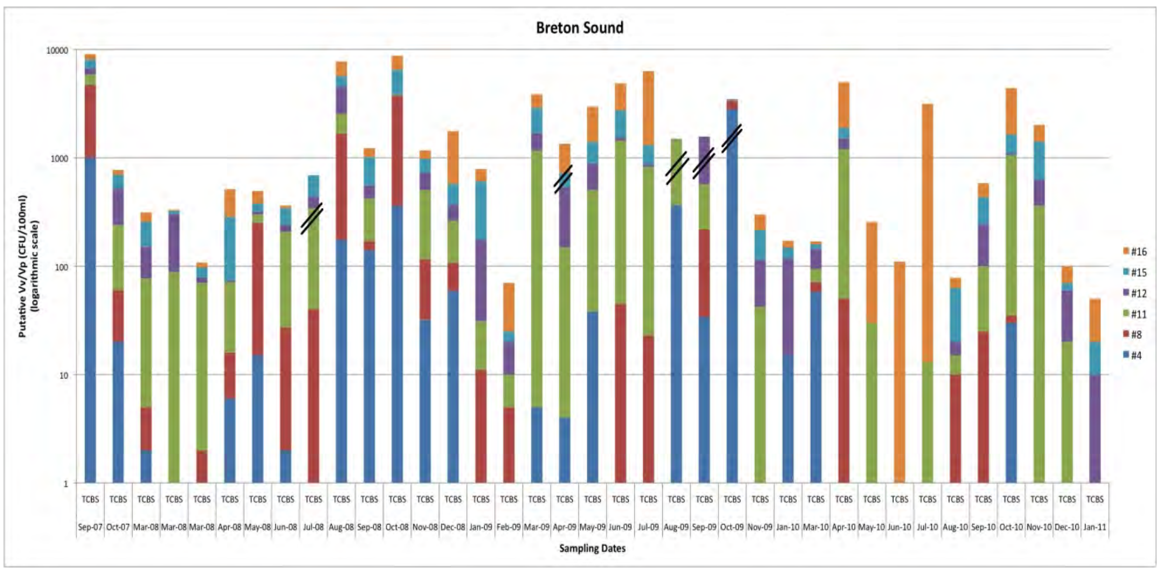


Figure 2. Seasonal populations of putative *V. vulnificus* and *V. parahaemolyticus* as grown on TCBS at six stations along a salinity gradient in Breton Sound waters; "//" indicates one or multiple sites had too many colonies to count on the TCBS plate

In conclusion, the field study seemed to have shown no significant oil/dispersant impacts on the abundance and virulence of *Vibrio vulnificu* and *V. parahaemolyticus* in Breton Sound and Barataria Bay; however, it indicated a possible increase in total *Vibrio* level in response to the oil/dispersant.

Preliminary laboratory results showed that the dispersant might likely enhance the presence of *V. parahaemolyticus*; while the oil did not have the same impact. Further studies will be carried out to confirm this observation.

A multiplex PCR protocol that can simultaneously detect genes *vvhA*, *viuB, tlh, tdh*, and *trh* from the isolates was developed. This novel approach has highly enhanced the efficiency of screening total and pathogenic *V. vulnificus* and *V. parahaemolyticus* isolates. An example of screening results was shown in Figure 3.

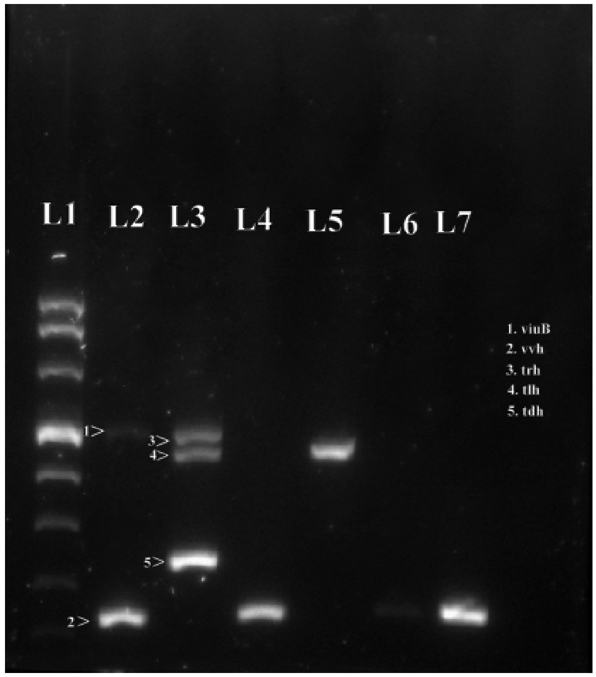


Figure 3. Agarose gel electrophoresis showing the results of multiplex PCR amplification of *V.vulnificus* and *V. parahaemolyticus*. Lane = L. (**L1**) DNA standard molecular marker; (**L2**) multiplex PCR for *V.vulnificus* reference strain showing 205-bp *vvh* amplicon and 504-bp viuB amplicon; (**L3**) *V. parahaemolyticus* reference strain showing 450-bp *tlh* amplicon, 269-bp *tdh* amplicon and 500-bp *trh* amplicon; (**L4**, **L6** and **L7**) Environmental isolates showing positive amplicon for *vvh* only: (**L5**) Environmental sample showing positive amplicon for *tlh* only.

13. Outreach activities

This project directly supported two graduate students' research projects, allowed them to attend meetings and presented their results, and gave them the opportunity to interact with scientists in different disciplines.

14. Peer Reviewed Articles: List peer reviewed articles about this project published during this period of reporting. If this is the final report for the project, list all peer reviewed articles published about this project's work. Do not include any publications before the start date of this project.

None at this point

15. Non-refereed articles and reports for this project: List all other articles about this project.

None at this point

16. List conference presentations and poster presentations for this project. Provide full citation including conference name and date. Please include copy, if available.

Colwell, S., N. Bhattacharyya, B. Matherne, M. Maxwell, and A.X. Hou. 2011. The Effects of Salinity and Temperature on the Populations of *Vibrio parahaemolyticus* and *Vibrio vulnificus* in Breton Sound and Barataria Bay. The 111th General Meeting, American Society for Microbiology. May 21-24, 2011, New Orleans, Louisiana, USA.

Colwell, S., N. Bhattacharyya, B. Matherne, M. Maxwell, and A.X. Hou. 2010. The Effects of Salinity and Temperature on the Populations of *Vibrio parahaemolyticus* and *Vibrio vulnificus* in Breton Sound and Barataria Bay: A 3-Year Study. Vibrios in the Environment. November 7-12, 2010, Long Beach, Mississippi, USA.

17. Has anyone from this project been hired by NOAA during this reporting period?

No

10-BP_GRI_LSU-01 (Task 7): Physics, Oil and Fish: Modeling the Effects of Pulsed River Diversion on Oil Transport and Fish Distribution

1. **NGI Project File Number:** 10-BP_GRI_LSU-01 (Task 7)

2. **Project title (exactly as submitted in proposal):** Physics, Oil and Fish: Modeling the Effects of Pulsed River Diversion on Oil Transport and Fish Distribution

3. **Project Lead (PIs and Co-PIs):**

Name	Project Lead or Co-PI?	Affiliation	Email
Haosheng Huang	Lead	Louisiana State University	hhuang7@lsu.edu
Dubravko Justic	Co-PI	Louisiana State University	djusti1@lsu.edu
Kenneth Rose	Co-PI	Louisiana State University	karose@lsu.edu
Chunyan Li	Co-PI	Louisiana State University	cli@lsu.edu

4. **All Non-Student Personnel funded by this project (including those listed above):**

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Haosheng Huang	PI	PhD	8.3%	no
Dubravko Justic	Co-PI	PhD	8.3%	no
Kenneth Rose	Co-PI	PhD	8.3%	no
Chunyan Li	Co-PI	PhD	8.3%	no

*If yes, list NOAA lab

5. **All Students funded by this project (including those listed above):**

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
None				

*If yes, list NOAA lab

6. **Project Abstract:**

We investigated how river diversions (river pulsing) affects the transport of oil from the Deepwater Horizon site into the Breton Sound Estuary, and the resulting exposure of fish to both oil and stressful environmental conditions due to pulsing-caused spatial displacement. Our project combined hydrodynamics (physics), water quality, an individual-based fish model, and an oil slick transport model into a single integrated modeling system. The modeling system has been used to evaluate the environmental stresses caused by the Deepwater Horizon oil spill, and can be used by coastal managers and emergency response authorities to help guide the restoration effort to mitigate the impacts of the spill. The site of our project is the Breton Sound Estuary, which includes the Caernarvon Freshwater Diversion, one of the largest diversions in coastal Louisiana. The Finite Volume Coastal Ocean Model (FVCOM) has been set-up to simulate the physics (hydrodynamics) for the Breton Sound. The hydrodynamic numerical simulations were carried out for the period from April 1 to July 1, 2010, for each of the following scenarios: 1) Caernarvon Diversion discharge set to its maximum value (the real

situation), 2) Caernarvon Diversion discharge set to the long-term averaged value, and, 3) Caernarvon Diversion discharge set to zero (diversion turned off). Hydrodynamic simulation results compared favorably with available observations

of sea surface elevations and ocean currents. These simulations provided water current, temperature, and salinity fields for the water quality, fish movement, and the oil slick transport models that were the focus of this project. Oil slick simulations indicated that large diversion discharge drove most of the oil particles, initial located at the entrance of the estuary, out of the estuary and moved them along the coastline to the Mississippi Sound, while turning off the diversion discharge allowed most particles to travel upstream into the estuary. This difference can be explained by the relatively large contribution to the residual currents from the maximum diversion freshwater release. Individual-based fish modeling involved development of cutting-edge simulation models in which Lagrangian particles exhibit complicated movement behavior (i.e., smart particles). The codes for simulating behavioral movement using kinesis, fitness, and game theory algorithms have been constructed and tested on both idealized test grid and Louisiana Continental Shelf—Breton Sound grid for the April 1 to July 1, 2010 time period. The analysis of fish movement results and improvement of fish behavior algorithms are still ongoing.

7. Key Scientific Questions/Technical Issues:

Coastal Louisiana has been the site of massive wetland loss, with rates as high as 100 km^2 yr^{-1}, amounting to about a quarter of the nearly 2 million ha which existed at the beginning of the century. This loss is attributed to a complex interaction of factors, including elimination of riverine sediment input to coastal wetlands (primarily due to flood control levees on the Mississippi River), altered wetland hydrology, and high relative sea-level rise. Controlled river diversions that create pulses of freshwater that flood wetlands are being increasingly used for coastal restoration. Most scientists and managers agree that diverting a fraction of the lower Mississippi River water back into coastal wetlands would slow down the coastal land loss. However, an important issue that arises with river diversions is their effects on aquatic biota in the area. Diversions may increase nutrient inputs and thus alter the spatial and temporal dynamics of productivity within the system. Nutrient inputs can also create eutrophication problems in estuaries adjacent to the diversion sites and, with large-scale diversions, could affect the coastal waters of the northern Gulf of Mexico, where a seasonally severe hypoxic zone has persisted for over fifteen years (Rabalais et al., 2007). In addition to altered productivity, diversions can also cause significant shifts in the spatial distributions of key aquatic fauna. How do pulsed releases of freshwater affect the spatial distribution and health of ecologically and economically important fish and invertebrates downstream? Do the animals experience physiological stress due to rapidly changing environmental conditions? What are the likely levels of exposure to oil during a pulsing with a spill event? Answering these questions is critical for the effective design and implementation of diversions.

Recent BP Deepwater Horizontal oil spill incident posed another challenge to the Louisiana coastlines and wetlands. Ever since the beginning of the oil spill, the idea has emerged to open up all coastal freshwater diversions to flush oil slicks out of coastal estuaries and bays. However, a simple back-of-the-envelope calculation shows that the ratio of maximum diversion flow capacity (e.g., 227 m^3 s^{-1} for Caernarvon Freshwater Diversion in Breton Sound and 300 m^3 s^{-1} for Davis Pond Freshwater Diversion in Barataria Bay) to tidal flux at the bay mouth (on the order of 4000 m^3 s^{-1}) is a small number (Swenson et al., 2006). In addition, wind-driven estuary-shelf exchange, which is about the same order as the tidal flux, makes the contribution from diversion discharge even smaller (Snedden et al., 2007; Huang et al, 2011). Therefore, the effectiveness of utilizing freshwater diversions to keep oil slicks from drifting into coastal bays is unclear. This question can quantitatively be addressed by numerical model simulations.

8. Collaborators/Partners:

Our project is coordinated with other NGI efforts at LSU. Our connections to state agencies in Louisiana ensure that decision makers are informed about our proposed project.

9. Project Duration:

a. Start date: 7/2/2010
b. No Cost Extension end date: 3/31/2011

10. Project Baselines:

a. Contributions to specific NOAA Goals/Objectives: The proposed research directly addresses NOAA's Ecosystem Mission Goal: Protect, Restore and Manage Use of Coastal and Ocean Resources through Ecosystem Approaches to Management, by contributing to three specific research areas outlined in the NOAA 5-year Research Plan (NOAA, 2008): (1) Advancing understanding of ecosystems to improve resource management, (2) Forecasting ecosystem events, and (3) Developing integrated ecosystem assessments and scenarios, and building capacity to support regional management.

b. Contributions to regional problems and priorities: Rehabilitating the Mississippi River delta ecosystem is a formidable challenge whose failure and ineffectiveness would have huge consequences to the Gulf coast region and the nation's ecological and economic resources. Research activities within this project significantly contribute to the two of the four NGI research themes: (1) Ecosystem Management – Characterize northern Gulf of Mexico coastal wetland and fisheries habitats, including restoration strategies, and, (2) Coastal Hazards – Strengthen the integration of watershed, estuarine and coastal models in the northern Gulf of Mexico. Further, our research supports the Gulf of Mexico Alliance (GOMA) Water Quality Proposal for Action Plan #2 (Objective WQ4) by developing management tools that inform decision makers about existing water quality conditions and potential changes that could result from coastal land-use decisions. Lastly, the proposal addresses five of the top six research topics identified by the ongoing Sea Grant Gulf of Mexico Research Plan Strategic Planning Process: (1) Freshwater input and hydrology, (2) Connectivity of habitats and habitats to resources, (3) Water quality and nutrients, (4) Ecosystem health indicators, and (5) Sediment management and river diversion.

c. Gaps: Our project will provide a quantitative tool to be added to the toolbox for assessing the utility and effects of river diversions for coastal restoration. Our model addresses the issue of diversions causing significant shifts in the spatial distributions of key fish species, whether the rapidity of changes in environmental conditions can cause stress in individual animals, as well as if maximum diversion discharge can prevent oil slicks from flushing into the Breton Sound Estuary. The area of animal movement is a relatively new discipline and the idea of vertically integrated or "physics to fish" modeling is gaining momentum in oceanography and coastal sciences. Our effort is a small but important step in the direction of developing physics to fish modeling tools relevant to the Gulf of Mexico ecosystem and to the missions of NOAA, NGI, GOMA and Sea Grant.

d. Contributions to BP_GRI goals: Our project is highly relevant to the BP_GRI research themes: (1) The physical distribution and ultimate fate of contaminants associated with the Deepwater Horizon incident, and (3) The environmental effects of contaminants on Gulf of Mexico ecosystems and the science of ecosystem recovery.

11. Milestones accomplished during entire project period. List major milestones completed (in terms of the project proposal).

1. We conducted literature review and developed a database of historical data on hydrodynamics and water quality in the upper Breton Sound Estuary and Louisiana Continental Shelf.
2. As a case study, we implemented FVCOM model to the upper Breton Sound Estuary, including the Caernarvon Diversion site. The model grid extends to the surrounding land areas to allow for wetting and drying of adjacent marshes. We performed FVCOM calibration using the sea surface elevation and ocean current data collected from NOAA CO-OPS, USGS, and LSU WAVCIS Lab for the time period from April 1 to July 1, 2010.
3. FVCOM has been coupled to an oil slick transport model to evaluate the effect of Caernarvon freshwater discharge on oil transport in the Breton Sound Estusry.
4. Individual-based fish model in which particles exhibit complicated movement behavior is being constructed and tested.

12. Describe all significant research results, protocols developed, and research transitions.

(If you have interesting graphs, photos, maps, etc., please include here or attach to your email. Images not used in previous progress reports are preferred.)

1) We searched various sources and collected available observational data and operational reanalysis products for the Breton Sound Estuary and the adjacent continental shelf regions. The gathered information was organized into a database of historical data and the data were used for providing forcing and initial conditions for the physics to fish modeling systems and for evaluating model performance. The main data sources include:

- Coastal sea level time series from NOAA CO-OPS (Center for Operational Oceanographic Products and Services)
- Sea level elevation, water salinity, and Caernarvon discharge rate from USGS National Water Information System
- The Mississippi River and Atchafalaya River daily discharge rate from USACE
- The 10 m above sea surface wind velocity from NOAA NOMADS (National Operational Model Archive & Distribution System)
- The ADCP current observation from LSU WAVCIS Lab
- The three-dimensional temperature and salinity distribution in the Gulf of Mexico from HYCOM forecast product (NOAA NOMADS).

2) We have implemented a high-resolution three-dimensional unstructured-grid Finite Volume Coastal Ocean Model (FVCOM) for the Breton Sound Estuary, including the Caernarvon Freshwater Diversion site and part of the Louisiana continental shelf. The model horizontal grid consisted of 77,628 nodes and 145,713 triangular elements, with a variable spatial resolution of 1-10 km over the shelf regions and 20–500 m in the Breton Sound Estuary (Fig.1). The model included 19 vertical sigma layers. The model grid in the

estuary extended to the surrounding wetland areas to allow for wetting and drying of estuarine marshes. A time step of 0.3 seconds was used for the external mode. The Mellor-Yamada turbulence closure scheme was used to compute the vertical viscosity and diffusivity. Model prognostic variables included sea surface elevation, three-dimensional velocity, salinity and turbulent variables. Temperature was kept constant and not simulated in the present version of the model.

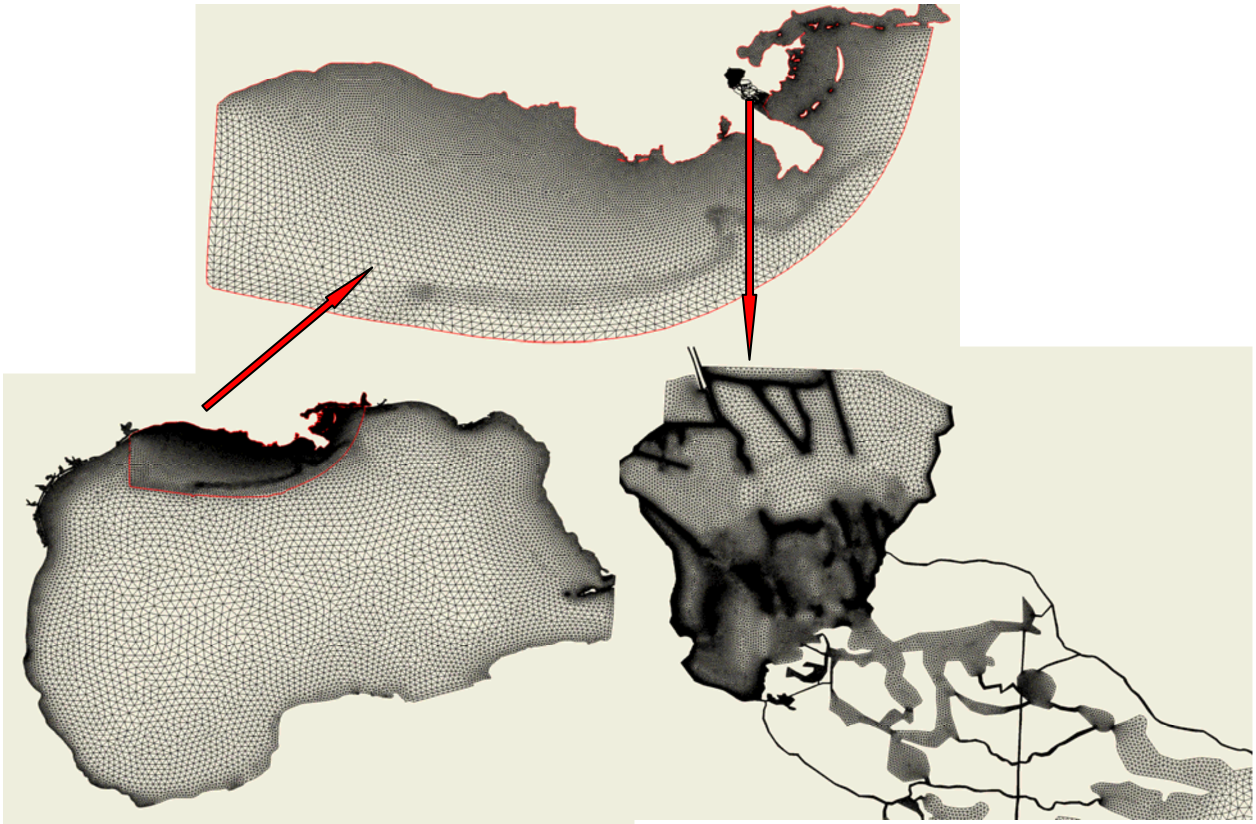


Fig. 1 FVCOM numerical grid for the Breton Sound Estuary.

3) Three different numerical simulations have been run for the period from April 1 to July 1, 2010, during which the Caernarvon Diversion discharge rate was set to its maximum values (currently the real situation), to the long-term averaged value, and to zero (diversion completely turned off). Preliminary model results were encouraging. Without fine tuning of model parameters, for the real case (maximum value) simulation, simulated sea surface elevations showed good correspondence with observations on all 8 coastal sea level stations (Fig. 2). The correlation coefficients and Index of Agreement (Willmott, 1981) were greater than 0.90 for all stations. The predicted horizontal ocean currents also compared favorably with available ADCP data (Fig. 3). However, the salinity comparison showed relatively large error. This is probably related to an inaccurate salinity distribution assumed in the initial conditions of the simulation. The initial condition for salinity was interpolated and extrapolated from the HYCOM product. For example, the HYCOM model domain does not include the Breton Sound Estuary. Therefore, we used extrapolation to specify the initial salinity values in the estuary to be equal to the salinity at one single point in HYCOM domain that was closest to the estuary.

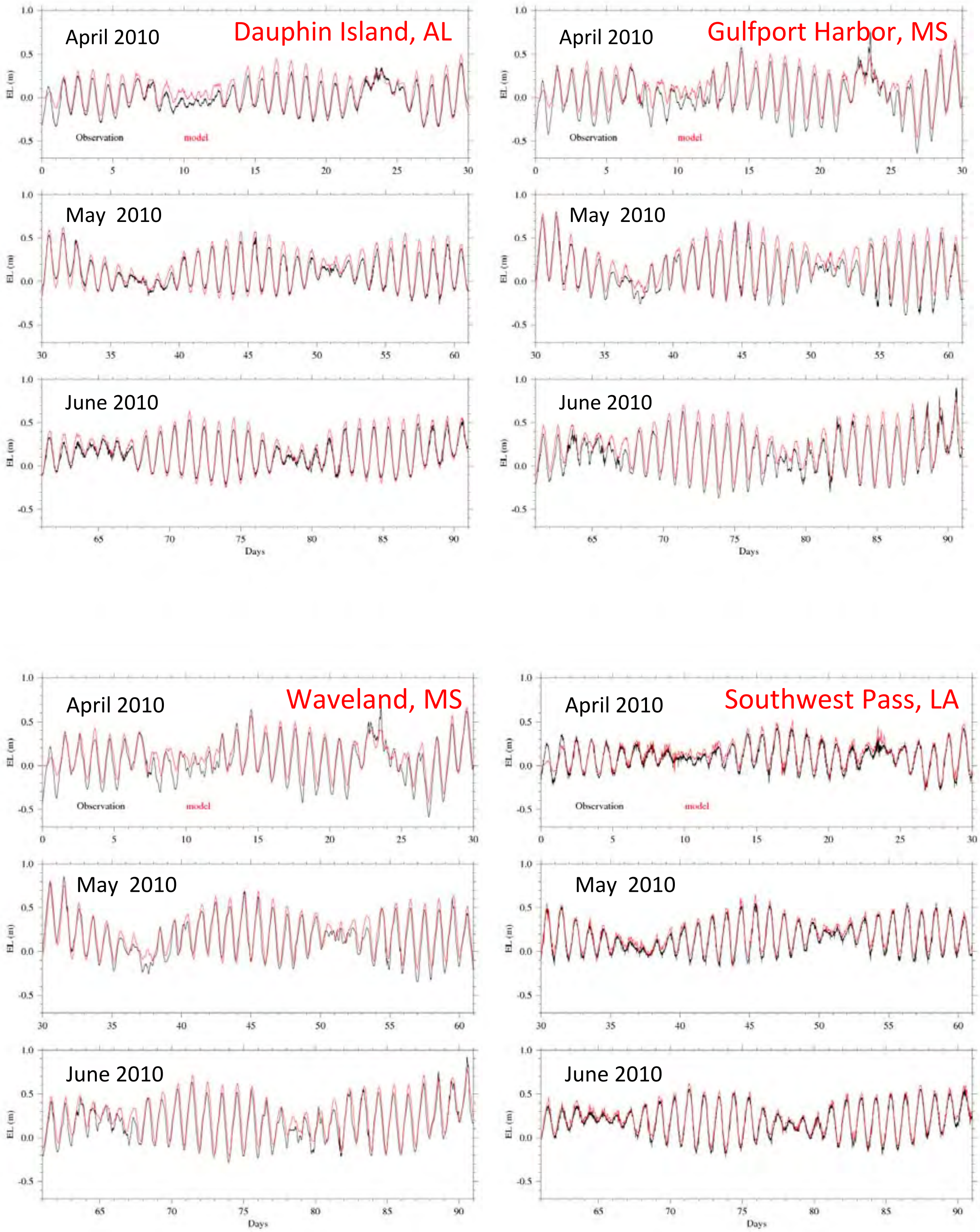


Fig. 2 Model-observation comparison of the sea surface elevation

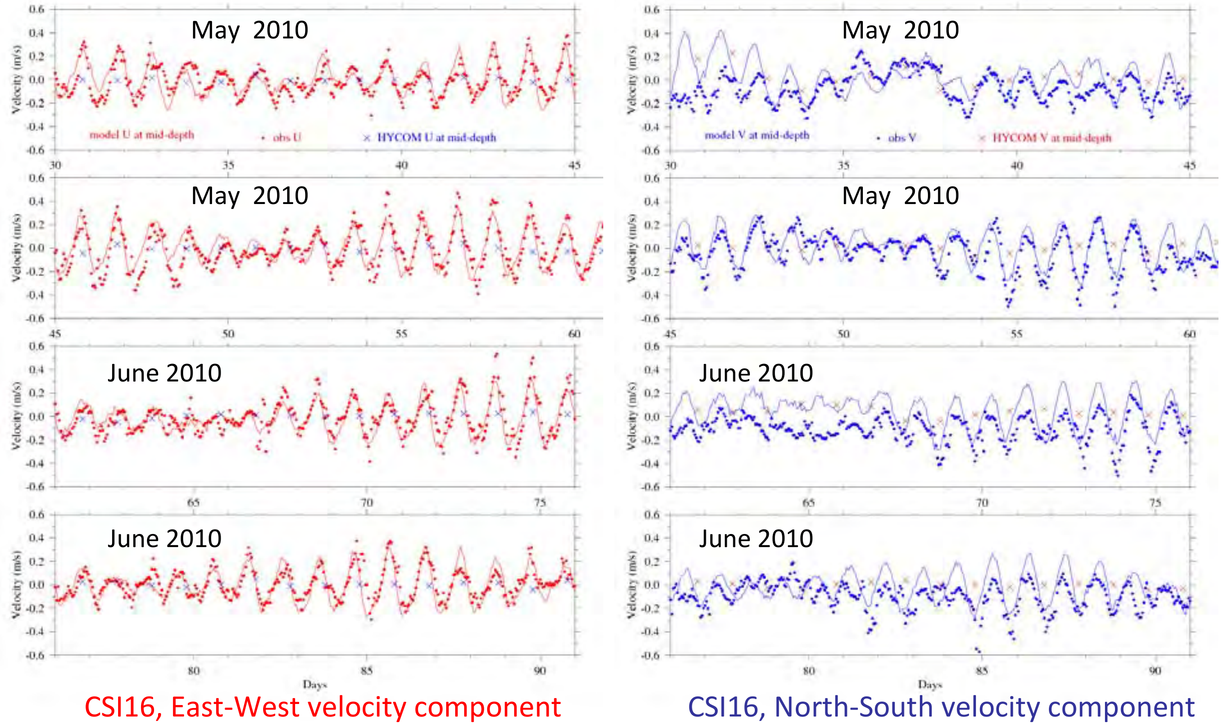


Fig. 3 Model-observation comparison of the ocean current

1) Using the simulated hydrodynamic fields, we conducted oil slick transport modeling under various hypothetical scenarios of different initial oil distribution and different Caernarvon discharge rates. In these simulations, oil was treated as particles which are made of a single substance rather than a composite of multiple hydrocarbon products. No weathering processes were considered. Therefore, simulated oil particles tended to exist longer than their real world counterparts. Preliminary numerical experiments have been run. As shown in Fig. 4, for particles released at 17:00 (GMT) April 29, 2010 (dots aligned in straight lines), when their initial locations were away from the estuary entrance (green and blue particles), the virtual oil tended to move in the northeast direction regardless of the magnitude of the Caernarvon Diversion discharge. In fact, in case of particles released at the entrance of the estuary (red particles), large diversion discharge drove the particles out of the estuary and moved them along the coastline in the northeast direction, although some particles still landed on the island inside the Breton Sound Estuary (Fig 4a). Turning off the diversion discharge allowed these particles to travel farther up into the estuary (Fig 4b). This difference can be explained by the relatively large contribution to the residual currents from the maximum diversion freshwater release.

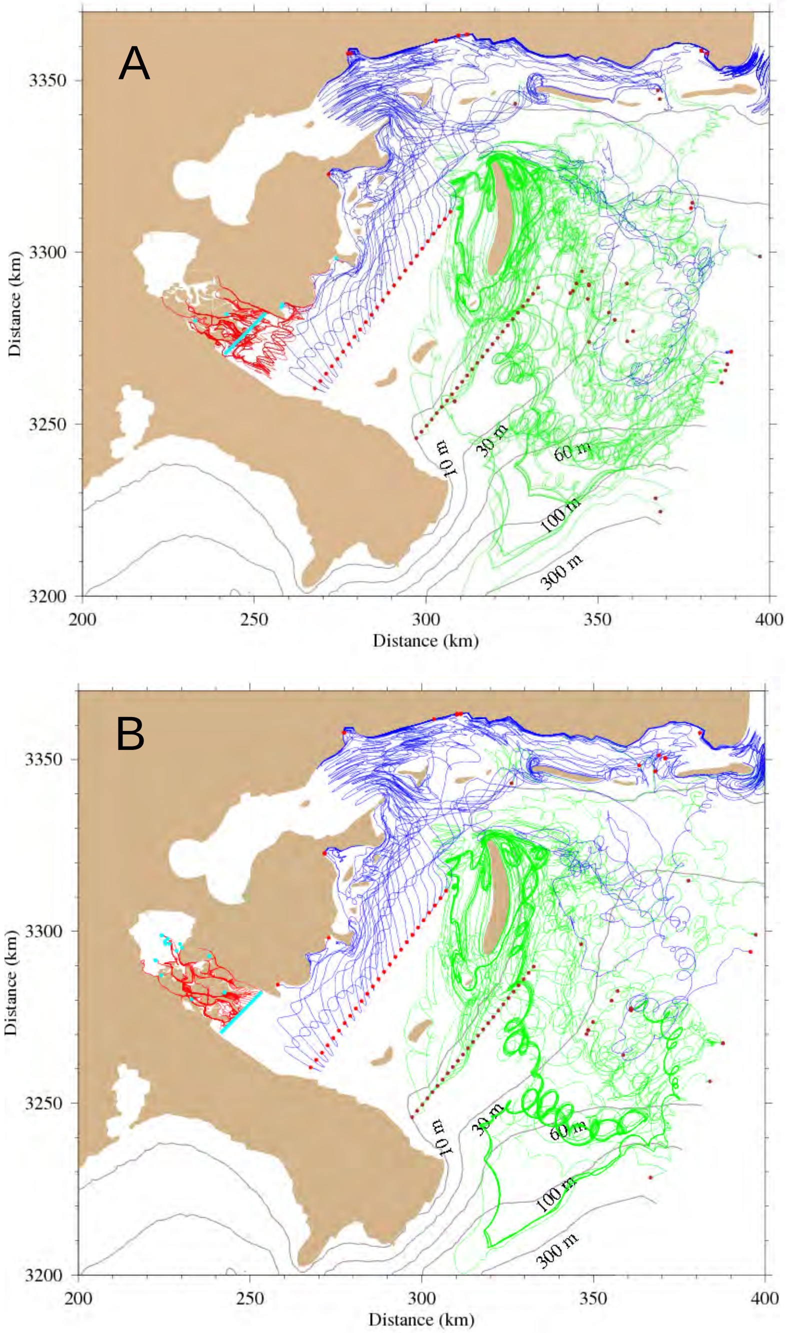


Fig. 4 Surface trajectories of oil particles released in and near Breton Sound Estuary at 17:00 GMT, April 29, 2010 for the scenario with Caernarvon Diversion discharge set at maximum (A) and zero discharge scenario (B). The dots are particles' initial and final (at 00:00 GMT July 1, 2010) locations.

2) The individual-based fish model in which particles exhibit complicated movement behavior (i.e., smart particles) is being constructed and tested. The codes for simulating behavioral movement using kinesis (Humston et. al., 2004), fitness (Railsback et. al., 1999), and game theory (Anderson, 2002; Goodwin et. al., 2006) algorithms have been completed and are currently being tested on an idealized test grid with steady state salinity distribution and zero physical transport (Fig. 5). In addition, we are coupling the game theory fish movement model with the FVCOM hydrodynamic model. Some preliminary results are shown in Fig. 6.

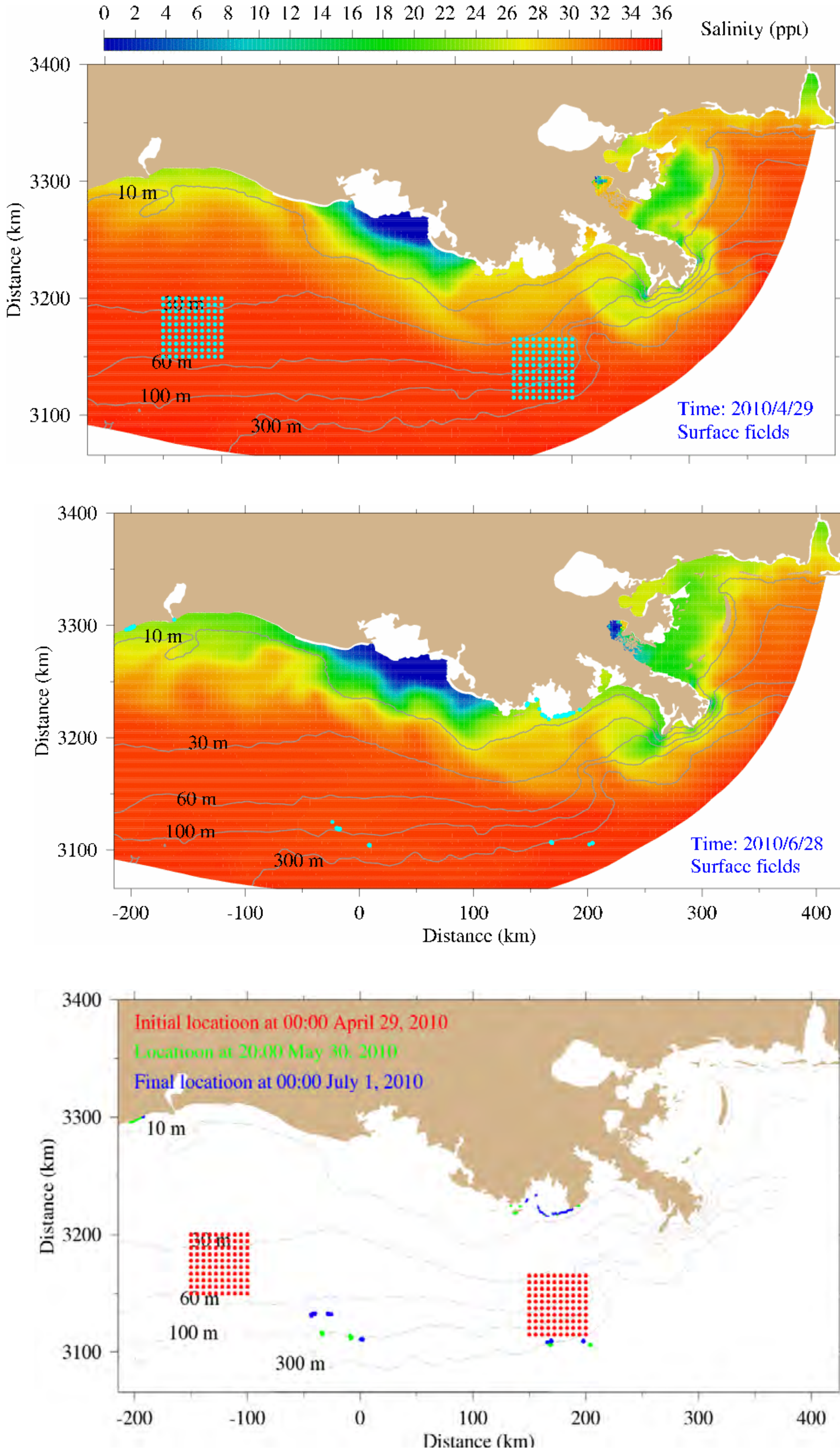


Fig. 6 Fish movements over the Louisiana Continental Shelf using game theory algorithm.

13. Outreach activities

a. General Description

The proposed research involves a significant amount of modeling research, with opportunities for student training in both graduate and undergraduate settings that advance the educational mission of Louisiana State University. Participants in our project will contribute to community outreach by participating in stakeholder meetings, such as the Caernarvon Interagency Advisory Committee (CIAC), whose members represent all major stakeholders of the region.

b. Have you hosted speakers, workshops and/or any training?

No

14. Peer Reviewed Articles: List peer reviewed articles about this project published during this period of reporting. If this is the final report for the project, list all peer reviewed articles published about this project's work. Do not include any publications before the start date of this project.

In preparation

15. Non-refereed articles and reports for this project: List all other articles about this project. Provide full citation and include copy, if available.

None

16. List conference presentations and poster presentations for this project. Provide full citation including conference name and date. Please include copy, if available.

Huang, H., D. Justic, K. Rose and C. Li, 2011. The feasibility of using Caernarvon Freshwater Diversion to prevent oil slicks from flushing into the Breton Sound Estuary. 2011 Northern Gulf Institute Annual Conference, May 17-19, 2011, Mobile, Alabama (Oral presentation).

Justic, D., K.A. Rose, L. Wang, and H. Huang, 2011. From Physics to Fish: Coupling Three-Dimensional Hydrodynamic-Biological Hypoxia Models with Individual Based Fish Models. 2011 Northern Gulf Institute Annual Conference, May 17-19, 2011, Mobile, Alabama (Oral presentation).

Justic, D., K.A. Rose, L. Wang, A. Hoda, and H. Huang, 2011. Beyond Conventional Modeling of Coastal Hypoxia: Coupling Three-Dimentional Hydrodynamic-Biological Hypoxia Models with Individual Based Fish Models. 2011 ASLO Aquatic Sciences Meeting, San Juan, Puerto Rico (Oral presentation).

Huang, H., D. Justic, K.A. Rose, and C. Li, 2011. The feasibility of using Caernarvon Freshwater Diversion to prevent oil slicks from flushing into the Breton Sound Estuary. Deepwater Horizon Oil Spill Conference, April 29, 2011, Baton Rouge LA. (Poster presentation)

17. Has anyone from this project been hired by NOAA during this reporting period? If yes, give date hired and NOAA duty station they were assigned to.

No

10-BP_GRI-MSU-01 (Tasks 1-5 as appendices A-E): Integrated Assessment of Oil Spill

1. NGI Project File Number: 10-BP_GRI-MSU-01 (Tasks 1-5 as appendices A-E)

2. Project Title: Integrated Assessment of Oil Spill

3. Project Lead (PIs and Co-PIs):

Name	Project Lead or Co-PI?	Affiliation	Email
William H. McAnally	Lead	Northern Gulf Institute	mcanally@ngi.msstate.edu
Patrick J. Fitzpatrick	Co-PI	Geosystems Research Institute	fitz@erc.msstate.edu
Gary N. Ervin	Co-PI	Dept of Biological Science and Geosystems Research Institute	gervin@biology.msstate.edu
James L. Martin	Co-PI	Dept of Civil and Environmental Engineering	jmartin@cee.msstate.edu

4. All Non-Student Personnel funded by this project:

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
William H. McAnally	Lead	Ph.D. Coastal and Oceanographic Engineering	8/16/10 to 1/15/11 – 16.43% 1/16/11 to 1/31/11 – 83.33%	No
Gary N. Ervin	Co-PI	Ph.D. Biology	8/16/10 to 9/30/10 – 16.67% 10/1/10 to 2/28/11 -33.33%	No
Robert Moorhead	Senior Researcher	Ph.D. Electrical and Computer Engineering	8/16/10 to 12/31/10 – 5.43%	No
Patrick J. Fitzpatrick	Co-PI	Ph.D. Meteorology	7/1/10 to 2/28/11 -28.89%	No
James L. Martin	Co-PI	Ph.D. Civil/Environmental Engineering	7/16/10 to 7/31/10 8/1/10 to 8/31/10 – 15.62% 9/1/10 to 12/31/10	No
Elton Amburn	Senior Researcher	Ph.D Electrical and Computer Engineering	8/1/10 to 12/31/10 – 12%	No
Deepak Mishra	Senior Researcher	Ph.D. Natural Resources	8/16/10 to 12/31/10 – 50%	No
Saurabh Prasad	Senior Researcher	Ph.D degree in Electrical Engineering	6/16/10 to 12/31/10 – 10% 1/01/11 to 2/28/11 – 67%	No
Jairo Diaz-Ramirez	Senior Researcher	Ph.D. Civil Engineering	6/16/10 to 7/31/10 -100% 8/01/10 to 10/15/10 – 75%	No
Rodrigo Nobrega	Senior Researcher	Ph.D in Transportation Engineering	8/16/10 to 12/31/10 – 59.77%	No
Vladimir Alarcon	Senior Researcher	PhD Civil and Environmental Engineering	6/16/10 to 2/28/11 – 100%	No
Karen McNeal	Senior Researcher	Ph.D Geology	8/16/10 to 12/31/10 - 40%	No
Chris Hill	Senior Researcher	Ph.D Tropical Meteorology	7/01/10 to 2/28/10 - 28.89%	No

Susan Diehl	Senior Researcher	PhD Plant Pathology	10/01/10 to 11/15/10 – 21.96% 11/16/10 to 11/30/10 – 35.83% 12/1/10 to 12/31/10 – 74.09% 1/1/11 to 1/15/11 – 15.2%	No
El Barbary Hassan	Senior Researcher	PhD Chemistry	9/16/10 to 10/31/10 – 72.7% 11/1/10 to 11/15/10 – 15.11%	No
Haibo Yao	Senior Researcher	PhD Engineering	9/1/10 to 9/30/10 – 46.15% 9/26/10 to 10/02/10 - travel	No
Ashli Brown	Senior Researcher	PhD Chemistry/Biochemistry	12/1/10 to 1/11/11 – 50%	No
Yee Lau	Research Associate	MS Engineering	7/1/10 to 2/28/10 – 28.89%	No
John Cartwright	Research Associate	MS Geology	6/16/10 to 12/31/10 61.35%	No
Rita Jackson	Research Associate	MS Counselor Education	6/16/10 to 12/31/10 – 90% 1/1/11 to 1/31/11 – 50%	No
Louis Wasson	Research Associate	MS Meteorology	7/1/10 to 12/31/10 – 25% 1/1/11 to 2/28/11 – 50%	No
John van der Zwaag	Research Associate	MS Computational Engineering	8/1/10 to 12/31/10 – 12%	No
Haldun Karan	Research Associate	MS	7/01/10 to 1/31/10 - 28.89%	No
Johnny Black	Research Associate	MS	11/01/10 to 11/30/10 – 100%	No
John Ramirez Avila	Research Associate	MS Civil& Environmental Engineering	11/2/10 to 11/04/10 - travel	No

5. All Students funded by this project:

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Yi Xiong	MS	Civil & Environmental Engineering GR	8/16/10 to 11/15/10 wages 12/1/10 to 1/31/11 wages	No
Shankar Ganapathi	MS	Ag & Life Sciences GR	8/16/10 to 12/31/10 – 100%	No
Samiappan Sathishkumar	MS	Electrical Engineering GR	06/16/10 to 8/15/10 wages 8/16/10 to 2/28/10 – 100%	No
Shuvankar Ghosh	MS	Arts and Science GR	8/26/10 to 1/31/11 - 48%	No
Jennifer Sloan	BS	Civil & Environmental Engineering GR	8/16/10 to 12/31/10 – 100%	No
Nathan Clifton	BS	Civil & Environmental Engineering GR	8/16/10 to 9/30/10 – 100%	No
Natalie Sigsby	BS	Civil & Environmental Engineering Gr	9/1/10 to 1/31/10 – 100%	No
Kimberley Pevey	MS	Civil & Environmental Engineering GR	8/16/10 to 11/30/10 - wages	No
Jamie Scott	Undergraduate	Microbiology SR	8/16/10 to 12/15/10 wages 1/1/11 to 1/31/11 wages	No
Brigitte Martin	Undergraduate	Ag & Life Sciences JR	11/16/10 to 12/15/10 wages	No
Ashley Meredith	Undergraduate	Ag & Life Sciences SR	9/16/10 to 10/1/10 wages 11/1/10 to 11/30/10 wages	No
William Ford	Undergraduate	Ag & Life Sciences SO	9/16/10 to 12/15/10 wages	No
Jessica Tucker	Undergraduate	Arts and Science SR	9/7/10 to 13/3/10 wages 11/16/10 to 11/30/10 wages	No
Amy Bowling	Undergraduate	Biological Sciences JR	9/16/10 to 11/30/10 wages 12/16/10 to 1/15/11 wages 2/1/11 to 2/28/11 wages	No
Mary Kate	Undergraduate	Biological Sciences JR	10/21/10 to 11/3/10 wages	No

Mohammadi				
Kirby Thomas	Undergraduate	Business JR	7/22/10 to 8/22/10 wages 9/7/10 to 10/5/10 wages 11/1/10 to 11/30/10 wages	No
William Ford	Undergraduate	Biological Sciences JR	9/16/10 to 12/15/10 wages	No
Chananan Kummauang	Undergraduate	Biological Sciences JR	10/6/10 to 10/20/10 wages 11/1/10 to 11/30/10 wages	No
Maryam Mohammadi	Undergraduate	Biological Sciences JR	10/1/10 to 10/31/10 wags 11/16/10 to 11/30/10 wages	No

6. Project Abstract

The overall goal was to provide research results that both provided (a) immediate contributions and (b) built a foundation for future beneficial research within NGI themes, NOAA goals, and BP research priorities.

Specific primary objectives of this Phase are to: 1. Provide early predictions of a representative hurricane ensemble so that pre-planning can be accomplished; 2. Predict the physical distribution, dispersion and dilution of contaminants under the action of currents and storms in coastal estuaries; 3. Determine environmental effects of the oil/dispersant system on shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery; 4. Improve understanding of biological degradation of the oil/dispersant systems and subsequent interaction with the marine and coastal ecosystems; 5. Provide a Coastal and Marine Spatial Planning toolkit for displaying results useful in recovery management; and 6. Produce a sound scientific base and plans for multi-institutional research that will fully address BP's priorities within NGI's mission.

The work will be accomplished in four interrelated tasks: A. Hurricane Effects; B. Fate and Transport of Oil and Dispersants; C. Natural Systems; and D. Technology and Data Integration. Task A will examine the impact of six tropical cyclone scenarios on the Deepwater Horizon oil spill for the Northern Gulf Coast by 15 August 2010. Recommendations for further research in Phase 2 will also be made based on these results for studies after the 2010 Gulf hurricane season. Task B will focus on indentifying and applying available calibrated hydrologic and hydraulic models of Gulf estuaries, demonstrating how they may be used to assess the long-term impacts of the oil spill (e.g. on hypoxia, sequestration in sediments, toxicity to algae, etc.), establishing and prioritizing remedial actions, and indentifying deficiencies in the literature impacting or introducing uncertainty into those predictions, such as kinetic rates impacting fate. Task C will assess early responses of intertidal habitats to oil/dispersant contamination and interaction between oil/dispersant system and soil/sediment microbial assemblages. Task D will make the results of Tasks A, B, and C accessible and understandable and build a foundation for future research by providing a platform and mechanism for integration of results.

7. Key Scientific Questions/Technical Issues:

The overall goal was to provide research results that both provided (a) immediate contributions and (b) built a foundation for future beneficial research within NGI themes, NOAA goals, and the BP research priorities listed above.

Specific primary objectives are to:

a. Provide early predictions of a representative hurricane ensemble so that pre-planning can be accomplished.

b. Predict the distribution, dispersion and dilution of contaminants under the action of currents and storms in estuaries.

c. Determine environmental effects of the oil/dispersant system on shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery.

d. Improve understanding of biological degradation of the oil/dispersant systems and subsequent interaction with the marine and coastal ecosystems.

e. Provide a Coastal and Marine Spatial Planning toolkit for displaying results useful in recovery management.

f. Produce a sound scientific base and plans for multi-institutional research that will address BP's objectives within NGI's mission.

8. Collaborators/Partners:

See attached.

9. Project Duration:

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

1	Strategic Goal #1: Protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management;
	Strategic Goal #2: Understand climate variability and change to enhance society's ability to plan and respond;
2	Strategic Goal #3: Serve society's needs for weather and water information;
2	Strategic Goal #4: Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation
2	Strategic Goal #5: Provide critical support for NOAA's mission

Contributions to regional problems and priorities: How is the project tied to regional issues and priorities? Identify priority stakeholders, e.g., Gulf of Mexico Alliance, specific user groups.

2	Water Quality
2	Habitat Conservation and Restoration
1	Ecosystem Integration and Assessment
	Nutrients and Nutrient Impacts
2	Coastal Community Resilience
	Environmental Education

Gaps: Describe how the project has narrowed gaps in regional knowledge, data, model performance, geographic coverage, etc.

Contributions to BP_GRI goals:

2	Physical distribution, dispersion and dilution of contaminants under the action of ocean currents and tropical storms;
2	Chemical evolution and biological degradation of the oil/dispersant systems and subsequent interaction with the marine and coastal ecosystems;
1	Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery
2	Technology developments for improved mitigation, detection, characterization and remediation of oil spills;
2	Fundamental scientific research integrating results from the other four themes in the context of public health.

11. Milestones accomplished during entire project period:

See Attachments A-E.

12. Describe all significant research results, protocols developed, and research transitions:

See Attachments A-E.

13. Outreach activities:

See Attachments A-E.

14. Peer Reviewed Articles:
See Attachments A-E.

15. Non-refereed articles and reports for this project:
See Attachments A-E.

16. List conference presentations and poster presentations for this project:
See Attachments A-E.

17. Has anyone from this project been hired by NOAA during this reporting period?
No

Attachments A-E :

A: NCOM wind validation in the Intra-American Seas (AMSEAS) domain in the Gulf of Mexico during 20 June to 10 July 2010 and the use of NCOM data to examine the impact of cyclones on the Deepwater Horizon oil spill

B: Final Report Task B: Amount, Fate, and Transport of Oil and Dispersants in Estuarine Environments

C: Final Report Task C: Natural Systems

D: Final Report Task D: Technology and Data Integration

E: Interim Report Task E: Innovations

Attachment A: NCOM wind validation in the Intra-American Seas (AMSEAS) domain in the Gulf of Mexico during 20 June to 10 July 2010 and the use of NCOM data to examine the impact of cyclones on the Deepwater Horizon oil spill

Pat Fitzpatrick, Yee Lau, Chris Hill, and Haldun Karan
Geosystems Research Institute
Mississippi State University

Overview

The Deepwater Horizon explosion reopened debate on the role of synoptic weather features versus ocean currents in transporting oil spills. Lagrangian models generally assume oil concentrations travel largely proportional (80-100%) to ocean currents' speed and direction, plus an additional 3% contribution from surface winds, diffused with each time step. However, cyclones are known to highly perturb water pollutants with positive and negative results. A mid- latitude cyclone expanded the Exxon Valdez oil spill over a large region, while in contrast Hurricane Henri (1979), in combination with a non-tropical low, cleansed the oil-polluted south Texas beaches (Gundlach et al. 1981).

We identified the late June to early July timeline as a period of interest since oil briefly impacted the Rigolets, Lake Borgne, and western Mississippi coast, and represented the innermost penetration of oil pollution east of the Mississippi River. An important component to understanding the oil transport is to distinguish the influences behind this apex moment. An oil spill simulation was conducted for the period 20 June to 10 July 2010 to understand this inland transport. Meteorology and ocean data, as well as synoptic maps also facilitated this analysis. The results of this analysis, as well as validation of numerical model wind analysis, are presented in this report. We also briefly discuss hydrology modeling software designed to predict the movement of oil pollution in the event of a hurricane landfall in the oil spill region at the end of this report.

Model overview

We developed a Lagrangian particle tracker with random walk diffusion to simulate the oil spill from 0000 UTC 20 June to 0000 UTC 11 July 2010 (Hunter et al. 1993; Dimou and Adams 1993). Input consisted of latitude and longitude parcel positions in the oil-contaminated area, wind, current, and an array of pseudo-random numbers. In addition, new parcels were released at the location of the damaged Macondo rig at each timestep. Twenty-five parcels were released at each position, and when combined with a 10 m^2s^{-1} diffusion coefficient, resulted in a natural trajectory spread with time. Initialization was based on NASA MODIS satellite imagery, SAR imagery from http://www.cstars.miami.edu, NOAA's Office of Response and Restoration oil trajectory maps at http://response.restoration.noaa.gov, and the NOAA/NESDIS Satellite Analysis Branch (SAB) experimental surface oil analysis products at http://www.ssd.noaa.gov/PS/MPS/deepwater.html. The parcels moved at 80% of the ocean current speed and at 3% of the wind speed[1]. Bilinear interpolation was applied at each timestep to determine the currents and winds at each parcel position.

[1] Sensitivity experiments were performed with the diffusion coefficient and current ratios. The chosen values reported herein provided the most accurate results. More work is underway using variational analysis to quantify the optimum weights for wind and ocean current influence on parcels movement.

The pseudo-random numbers were uniformly distributed between 0 and 1 and generated by the efficient Mersenne Twister algorithm (Matsumoto and Kurita 1998). This modern technique has passed stringent "diehard" and NIS tests for randomness, and will generate an incredibly long sequence of numbers (2^{19937}-1) before repeating. The initial seed was randomly obtained from machine noise (/dev/urandom on Linux machines).

The 10-m wind and near-surface currents were provided from an operational, data assimilating forecast system (Ko et al. 2003; 2008) run daily by the Naval Oceanographic Office called the Navy Coastal Ocean Model (NCOM). The model version simulated the Intra-Americas Sea (AMSEAS) domain, which covers the Gulf of Mexico, Caribbean, and western Atlantic, and is interpolated to a 3-km Cartesian grid. The AMSEAS data includes tidal components and a dynamic water surface which fluctuates from wind forcing even capable of capturing storm surge events (Korobkin et al. 2010). The Coupled Ocean-Atmosphere Prediction System (COAMPS) provided the atmospheric forcing. COAMPS wind stress was converted to wind speed by using a wind drag formula and assuming a drag coefficient of 0.001. The COAMPS winds were used at initialization time up to 24-h forecasts, whereupon a new NCOM dataset was used from the next day.

COAMPS validation

COAMPS winds were validated against moored buoys and CMAN stations using standard error metrics and vector correlation[2]. Internal tests of three different vector correlation schemes (Hanson et al. 1992; Crosby et al. 1993 [also see Breaker et al. 1994]; Kundu 1976) showed the Hanson et al. algorithm possessed the best attributes: it provides parametric coefficients; it is invariant under rotation; it provides an angle of rotation as well as a scaling factor between two vector datasets; and is analogous to linear regression. With regard to the latter property, it provides a correlation coefficient between -1 and 1 as well as least square fit coefficients. The Hanson et al. scheme also quantifies vector reflection, although that property is irrelevant to meteorology validation.

An examination of bias and absolute errors during the summer study period show very small wind direction or speed bias, computed as buoys minus NCOM (Table 1). However, NCOM consistently underpredicted wind speed (to be discussed in a moment). The buoy/CMAN data were converted to 10-m height and 1-min averages for consistent comparisons[3]. The absolute errors for wind speed also are minimal, from 1.4 to 1.6 ms^{-1}. The wind direction absolute errors are small but not negligible from 31.0 to 37.9 deg; however, much of this error is due to the weak pressure gradients that favor variable winds during this period. An examination of NCOM during a windy winter period containing several frontal

[2] It can be shown that vector correlation is a two-dimensional version of canonical correlation multivariate analysis.
[3] The 10-m adjustment was performed assuming a Charnock roughness length relationship and logarithmic wind profile. The 8-min average moored buoy winds were converted to 1-min average winds assuming a 9% gust factor increase.

passages (0000 UTC 1 December 2010 to 0000 UTC 15 January 2011) show similar error statistics except the wind direction absolute error is reduced by approximately 10 deg.

Other metrics and plot provide additional insight into the wind validation. Figure 1 shows the Hanson et al. methodologies and absolute error for wind validation at four offshore moored buoys. The “variance explained” ranges from 50 to 75%; most of the lost correlation is due to wind direction variability and the small model negative bias. The scalar factors are slightly greater than one, another indirect measure of model wind speed underforecasts. The rotation angles show equally small positive and negative values, another indication of no model wind direction bias. However, the wind direction absolute errors are less than the 37-buoy averages shown in Table 1. As will be shown, the larger wind direction errors are associated with coastal platforms.

Figure 2 depicts scatterplots of NCOM data versus two offshore buoys. In general, the wind direction show a good positive linear correlation. However, while the wind speed scatterplots show a positive linear trend, a negative speed bias is evident. Furthermore, this bias increases with wind speed. Ovals representing one standard deviation of NCOM and each buoy is shown in Fig. 2 for wind speed. Circular plots indicate both the model and buoys have the same data ranges, and elliptic plots indicate one dataset has less range than the other. Figure 2 shows generally elliptical patterns centered to the right, showing the NCOM negative speed bias.

Case studies were also performed to assess COAMPS initialization fields. A typical summertime example for wind direction and wind speed is shown in Figs. 3 and 4, respectively, for 0000 UTC 22 June 2010. They show generally small errors offshore with larger errors on the coast. Since the wind forcing of the oil spill is mostly dictated offshore, the mid-summertime COAMPS winds are deemed sufficiently accurate for utilization in the Lagrangian particle tracker model. Validation of the Gulf of Mexico flow features are underway by other scientists, but as will be shown, our examination of NCOM surface elevation data suggests the ocean model produces relatively accurate currents.

An appendix at the end of this report provides all the validation graphics for both the summer and winter NCOM analyses.

<u>Oil spill simulation analysis</u>

Figure 5 shows four snapshots of the oil spill evolution simulated by the Lagrangian model for 20 June, 25 June, 30 June, and 5 July 2010, all at 0000 UTC. The first 8 days show two flow regimes: 1) east of the Mississippi River, oil moves northeast from the Macombo rig towards the Breton Sound islands, and the Alabama and west Florida coasts; and 2) west of the Mississippi River, a northwest current impacting the west Delta Region, Sandy Point Beach, Barataria Bay, Terrebonne Bay, and the shorelines/estuaries further west ending in the vicinity of Atchafalaya Bay. Animations (not shown) include a pulsing action due to the diurnal tides common in this region. By the end of June, the simulation shows a sudden inward shift of the oil concentrations in western Mississippi Sound and Lake Borgne. A brief retreat occurs afterwards followed by a more prolonged inward penetration to these same regions.

Synoptic data analysis followed to clarify the cause of these two events. We examined scatterometer data, satellite/radar imagery, high-frequency radar (HFR) currents, COAMPS wind fields, buoy data, and North American surface map analyses. The HFR data (now shown) indicated a switch of eastward to westward currents off of Mississippi in late June, providing support that the NCOM ocean current changes were valid. An inspection of the weather maps shows a sequence of four distinct weather regimes that contributed to the two influxes of oil. A typical summertime pattern existed on 20 June, dominated by light winds and high pressure (Fig. 6; also see Figs. 3 and 4 for 22 June). Starting 25 June (Fig. 7) through 30 June (Fig. 8), a tropical system affected the Gulf as a tropical wave entered the region and eventually became Hurricane Alex. The tropical wave became a depression by 1800 UTC 25 June about 80 n mi north-northeast of Puerto Lempira, Honduras, moved west-northwestward, became a tropical storm on 0600 UTC 26 June, and made its first landfall in the Yucatan Peninsula near Belize City around 0000 UTC 27 June. The weakened tropical storm then re-entered the southwest Gulf, strengthened to a category 2 hurricane, and made its final landfall near Soto la Marina, in northeastern Mexico around 0200 UTC 1 July. It is during the period the first inward oil incursion happened into the Lake Borgne region.

Afterwards, a cold front moved offshore into the eastern Gulf of Mexico (Fig. 9), creating a northerly wind flow off in the northern Gulf Coast region. During this period, the oil retreated slightly. However, a non-tropical low pressure system formed on the western edge of this front (Fig. 10), and slowly moved westward then stalling south of eastern Louisiana (Fig. 11). This period is accompanied by a second oil incursion into the Mississippi Sound and Lake Borgne area. COAMPS analyses (Fig. 12) summarizes the wind patterns associated with these found weather regimes.

The fringe effect of Alex, as well as the close proximity of the non-tropical low, not only switched alongshore westerly coastal currents (not shown) to an easterly direction, but also increased inland water levels by 0.6 m to 0.8 m above normal as mini-surge events. The Shell Beach CMAN (Fig. 13, top) located in Lake Borgne, LA, shows peak water levels of 0.5 and 0.6 m above normal on 29 and 30 June, followed by slightly above normal conditions as the front pushed through, then a more prolonged elevated water period of 0.6-0.8 m above normal for 4-7 July. CMAN stations in Waveland, MS, and East Pascagoula, MS display similar patterns (not shown). NCOM captured these two elevated water periods in Lake Borgne (Fig. 13, bottom), but the magnitudes are too low. This is probably because the resolution cannot adequately capture the surge magnitudes this far inwards into the estuaries.

Development of operational storm surge modules for oil pollutant transport

These results thus far show that cyclones can dramatically alter oil transport, even by fringe effects. Indeed, the Northern Gulf Coast – especially the wetlands – may have escaped even worse oil pollution due to the lack of landfalling tropical cyclones in the Gulf of Mexico in 2010. Part of the deliverables involved developing a storm surge module for transporting oil pollutants in the event of tropical cyclone impact. This forecast system involved the Advanced CIRCulation (ADCIRC) hydrodynamic model to provide water currents and surge elevations, and the Lagrangian particle model discussed earlier for predicting oil transport.

An example of this system is shown in Figs. 14 and 15, which simulated the hypothetical scenario of a category 2 hurricane making a September landfall in Fourchon, LA. In September 2010, the beaches from Sandy Point to Chalon Pass, as well as northeast Barataria Bay (near Bay Jimmy), contained oiled shorelines as well imbedded oil on the sea bottom. It is assumed the oil remains on the bottom until a minimum velocity of 0.4 ms^{-1} is reached. In this scenario, oil would have been displaced westward, covering parts of Grant Isle, then moving northwards deep into the marsh north of Barataria Bay. The oil residual would have remained in the marsh as the surge retreated. Fortunately, this forecast system was never tested. It was also noted the results were sensitive to the initial displacement velocity. However, experiments with different diffusion coefficients yielded similar oil movement, just different dispersion spread widths.

Acknowledgments

BF funded this work through the Northern Gulf Institute with Award # 10121360. This work was also sponsored by NOAA with Grant 2010-012 through the U.S. IOOS Program and administered by the Southeastern Universities Research Association (SURA), and by the U.S. Department of Homeland Security under Award Number 2008-ST-061-ND 0001. The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily representing the official policies, either expressed or implied, of the U.S. Department of Homeland Security, BP, or NOAA. We appreciate Bruce Lipphardt of the University of Delaware for supplying the MATLAB code for the Kundu algorithm. Brian Hanson of the University of Delaware provided the FORTRAN code for Hanson et al. (1992) algorithm (available at: http://hanson.geog.udel.edu/~hanson/hanson/Research.html).

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Table 1. Wind validation of COAMPS initialization and 6-, 12-, 18-h, and 24-h forecasts for 21 NCOM forecasts during 0000 UTC 20 June 2010 to 0000 UTC 10 July 2010. The average errors of bias and absolute error are based on 37 buoys and CMAN stations. The observations are adjusted to 1-min averages and 10-m height elevation. COAMPS' wind vector stresses are converted to wind speed u and v components assuming a drag coefficient of 0.001.

	Analysis	6-h	12-h	18-h	24-h
Wind direction bias (ms^{-1})	-2.6	-5.7	3.8	13.3	-4.8
Wind direction absolute error (deg)	33.6	31.0	37.9	35.7	33.6
Wind speed bias (ms^{-1})	-0.1	0.4	0.5	0.8	0.1
Wind direction absolute error (deg)	1.4	1.4	1.6	1.6	1.4

Table 2. As in Table 1, but for 46 NCOM forecasts during 0000 UTC 1 December 2010 to 0000 UTC 15 January 2011. The average errors of bias and absolute error are based on 23 buoys and CMAN stations.

	Analysis	6-h	12-h	18-h	24-h
Wind direction bias (ms^{-1})	2.6	4.9	-2.6	1.7	1.8
Wind direction absolute error (deg)	26.0	22.1	21.8	28.1	26.2
Wind speed bias (ms^{-1})	0.7	0.4	0.4	0.9	0.8
Wind direction absolute error (deg)	1.8	1.7	1.7	1.6	1.8

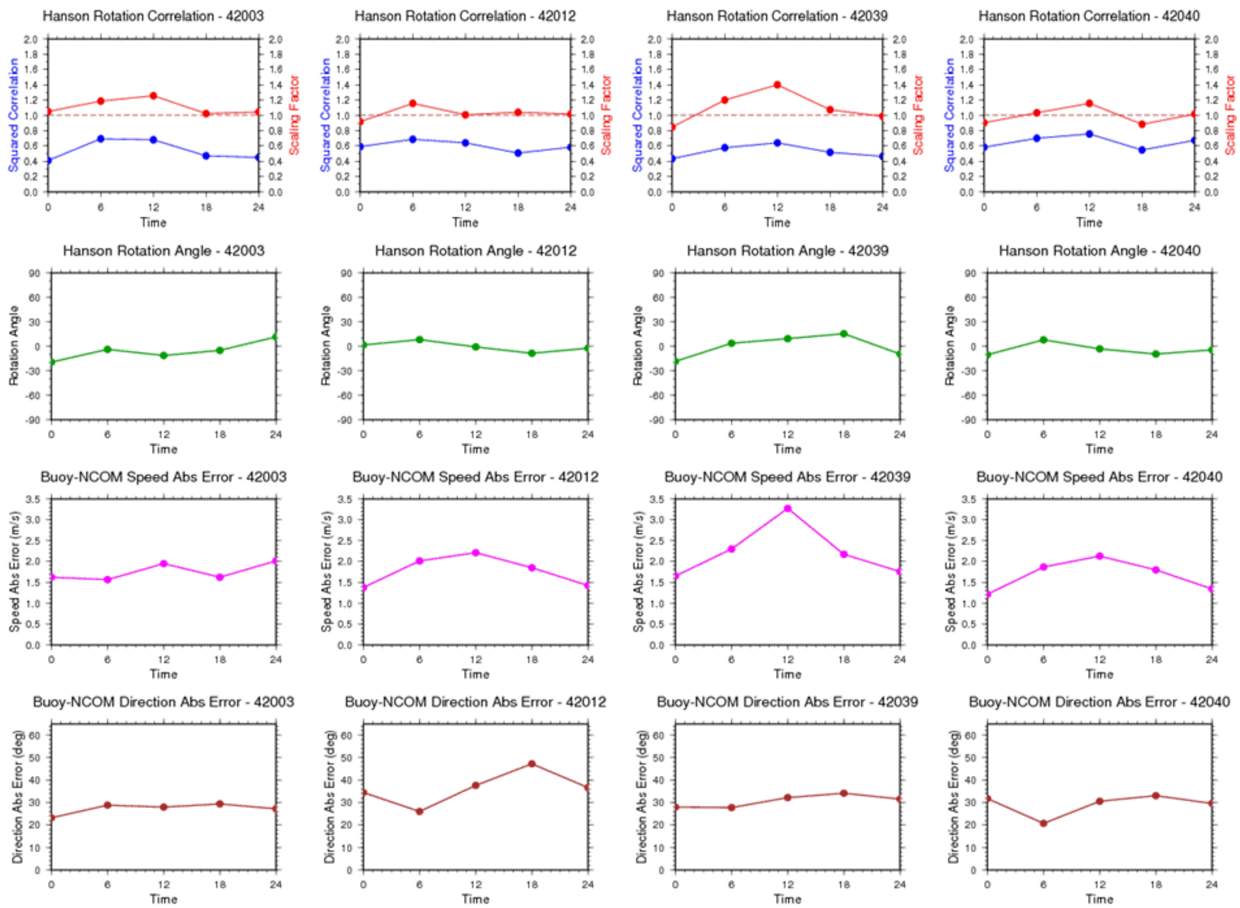


Figure 1. Top two rows - Example of vector correlation squared, scaling factor, and rotation angle based on methodology of Hanson et al. (1992) for COAMPS winds initialization and forecast interpolated to 4 buoys (42003, 42012, 42039, and 42040), during the period 0000 UTC 20 June 2010 to 0000 UTC 10 July 2010. The dashed line corresponds to a squared correlation of 1. Bottom rows – absolute errors for wind direction and speed at the 4 buoys.

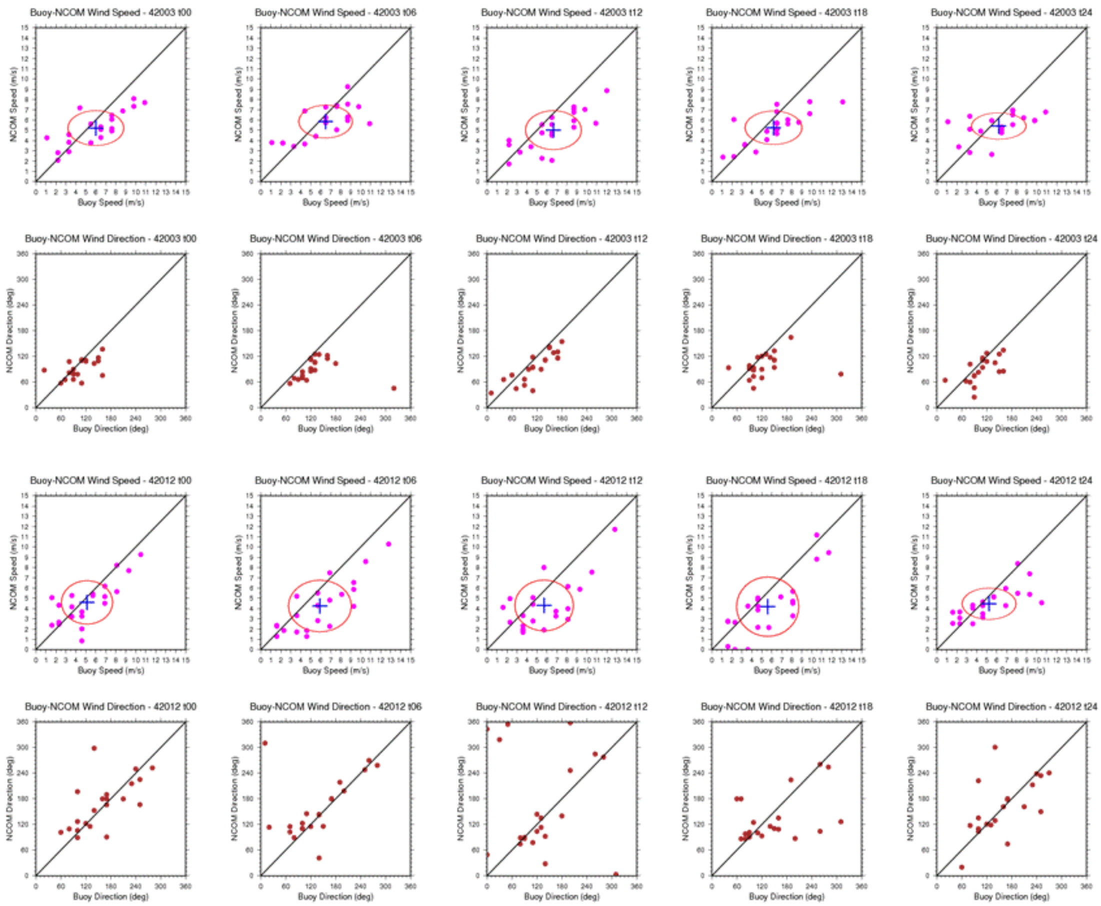


Figure 2. Example of scatterplots for COAMPS winds initialization and forecast interpolated to 2 buoys (42003 and 42012) during the period 0000 UTC 20 June 2010 to 0000 UTC 10 July 2010. Wind speed plots also include ovals representing one standard deviation of each dataset; circular plots indicate both the model and buoys have the same data ranges, and elliptic plots indicate one dataset has less range than the other.

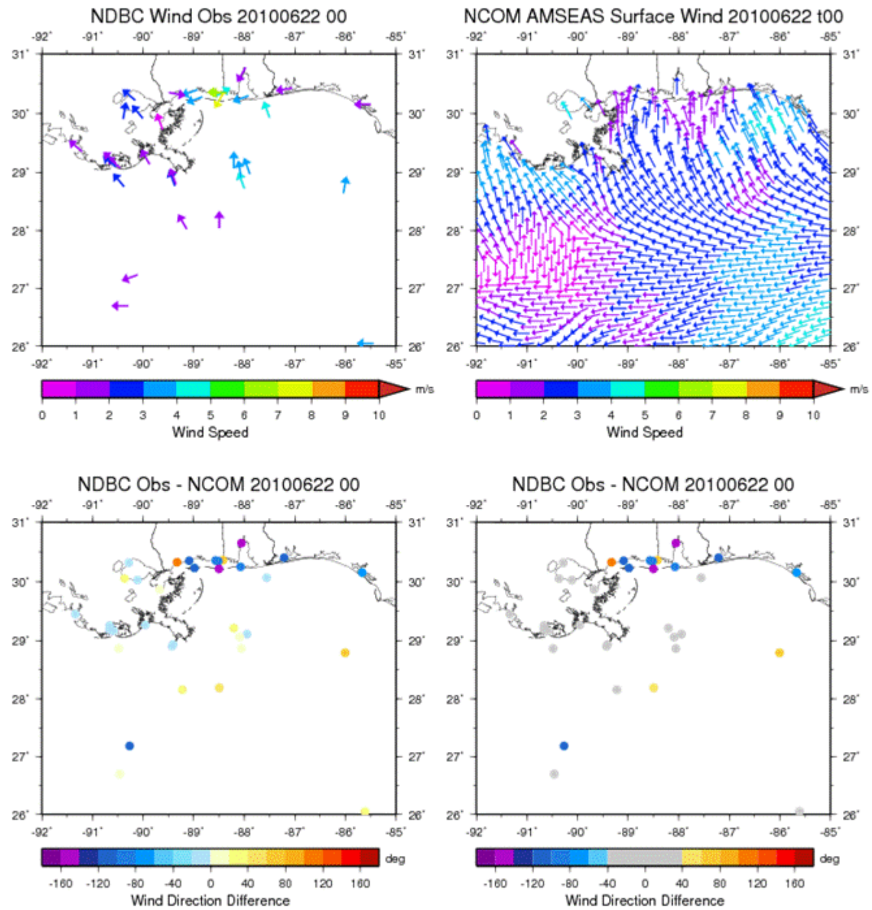


Figure 3. Example of a plot for daily analyses for COAMPS initialization for 0000 UTC 22 June 2010. Top left: Observed buoy vectors, shaded by wind speed. Top right: COAMPS wind vectors. Bottom left: Wind direction difference. Bottom right: same as bottom left, but "small" wind direction errors shaded grey.

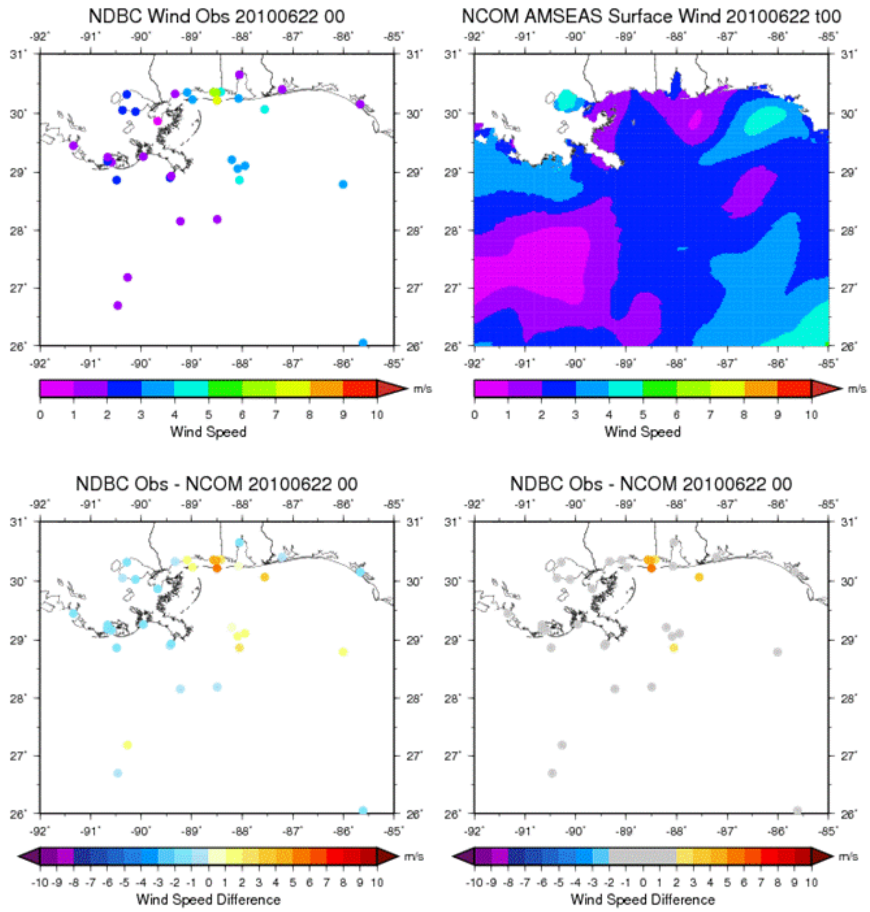


Figure 4. Example of a plot for daily analyses for COAMPS initialization for 0000 UTC 22 June 2010. Top left: Observed buoy wind speeds, shaded by wind speed. Top right: contours of COAMPS wind speed. Bottom left: Wind speed difference. Bottom right: same as bottom left, but "small" wind speed errors shaded grey.

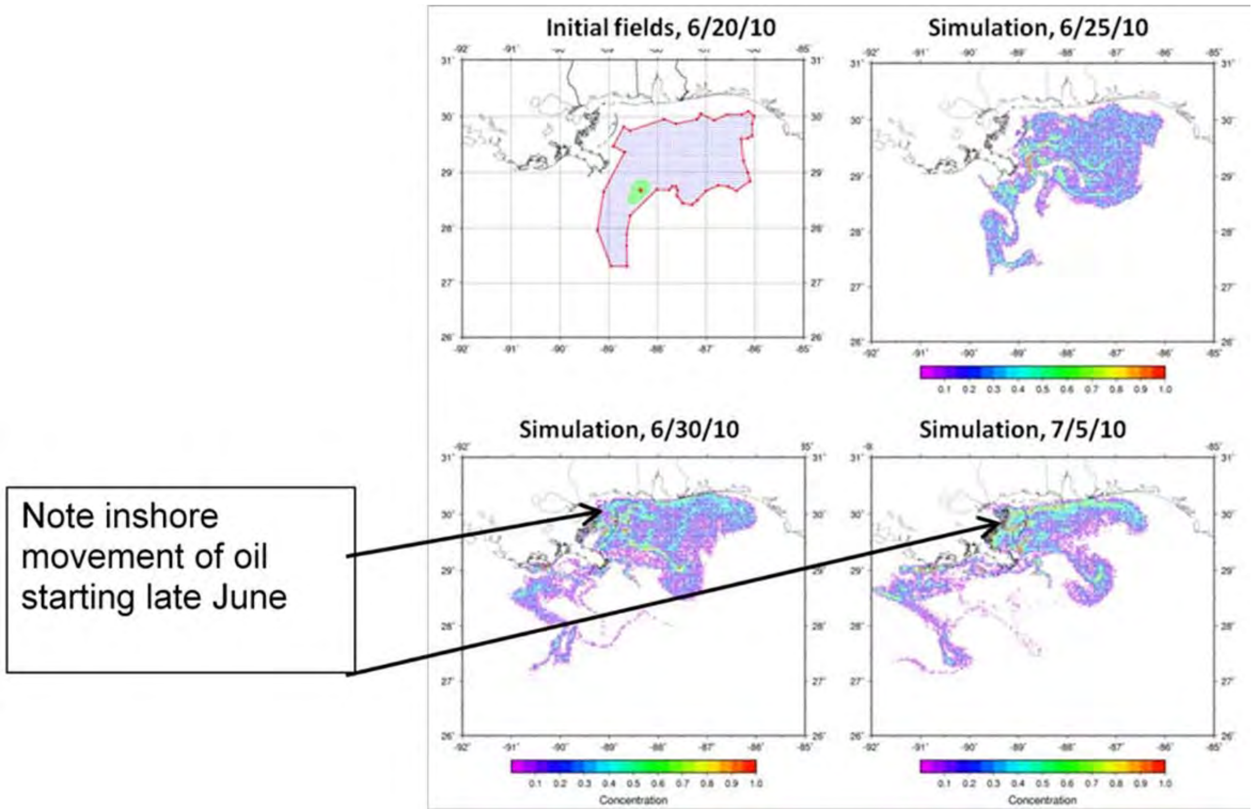


Figure 5. Snapshot images of the Deepwater Horizon oil spill simulation from 0000 UTC 20 June 2010 to 0000 UTC 10 July 2010. Note the inshore incursion into the Mississippi Sound and Lake Borgne regions starting in late June. Concentrations are computed as the ratio of parcels near a gridded point divided by the number of parcels originally released at each point. In these simulations, each point has 25 releases at initialization, then each trajectory is modified by a random number to mimic dispersion. Hence, concentrations in these runs are a fraction of 25.

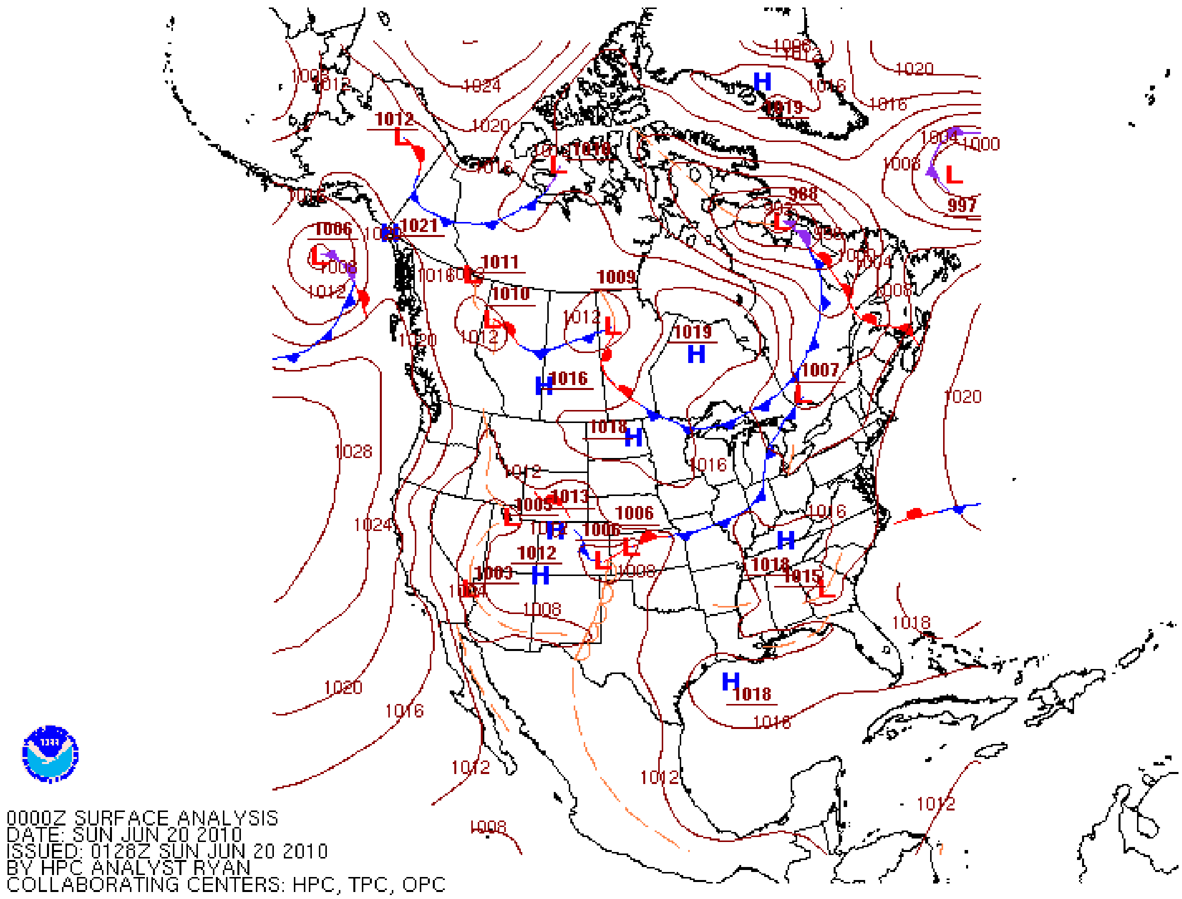


Figure 6. Hydrometeorological Prediction Center (HPC) North American surface analysis for 0000 UTC 20 June 2010 (available at http://www.hpc.ncep.noaa.gov/html/sfc_archive.shtml). HPC is part of the NOAA/National Weather Service National Centers for Environmental Prediction.

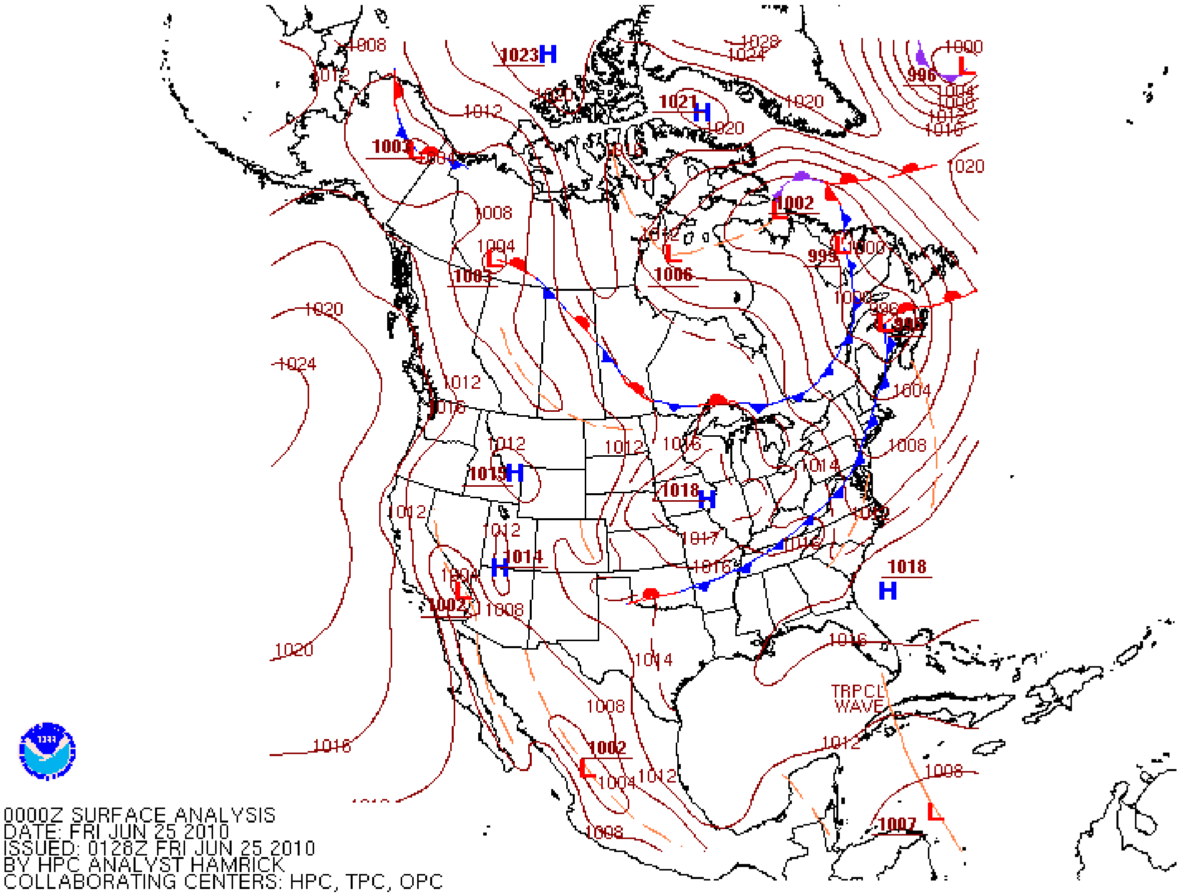


Figure 7. As in Fig. 6, but for 0000 UTC 25 June 2010.

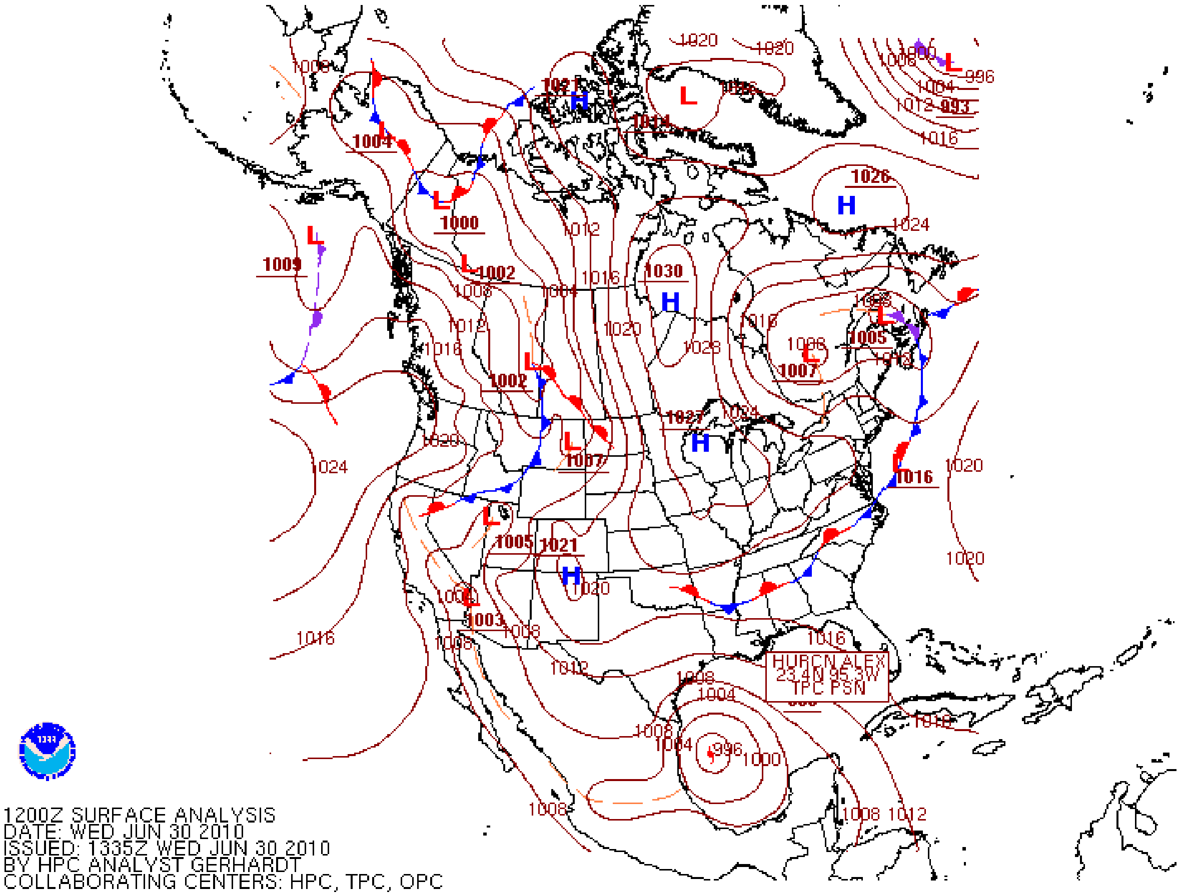


Figure 8. As in Fig. 6, but for 1200 UTC 30 June 2010.

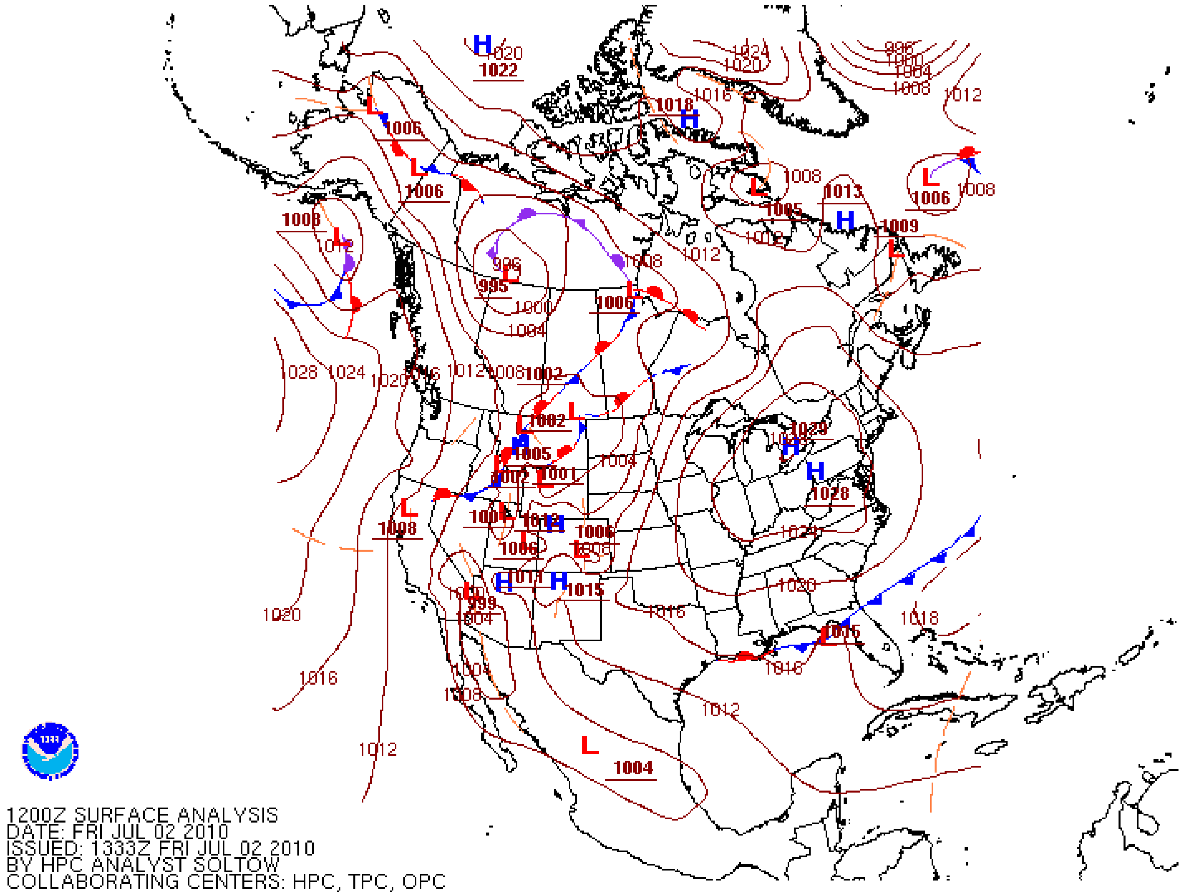


Figure 9. As in Fig. 6, but for 1200 UTC 2 July 2010.

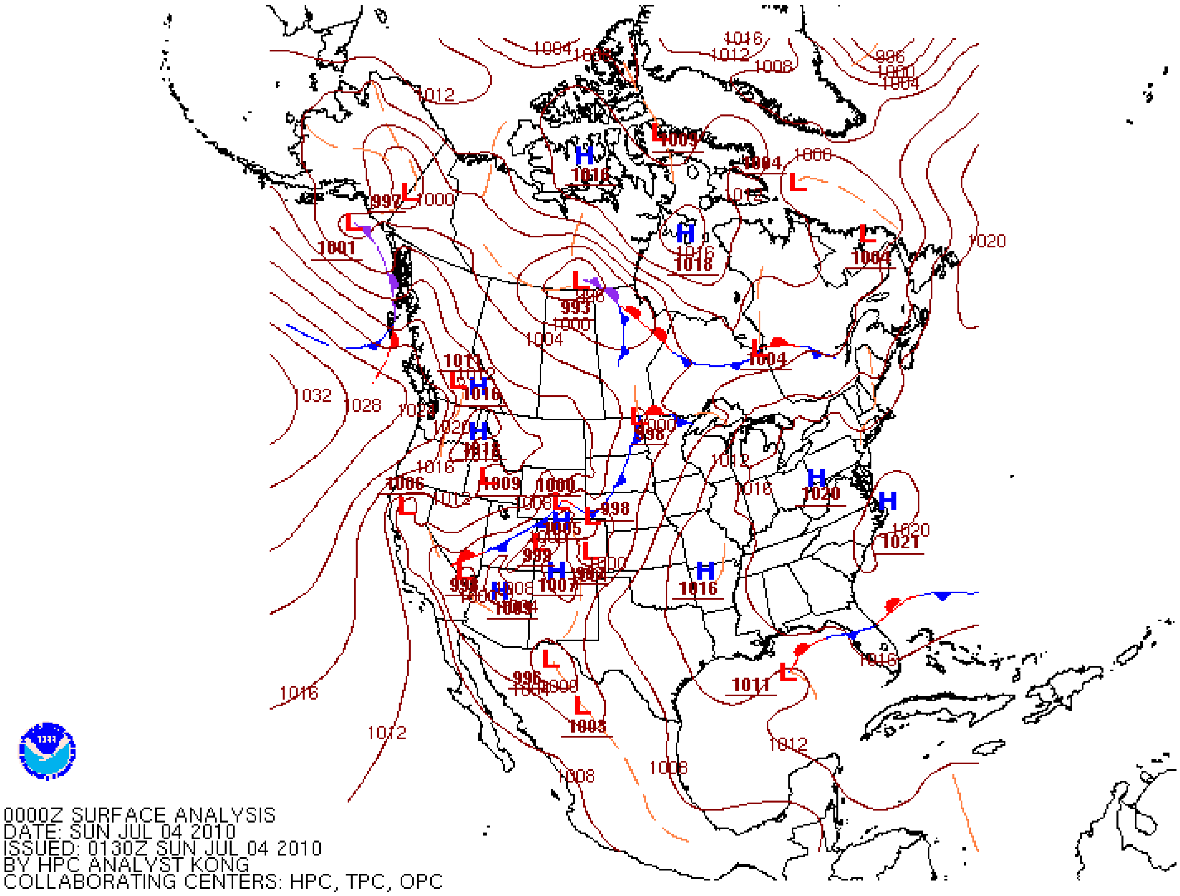


Figure 10. As in Fig. 6, but for 0000 UTC 4 July 2010.

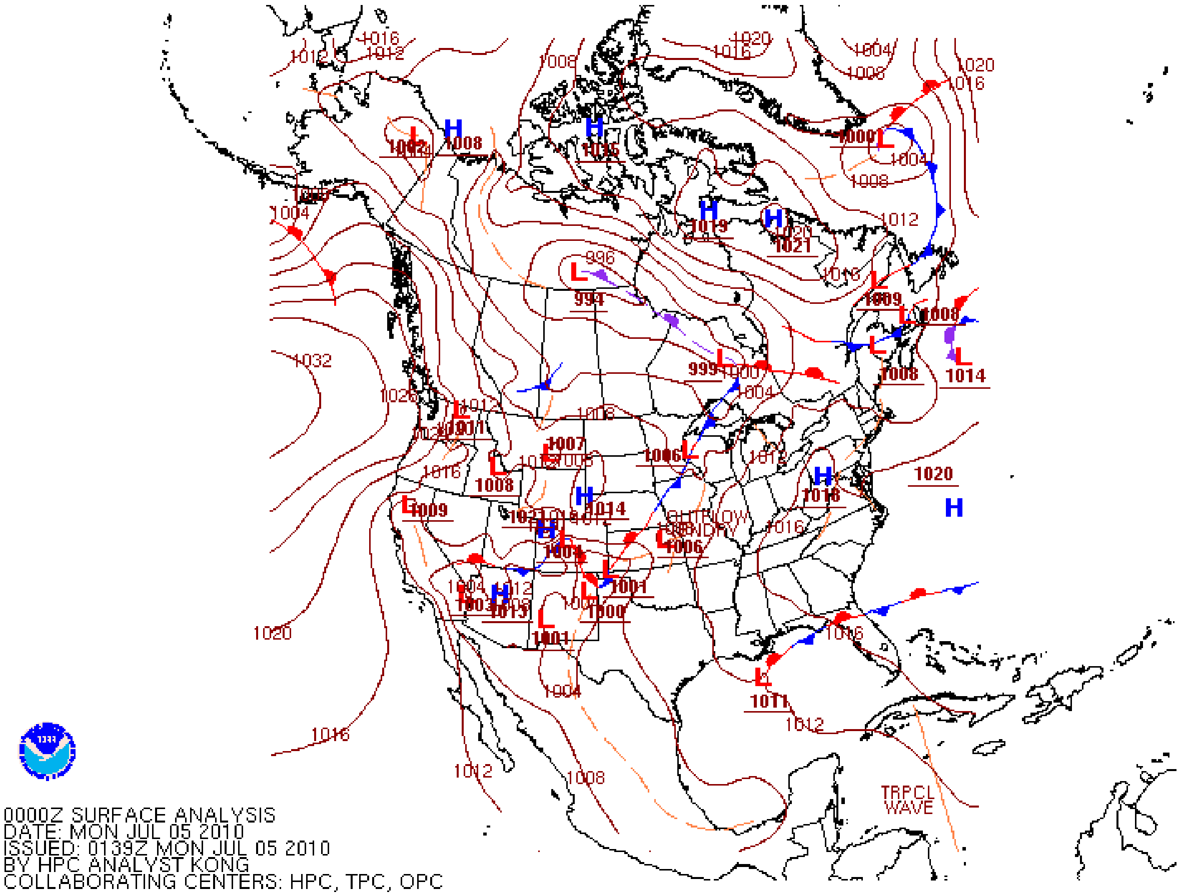


Figure 11. As in Fig. 6, but for 0000 UTC 2 July 5010.

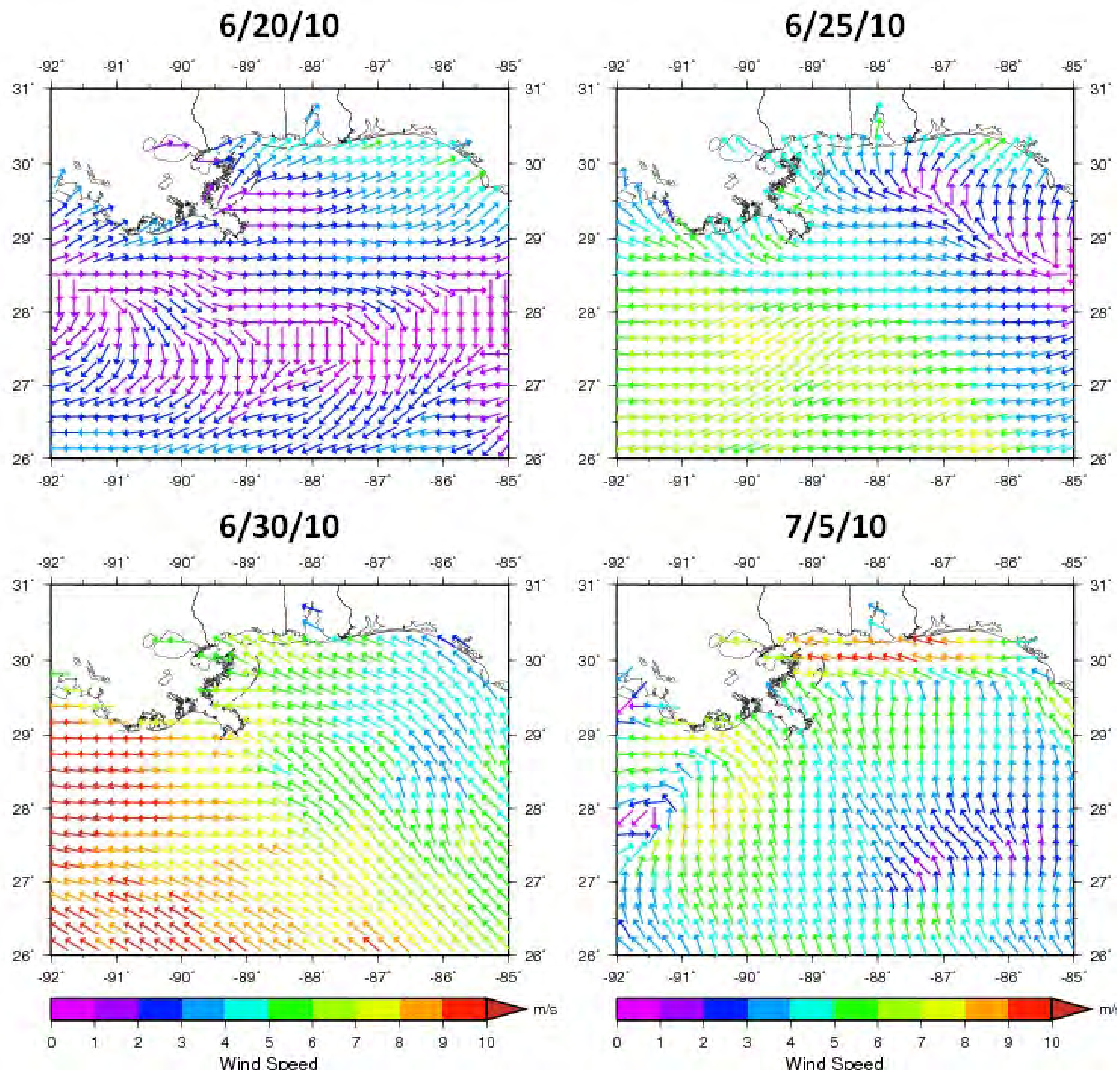
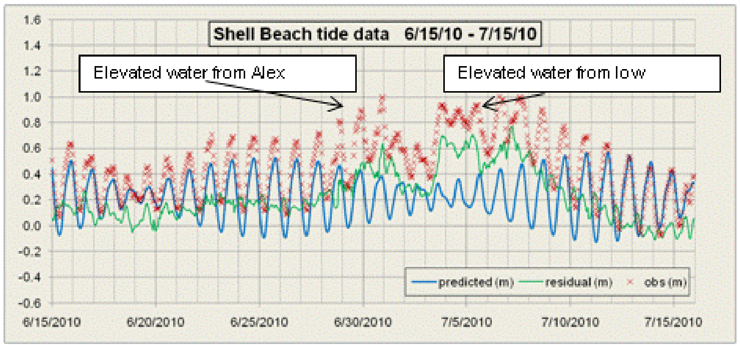


Figure 12. COAMPS winds for 0000 UTC 20 June, 25 June, 30 June, and 5 July 2010, depicting the weather regimes during this period. The period begins with typically weak summertime winds associated with a high pressure ridge (top left), then winds off of Mississippi becoming easterly associated first with a developing Tropical Storm Alex off of Yucatan, followed by fringe effects of category 2 Hurricane Alex as it approaches Mexico (lower left), concluding with an offshore cold front in the eastern Gulf (not shown) in which a non-tropical low forms on the front's western end and propagates south of Louisiana (lower right).



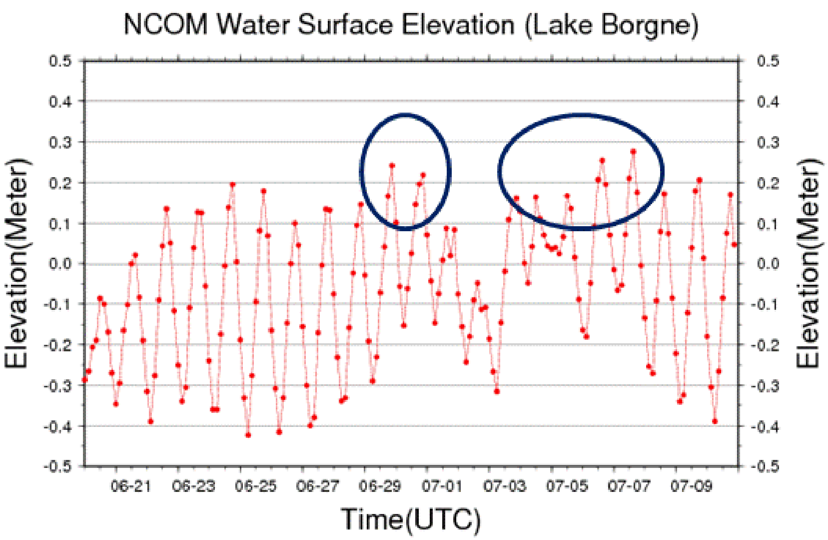


Figure 13. Top: Observed water level (red), tide prediction (blue), and residual (observed minus tide, in green) for Shell Beach CMAN station in Lake Borgne, LA, during 0000 UTC 15 June to 0000 UTC 15 July 2010. Bottom: NCOM surface elevation data for Lake Borgne from 0000 UTC 20 June to 0000 UTC 10 July 2010. Both plots indicate periods of above average water elevation associated with Hurricane Alex and the non-tropical low pressure system. The observed water level data is archived at http://tidesandcurrents.noaa.gov/ (see links under "Verified Data" then "Coastal Stations").

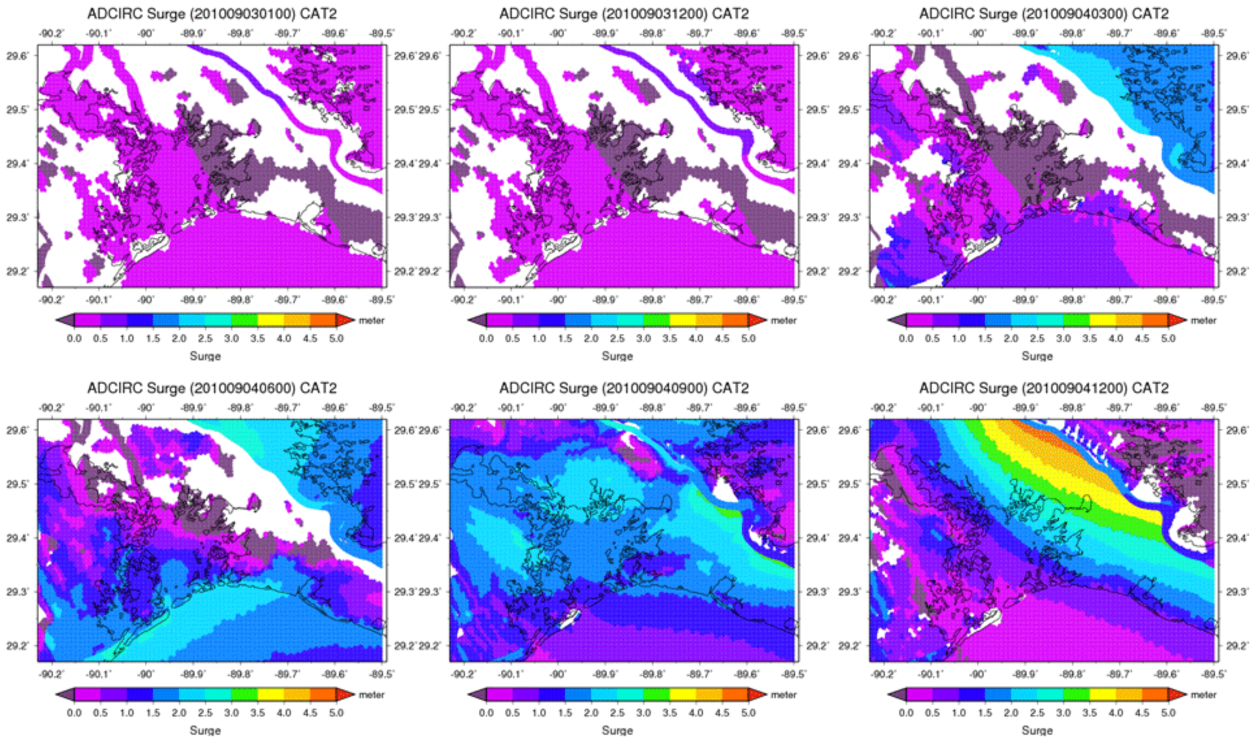


Figure 14. ADCIRC storm surge simulation of hypothetical category 2 hurricane making landfall in Fourchon, LA.

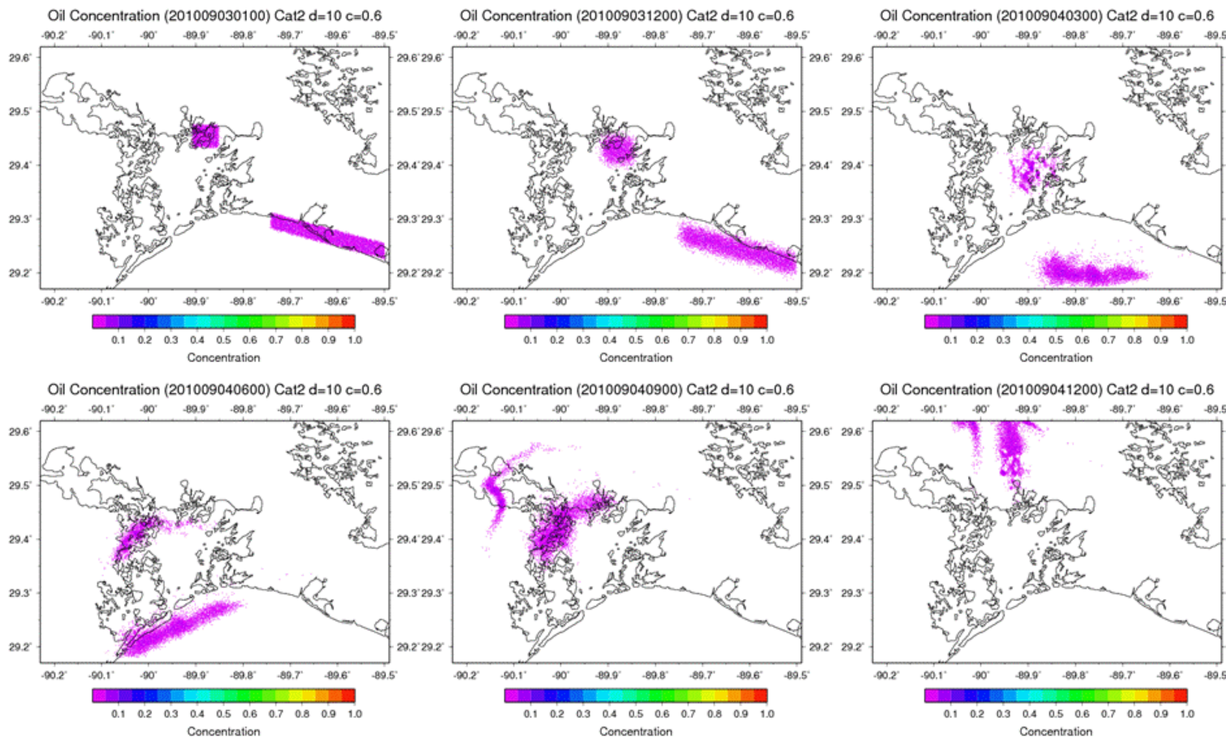


Figure 15. Displacement of oil from the beaches from Sandy Point to Chalon Pass and Bay Jimmy during storm surge depicted in Fig. 14.

Note: SURA Validation Plots, Oil Spill Research Plots, Oil Spill Animations available at SURA Testbed url: http://testbed.sura.org/node/403

Attachment B: Amount, Fate, and Transport of Oil and Dispersants in Estuarine Environments

Vladimir J. Alarcon, Yi Xiong, James Martin, William McAnally

Abstract

This task is focused on identifying and quantifying the fate, transport and potential effects of oil and dispersants that may impact Gulf estuaries in support of the general objectives:

1. Physical distribution, dispersion and dilution of contaminants under the action of ocean currents and tropical storms.
2. Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery.
3. Fundamental scientific research integrating results from the other four themes in the context of public health.

This effort provides additional and more detailed information on Gulf estuaries to supplement ongoing and planned studies of the transport, fate and impact of oils and dispersants in the open Gulf. The basic approach was to develop new models and compile existing models of hydrodynamics, sediment transport and water quality (eutrophication and/or contaminant transport) of Gulf estuaries that have been or are in use for addressing regulatory issues such as TMDLs and waste load allocations and apply them to address the fate and transport of oils and dispersants and potential impacts, such as on dissolved oxygen (e.g. hypoxia), nutrient cycling, and biota. This initial effort was focused on developing, identifying and compiling available models, coordination with other fate and transport efforts, and demonstrating the applicability of the approach on two selected Gulf estuaries: Grand Bay, MS, and Perdido Bay, FL.

1. Introduction

The oil spilled into the Gulf of Mexico is expected to have long-term residual impacts on human and environmental health, both in deep and near-shore sea waters as well as Gulf estuaries. In order to assess those impacts, quantitative cause and effect relationships are needed to relate the degree and extent of the contamination to physical, chemical, and biological processes to expected impacts. These relationships are most commonly expressed in predictive mathematical models.

The use of mathematical models is well established, such as in the regulatory environment to establish waste load allocations, estimate Total Maximum Daily Loads (TMDLs), to estimate impacts of remediation of contaminated sediments, and a variety of other purposes (Martin and McCutcheon 1999, Lung 2001). Each of these are quantitative analyses where numeric targets or endpoints are established that equate to attainment of the water quality standard (e.g. physical, chemical or biological integrity per Clean Water Act). Predictive water quality models are typically used to develop linkages between sources and targets. The models provide a quantitative link between sources and targets, or cause-and effect relationship, in order to determine the capacity of the waterbody to assimilate contamination and to address the site-specific nature of the problem. Models of open waters and Gulf estuaries most commonly include both hydrodynamic and water quality models, due to the importance of transport on the fate of water quality constituents (Martin and McCutcheon 1999). The models may then be focused on the kinetic and transformation process impacting the specific issue of concern (organic contaminants, mercury, dissolved oxygen, nutrients, oil spills, etc.) in order to address specific concerns such as excess algal growth, hypoxia, and others.

There are a variety of models available that have been targeted to the Gulf of Mexico and/or near-shore (shelf) areas. These large scale models are the primary focus of research and development by a number of NGI institutions. Similarly, there have been a large number of models that have been developed for Gulf estuaries by and for different agencies and institutions. These models may have been developed for research purposes or to address a specific regulatory question, such as establishing TMDLs and nutrient criteria. It is these estuarine models that will be the focus of this research effort.

The research will focus on developing hydrodynamic models, indentifying and applying available calibrated models of Gulf estuaries, demonstrating how they may be used to assess the long-term impacts of the oil spill (e.g. on hypoxia, sequestration in sediments, toxicity to algae, etc.), establishing and prioritizing remedial actions, and indentifying deficiencies in the literature impacting or introducing uncertainty into those predictions, such as kinetic rates impacting fate. Since the models selected and applied impact their availability and use, this study will focus on one specific model: EFDC: the Environmental Fluid Dynamics Code, a three—dimensional hydrodynamic and sediment transport model (Hamrick 1996, Tetra Tech 2002).

Focusing in EFDC provides potential for linking the developed and updated EFDC models resulting from this research to the Water Analysis Simulation Model (WASP). The WASP model (Ambrose et al. 1993, Wool et al. 2001, USEPA 2010), is a generalized water quality model most commonly applied using the transport information for EFDC along with specific water quality algorithms.

WASP and EFDC are arguably the most commonly applied models to Gulf estuaries for regulatory purposes, and both models are maintained and distributed by the U.S. Environmental Protection Agency. The WASP model includes kinetic algorithms for coliform bacteria, simple and complex eutrophication (dissolved oxygen and nutrient cycling), toxic metals, toxic organics, and mercury. Although there is not a specific module for fate and transport of oils, the model can receive and incorporate loading information from other models or observations.

Ongoing or recent EFDC/WASP applications include the Back Bay of Biloxi, MS (MDEQ 2002 and ongoing studies by MDEQ, pers. comm.); Bay St. Louis, MS (MDEQ 2001, Huddleston et al. 2007, and ongoing studies by MDEQ and MSU), Escatawpa and Pascagoula Rivers, MS (Rodriguez Borrelli et al. 2006); Mobile Bay, AL (Wool 2003, Wool et al. 2003, McAnally et al. 2007, Martin et al. 2008, Tetra Tech 2008, Diaz et al. 2008, Alarcon et al. 2009, Aziz et al. 2009, and ongoing studies); Weeks Bay, AL (ongoing studies by GOMA), Tampa Bay, FL(Wang et al. 1999 and ongoing studies by GOMA) and many others. The WASP model is presently planned for use in Florida to estimate site-specific nutrient criteria for all Florida estuaries (MDEQ pers. comm.). Other and inland applications include Lake Okeechobee, FL; eutrophication of the

Neuse River Estuary, NC; eutrophication Coosa River and Reservoirs, AL; PCB pollution of the Great Lakes, eutrophication of the Potomac Estuary, kepone pollution of the James River Estuary, volatile organic pollution of the Delaware Estuary, and heavy metal pollution of the Deep River, North Carolina, mercury in the Savannah River, GA (USEPA 2010).

2. Methodology

2.1 Initial approach

The research was focused in the Grand Bay (Mississippi Gulf Coast) area and Perdido Bay (Florida). The two bays are included in the study provide a spectrum of moderately impacted (Grand Bay) coastal waters, and not impacted (Perdido Bay) coastal waters to be modeled.

Ocean boundary conditions of the model(s) were interpolated from the nearest NOAA tidal stations to Grand Bay and Perdido Bay.

Fresh water boundary conditions (upland and coastal watersheds) were provided by existing in- house HSPF hydrological models of the regions draining to the bays included in this study.

The EFDC hydrodynamic model(s) (updated or developed) for this study were set up to include transport of an inorganic tracer (DYE related cards in EFDC) and hypothesize on the transport of oil-spill related contaminants based on tracer simulations, i.e., under what circumstances would those contaminants get to the coast/bay.

2.2 Hydrodynamic and water quality models

2.2.1 In-house EFDC/WASP models in the project area

Figure 1. Existing EFDC model of Mobile Bay. Exploratory dye transport experiment.

Our group counts with a hydrodynamic model of the Mobile Bay and surrounding coastal waters. The model has also been previously linked to a WASP water quality model. Figure 1 shows an exploratory simulation of hydrodynamic transport of dye concentration from a constant dye source. The objective of this experiment was to generate the expertise for simulating and visualizing dye transport using EFDC. The next step to this experiment was to design a tailored EFDC hydrodynamic model for Grand Bay and perform the same experiment on the new model.

2.2.2 Development of a new EFDC model for Grand Bay

2.2.2.1 Bathymetry and coastline data

Bathymetric and coastline information were acquired from the NOAA National Geophysical Data Center (NGDC). A custom bathymetric dataset was produced using the GEODAS Grid Translator available at the NGDC website. The downloaded data was converted to in ARCINFO GRID format for further geoprocessing. Similarly, a custom polygon shape was generated from downloaded coastline data. Both datasets, bathymetry and coastline, were re-projected to UTM coordinates.

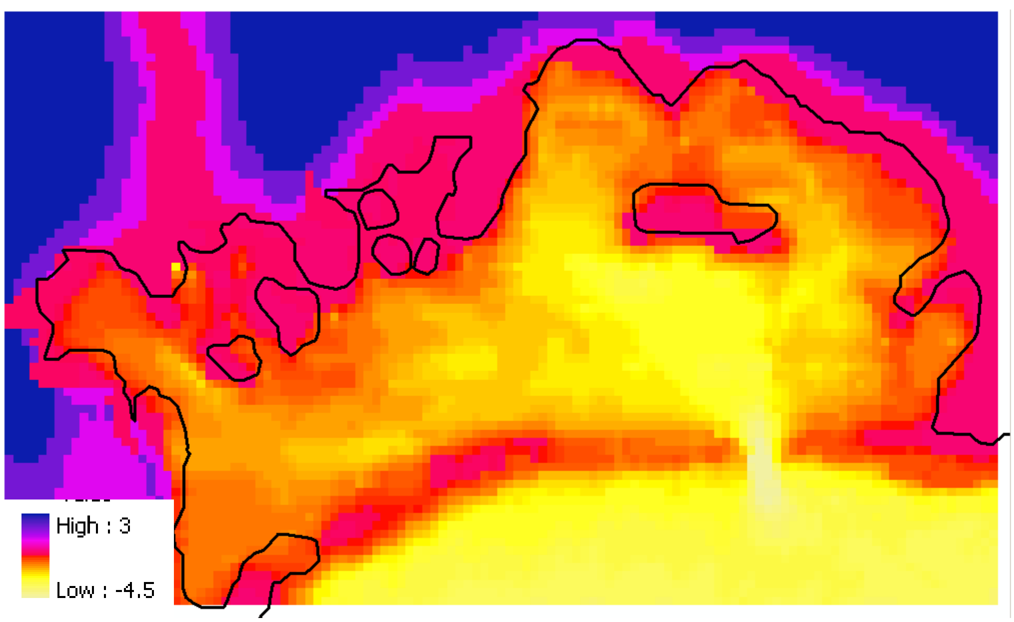


Figure 2. Bathymetry and coastline for Grand Bay.

2.2.2.2 Computational grid/mesh generation

The objective of the grid generation portion of this research was to capture the physiographic characteristics of the Grand Bay estuary into a computational mesh that is friendly to the EFDC requirement for computational grids. EFDC can use Cartesian (regular and irregular) grids, and also curvilinear convex-orthogonal grids. Figure 3 shows several curvilinear grids that were created through the process of choosing the best grid.

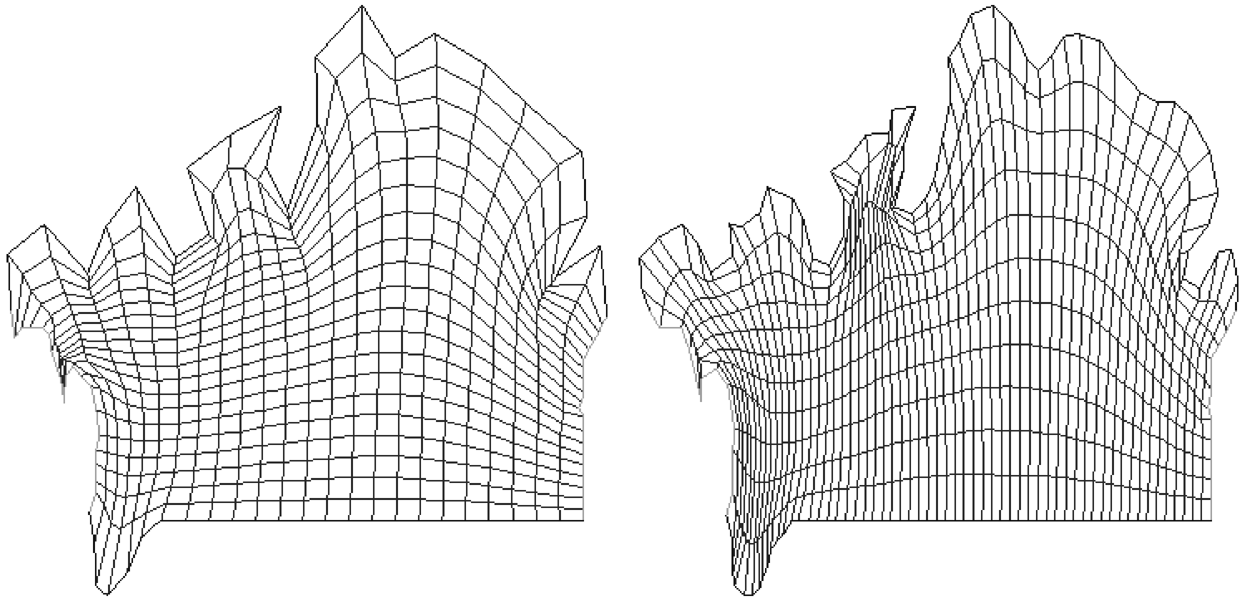


Figure 3. Curvilinear computational meshes for Grand Bay

Although the curvilinear grids shown in Figure 3 capture the coastline geometry for the bay adequately, convexity and orthogonality issues did not allow generating higher resolution grids (higher number of grid cells) for the project area. In addition to assessing curvilinear grids for the Grand Bay project area, a regular structured grid option was also explored. Figure 4 shows the resulting structured grid for Grand Bay superimposed on the bathymetry dataset.

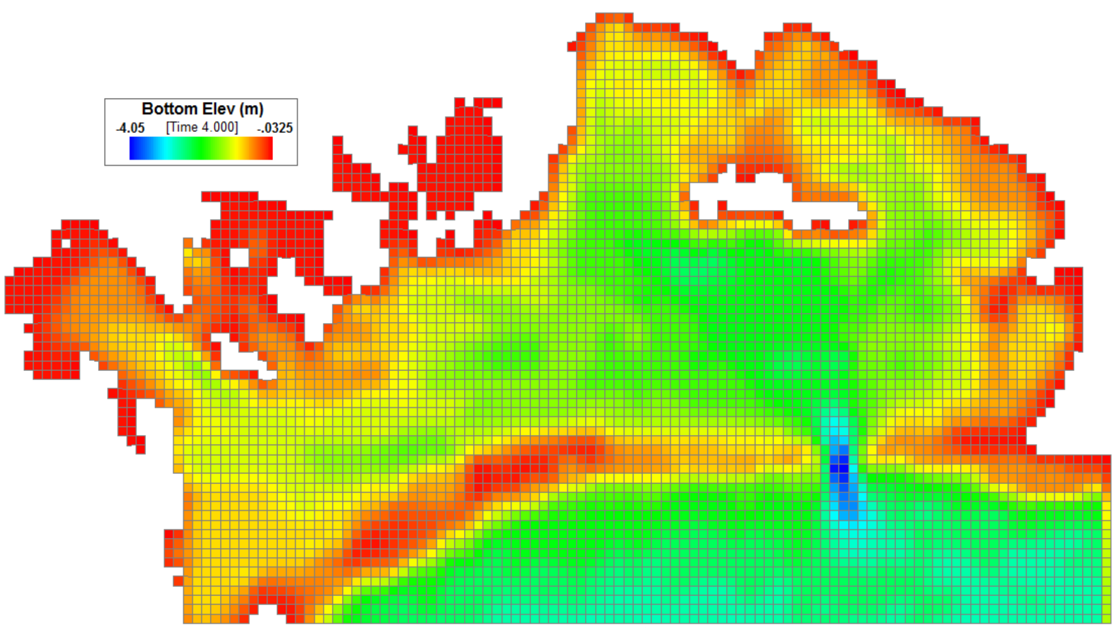
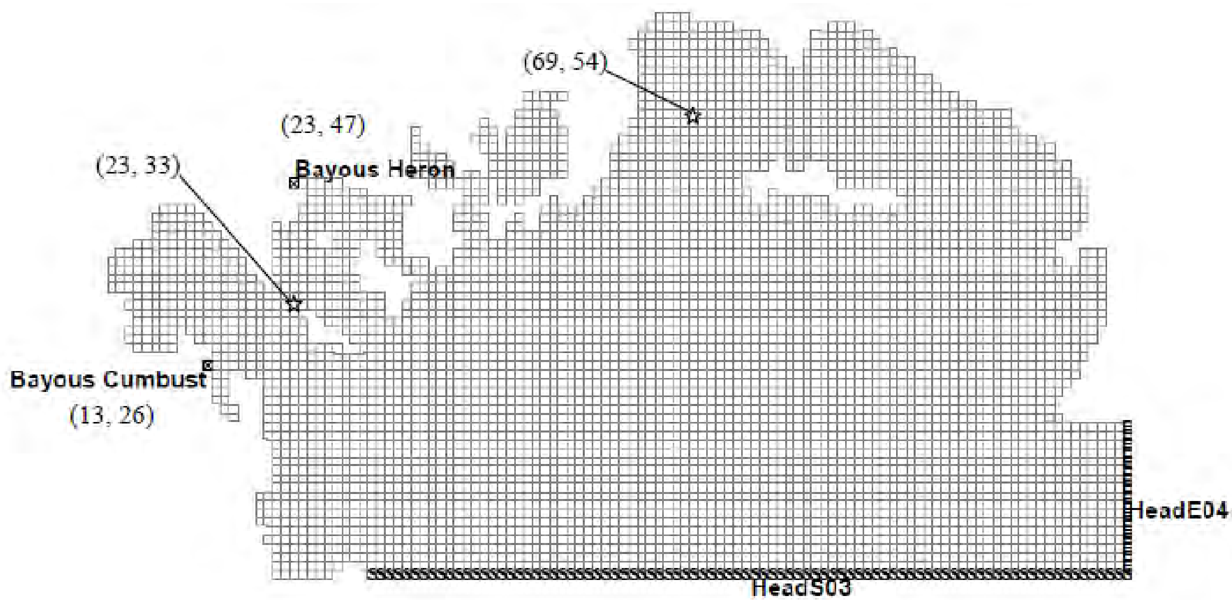


Figure 4. Final structured computational mesh for Grand Bay after assessing several options.

The number of cells of the resulting computational mesh (Figure 4) is 5202. The standard EFDC version can only use around 3000 cells. The high resolution of our computational mesh forced to use two flavors of the EFDC model: the Dynamic Solutions EFDC (EFDC_DS), and a tailored EFDC code re-compiled in house for allowing use of up to 6000 cells (EFDC_A), for subsequent hydrodynamic modeling. EFDC_DS provides a user friendly Graphical User Interface (GUI) for visualizing results and also run the EFDC model. The re-compiled EFDC_A code can generate the *.HYD file that links EFDC output to the water quality modeling system WASP.

The EFDC model application to Grand Bay requires, besides the grid files, a number of additional input files that establish boundary conditions, location of water and dye inflows and outflows, geographical data, etc. All of those files were generated using either the GEFDC program (grid generator for EFDC), tailor made C codes, spreadsheets, and other. Once all these files were produced, the initial EFDC model for Grand Bay was used to run the dye transport experiments shown in Figure 5.



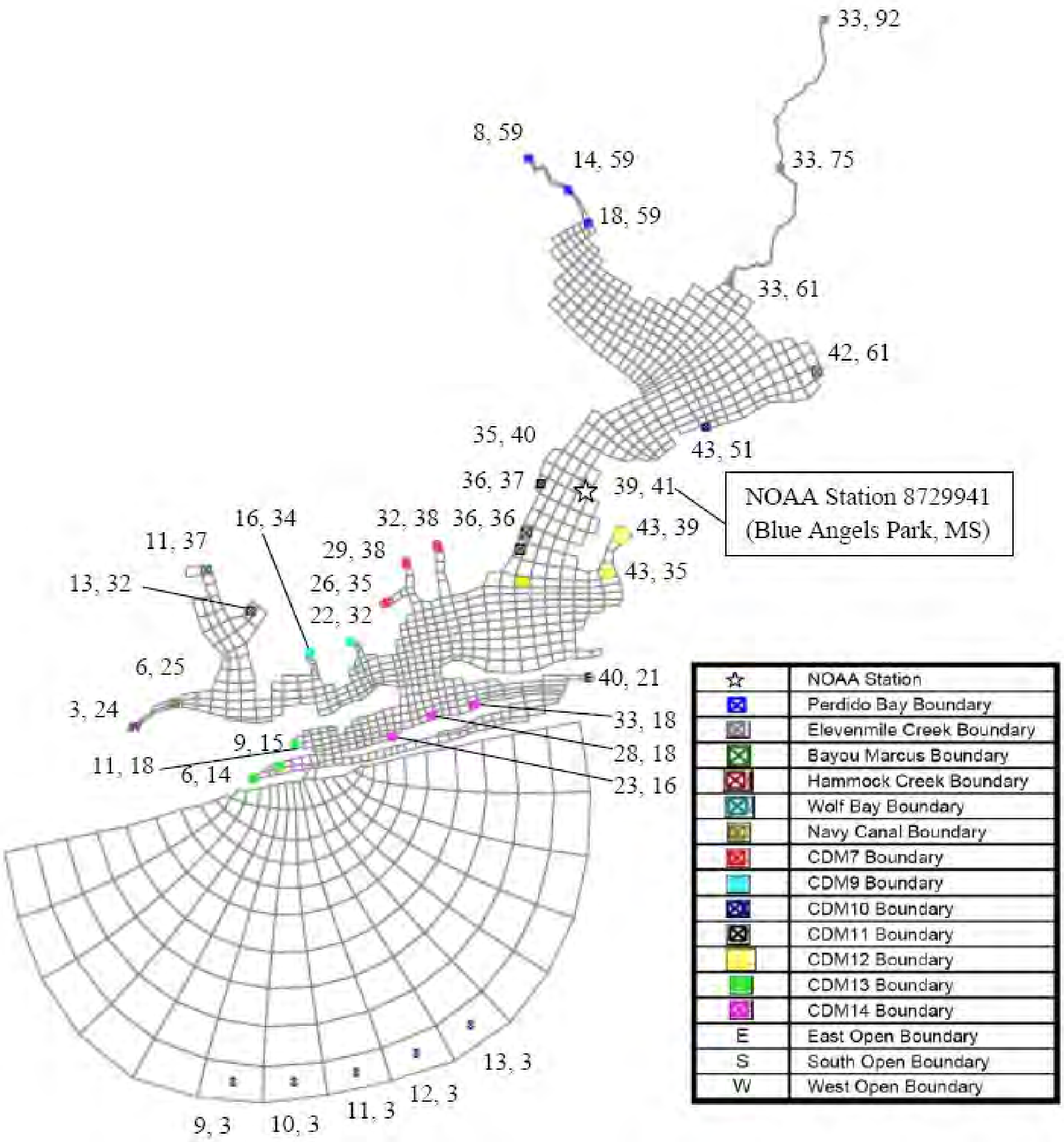
⊠	Freshwater Boundary
☆	Cells Providing Simulation Results
E	East Ocean Open Boundary Cells
S	South Ocean Open Boundary Cells

Figure 5. Final model set-up for the Grand Bay EFDC model.

Figure 5 shows the ocean boundary conditions and upland fresh water boundary conditions for the Grand Bay EFDC model.

2.2.3 EFDC Model for Perdido Bay

An existing Perdido Bay model[1] was used and modified for this Perdido Bay oil spill project. Perdido Bay EFDC simulation domain and model cell descriptions are shown in Fig. 6 and Table 1, respectively. There are 989 cells on the horizontal plane in the modeling domain, and each cell was further divided into 4 vertical layers with an equal depth. The locations of freshwater inflow, sea water open boundaries, and available NOAA Station are indicated. 2010
Dauphin Island (8735180) tidal elevation was used for south open boundary (Fig. 6).



[1] Perdido Bay Model provided courtesy of Jan Mandrup-Poulsen of Florida Department of Environmental Protection and Chris Wallen of Dynamic Solutions, LLC.

Figure 6. Perdido Bay EFDC Model Domain

Table 1. Perdido Bay Model Cell Descriptions

Cell	Location	Description
(8,59)	Freshwater Inflow	Perdido River Boundary
(14,59)	Freshwater Inflow	Perdido River Boundary
(18,59)	Freshwater Inflow	Perdido River Boundary
(33,61)	Freshwater Inflow	Elevenmile Creek Boundary
(33,75)	Freshwater Inflow	Elevenmile Creek Boundary
(33,92)	Freshwater Inflow	Elevenmile Creek Boundary
(42,61)	Freshwater Inflow	Bayou Marcus Boundary
(11'37)	Freshwater Inflow	Wolf Bay Boundary
(13,32)	Freshwater Inflow	Hammock Creek Boundary
(26,35)	Freshwater Inflow	CDM7 Boundary
(29,38)	Freshwater Inflow	CDM7 Boundary
(32,38)	Freshwater Inflow	CDM7 Boundary
(6,25)	Freshwater Inflow	Navy Canal Boundary
(16,34)	Freshwater Inflow	CDM9 Boundary
(22,32)	Freshwater Inflow	CDM9 Boundary
(43,51)	Freshwater Inflow	CDM10 Boundary
(36,37)	Freshwater Inflow	CDM11 Boundary
(36,36)	Freshwater Inflow	CDM11 Boundary
(35,40)	Freshwater Inflow	CDM11 Boundary
(43,39)	Freshwater Inflow	CDM12 Boundary
(43,35)	Freshwater Inflow	CDM12 Boundary
(6,14)	Freshwater Inflow	CDM13 Boundary
(9,15)	Freshwater Inflow	CDM13 Boundary
(11'18)	Freshwater Inflow	CDM13 Boundary
(28,18)	Freshwater Inflow	CDM14 Boundary
(33,18)	Freshwater Inflow	CDM14 Boundary
(23,16)	Freshwater Inflow	CDM14 Boundary
(3,24)	Sea Water Open Boundary	West Open Boundary
(40,21)	Sea Water Open Boundary	East Open Boundary
(9,3)	Sea Water Open Boundary	South Open Boundary
(10,3)	Sea Water Open Boundary	South Open Boundary
(11'3)	Sea Water Open Boundary	South Open Boundary
(12,3)	Sea Water Open Boundary	South Open Boundary
(13,3)	Sea Water Open Boundary	South Open Boundary
(39,41)	NOAA Station 8729941 (Blue Angel Park, FL)	For Water Level Data Comparison

3. Results

3.1 Grand Bay EFDC model

Figures 7 and 8 show 2010 observed tidal elevation data of Grand Bay adjacent NOAA tides and currents Stations and National Estuarine Research Reserve System (NERR) Water Stations, respectively, to confirm the accuracy of NERR water depth data. Then, 2010 water depth data at NERR Water Station – Poin Aux Chenes, MS (NERR – D) was used to determine Grand Bay ocean open boundary condition as described in Fig. 5.

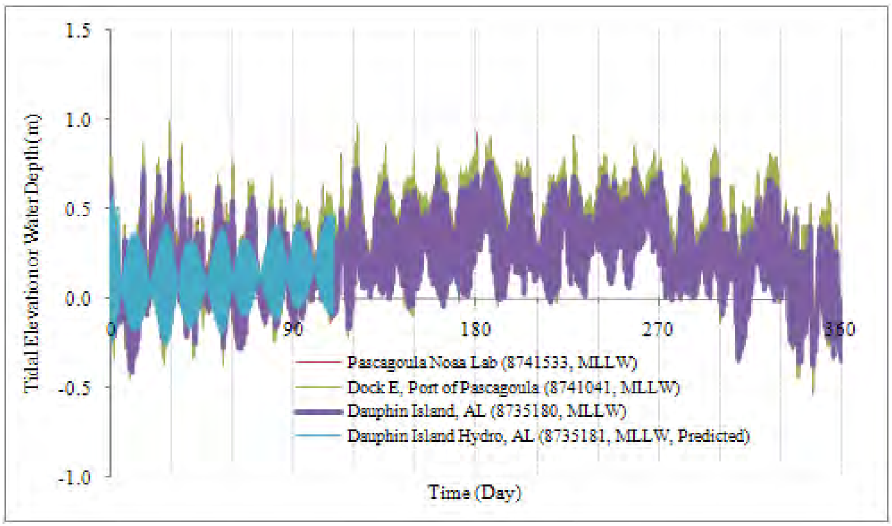


Figure 7. 2010 Observed Time Series Tidal Elevation Data of Grand Bay Adjacent NOAA Tides and Currents Stations

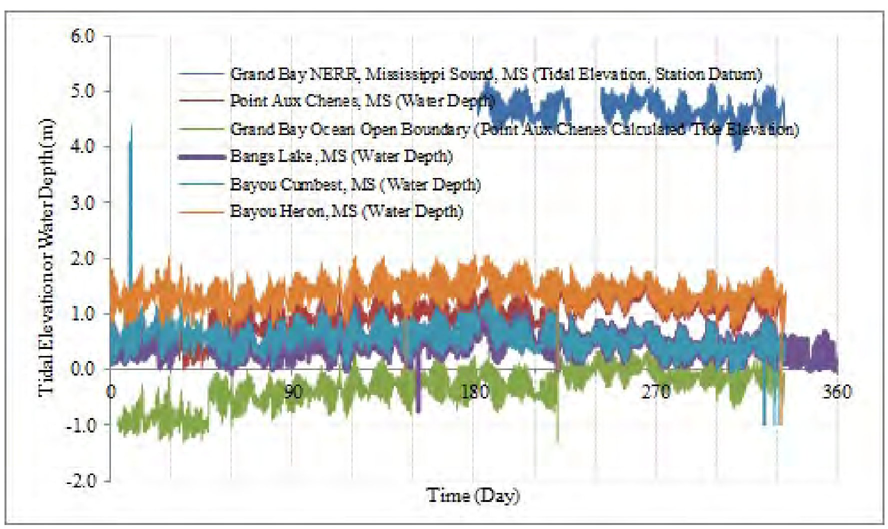


Figure 8. 2010 Observed Time Series Tidal Elevation Data of Grand Bay Adjacent National Estuarine Research Reserve System (NERR) Water Stations

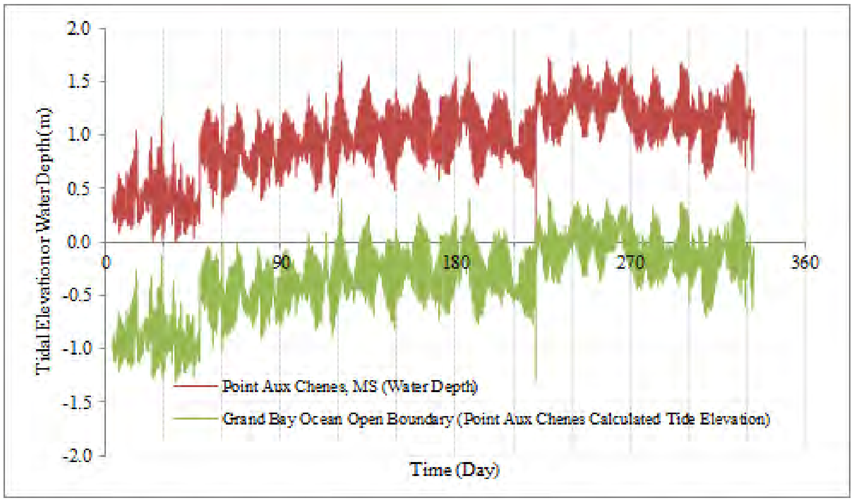


Figure 9. Determination of Grand Bay Ocean Open Boundary using Time Series Water Depth Data at National Estuarine Research Reserve System (NERR) Water Station– Point Aux Chenes, MS (NERR – D) in 2010

Furthermore, 2010 Grand Bay open boundary, EFDC simulation results at Cell (23, 33), Cell (23,47), and Cell (69, 54), and observed tidal elevation data at NOAA Station - Grand Bay NERR, Mississippi Sound, MS were compared to show the reasonability of Grand Bay EFDC model as shown in Fig. 9.

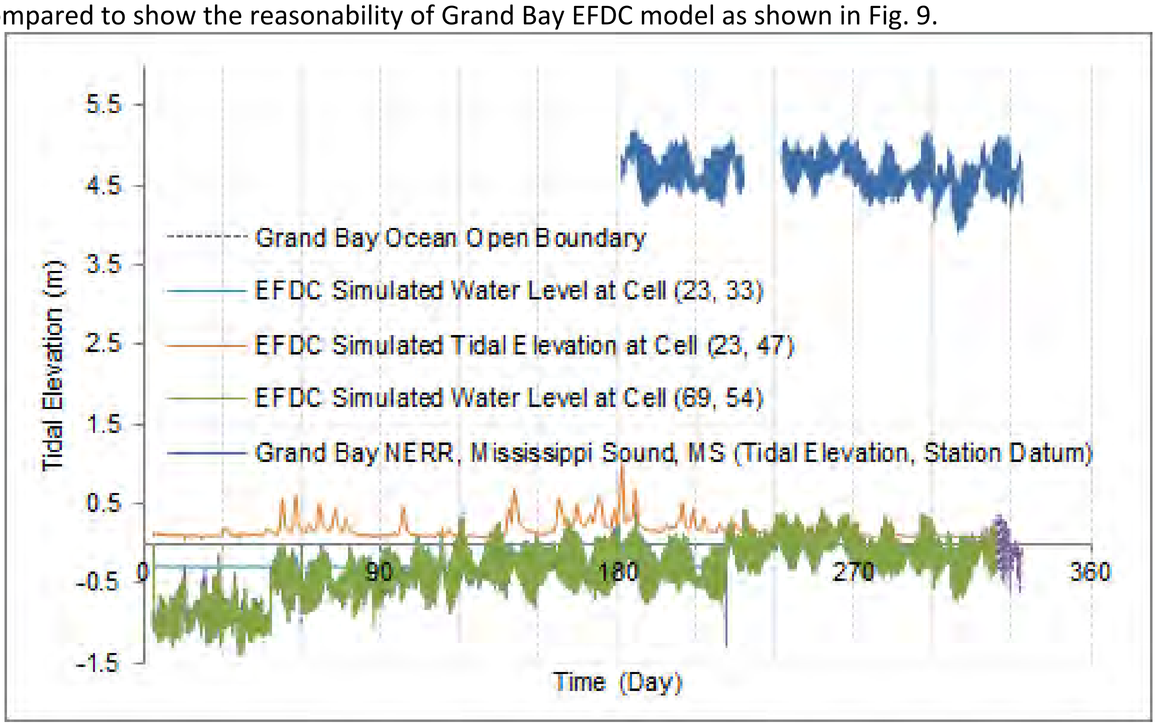


Figure 10. Comparison of Grand Bay Open Boundary, EFDC Simulated Results at Cell (23, 33), Cell (23, 47), and Cell (69, 54), and Observed Tidal Elevation Data at Grand Bay NERR, Mississippi Sound, MS in 2010

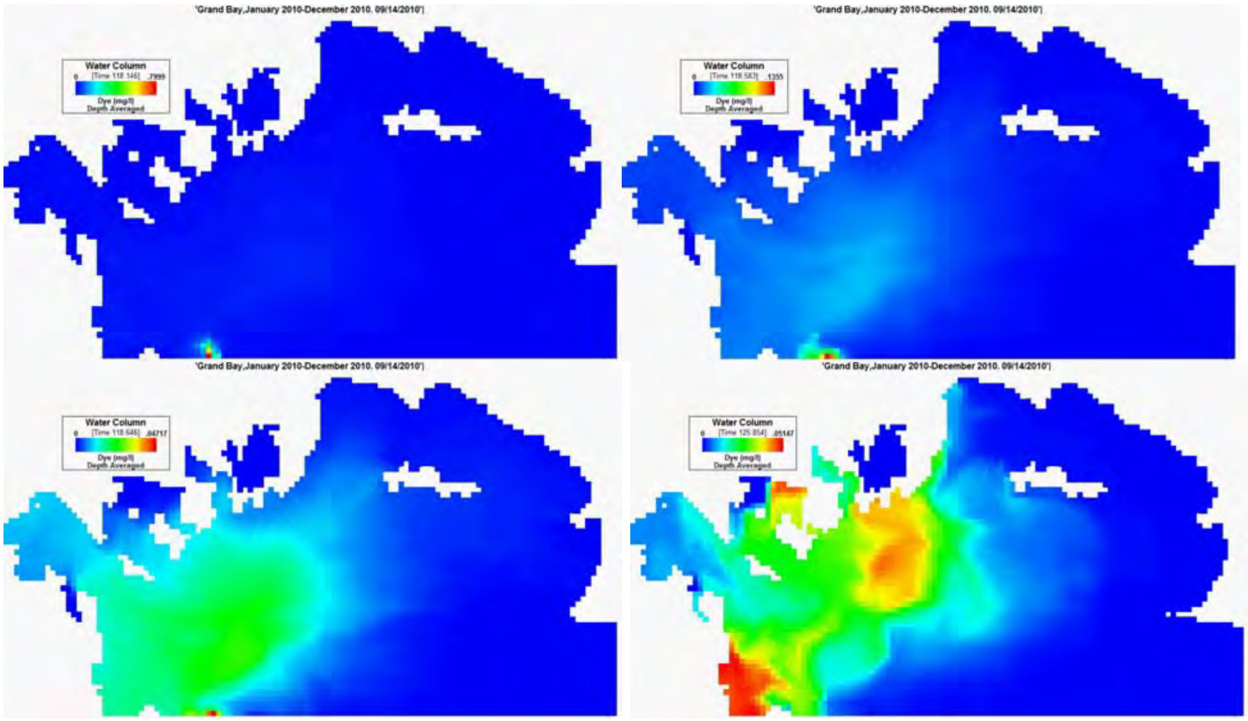


Figure 11. Dye transport experiment using the EFDC model application to Grand Bay. A constant dye concentration is applied at 3 cells located in the lower left ocean boundary.

Two experiments were performed to assess the capabilities of the developed EFDC model application to Grand Bay. Constant dye concentrations were applied to sets of three adjacent cells at the lower left ocean boundary (Figure 11), and at the lower right ocean boundary (Figure

12). The model, however, can be set up to receive dye concentrations along all the ocean boundary cells (105 cells in total). Since the actual input concentrations at the ocean boundaries will be determined by other research efforts (surge/hurricane models from other research groups), the model is currently set up to receive dye/contaminant concentrations at any or all ocean boundary cells.

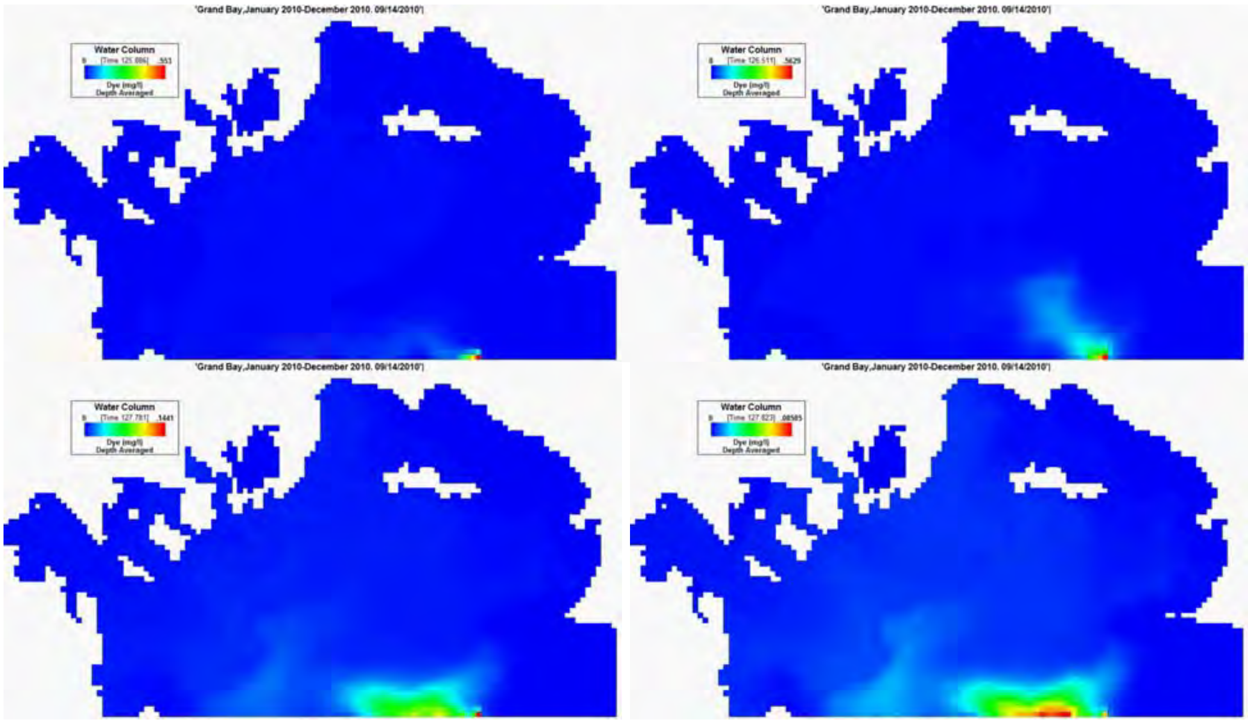


Figure 12. Dye transport experiment using the EFDC model application to Grand Bay. A constant dye concentration is applied at 3 cells located in the lower right ocean boundary.

The reader is welcome to explore the simulations of dye transport developed for this progress report at http://www.msstate.edu/~vja1/dye/dye.htm.

3.2 EFDC model for Perdido Bay

NOAA predicted and observed data at Station 8729941 (Blue Angels Park, MS), and the corresponding EFDC results were compared as described in Fig 113. EFDC water level simulation and observed data at Station 8729941 were also compared (Fig. 14).

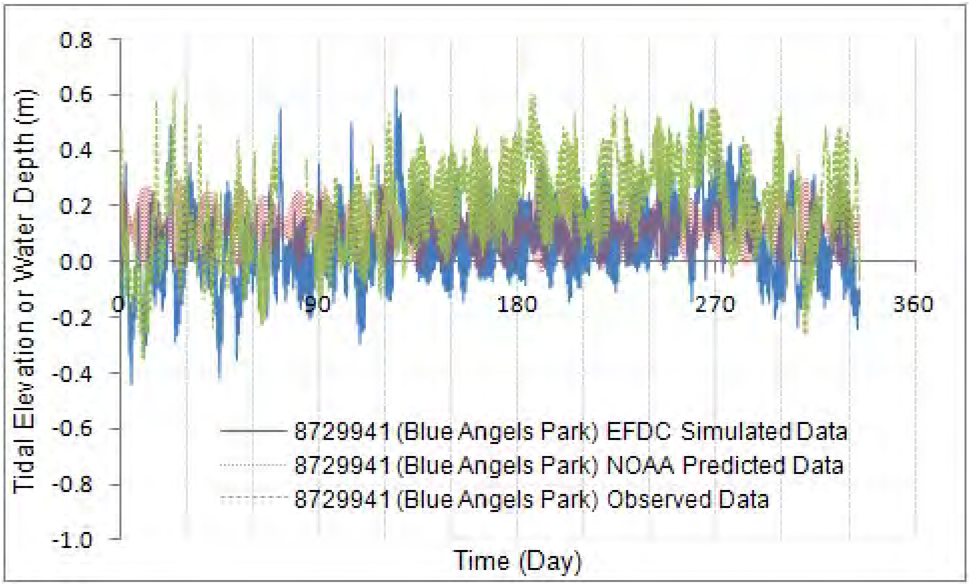


Figure 13. Comparison of EFDC Simulated Data, Observed Data and NOAA Predicted Data at Station 8729941 (Blue Angel Park, FL)

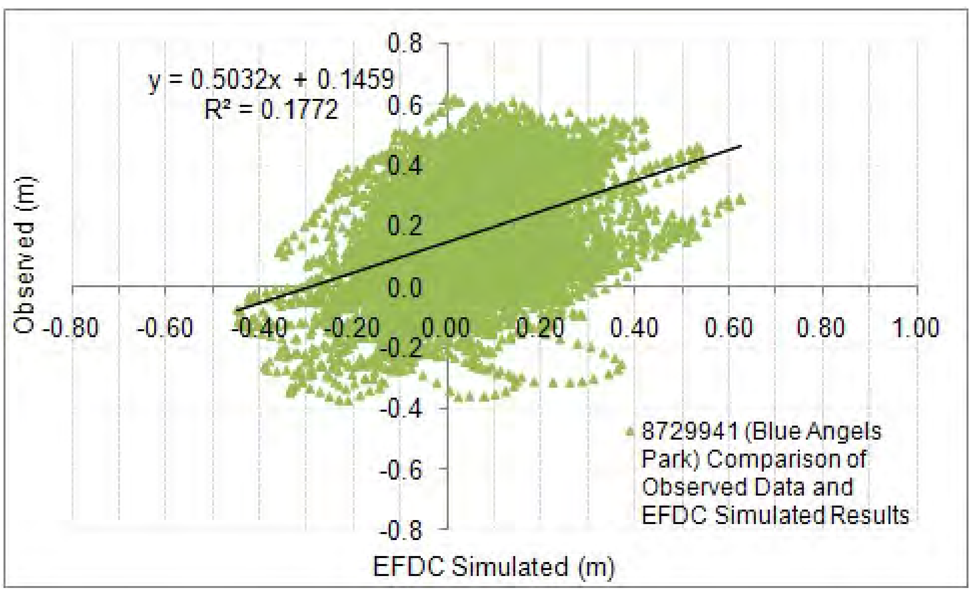


Figure 14. Comparison of EFDC Simulated Data and Observed Data at Station 8729941 (Blue Angel Park, FL)

Figure 15 shows a exploratory use of the model for simulating dye transport throughout Perdido bay. For this simulation, the initial model was modified by implementing a gradually decreasing dye input along the curved ocean boundary.

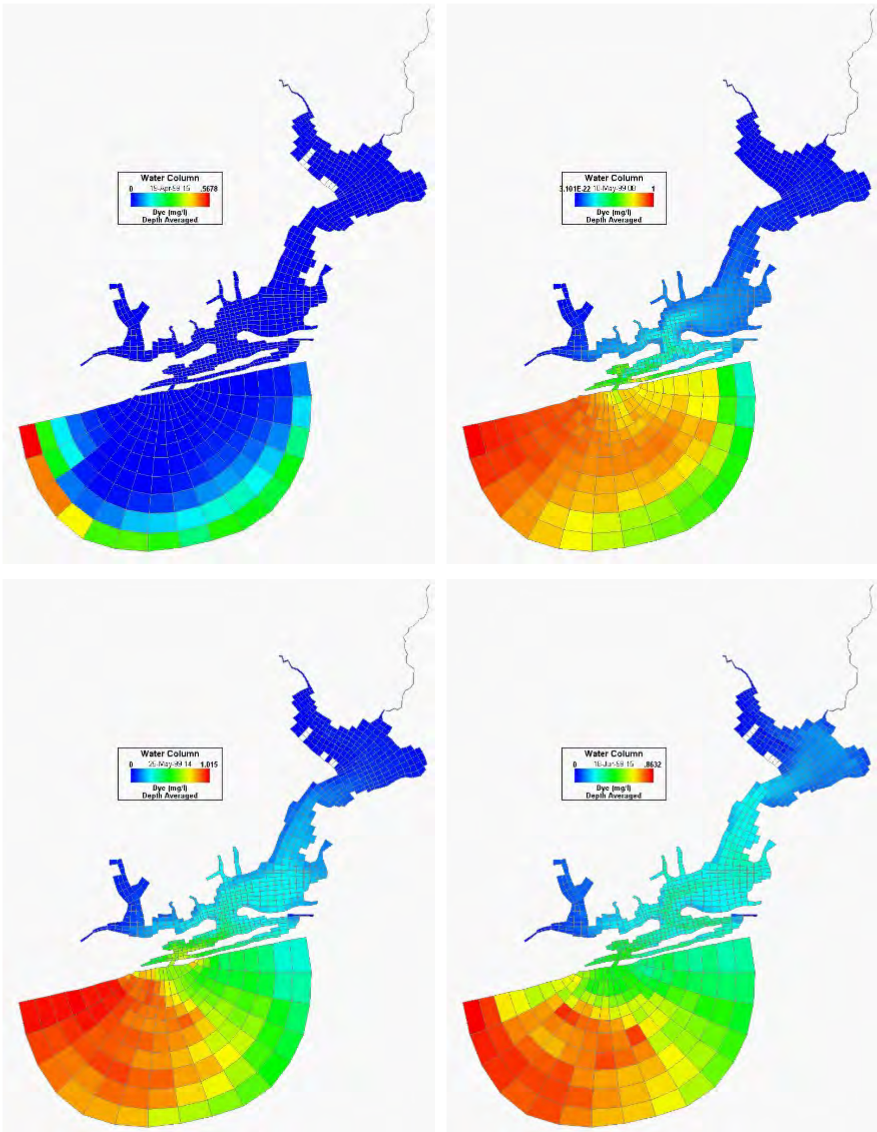


Figure 15. Simulation of transport of an inorganic dye source applied at the ocean boundary using the Perdido Bay EFDC model.

The reader is welcome to explore the additional simulations of dye transport developed for Perdido Bay at http://www.msstate.edu/~vja1/dye/dye.htm.

3.3. Other activities

In response to BP oil spill, EPA sampled surface water and sediment during the oil spill period and put the sampling data into website - http://www.epa.gov/BPSpill/. Hence the summarized sampling locations and IDs are listed in Table 2 and shown in Fig. 16.

Table 2. Surface Water/Sediment Sampling Locations

Station	Date	Matrix	Sample ID	Station Name	Latidude	Longitude	Description
BCH04	5/3/2010	Sediment	BCH04-SD-20100503	Pascagoula, MS	30.342867	-88.54795	For Grand Bay Analysis
	5/3/2010	Surface Water	BCH04-SW-20100503				
D002	6/2/2010	Surface Water	D002-SW-20100602	Pascagoula, MS	30.230267	-88.510216	For Grand Bay Analysis
D001	6/2/2010	Surface Water	D001-SW-20100602	Dauphin Island, AL	30.199783	-88.369067	For Grand Bay Analysis
MSS-UNK	6/7/2010	Surface Water	MSS-UNK	Dauphin Island, AL	30.24789	-88.25444	For Grand Bay Analysis
E004	6/7/2010	Sediment	E004-SD-20100607	Dauphin Island, AL	30.213933	-88.259617	For Grand Bay Analysis
	6/6/2010	Surface Water	E004-SW-20100606				
E002	6/6/2010	Surface Water	E002-SW-20100606	Dauphin Island, AL	30.213933	-88.259617	For Grand Bay Analysis
PERDB	5/5/2010	Sediment	PERDB-SD-20100505	Lillian, AL	30.344286	-87.461414	For Perdidi Bay Analysis
	5/6/2010	Sediment	PERDB-SD-20100506				
PERDBOUT	5/5/2010	Sediment	PERDBOUT-SD-20100505	Pensacola, FL	30.308651	-87.452506	For Perdidi Bay Analysis
	5/5/2010	Surface Water	PERDBOUT-SW-20100505				
E001	6/10/2010	Surface Water	E001-SW	Orange Beach, AL	30.274367	-87.546384	For Perdidi Bay Analysis
D006	6/8/2010	Surface Water	D006-SW-20100608	Orange Beach, AL	30.25205	-87.547333	For Perdidi Bay Analysis
D001	6/19/2010	Surface Water	D001-SW-20100619	Pensacola, FL	30.24232	-87.44253	For Perdidi Bay Analysis
D001	6/13/2010	Surface Water	D001-SW-20100613	N/A	30.26901	-87.58295	For Perdidi Bay Analysis

Figure 16. Surface Water/Sediment Sample ID Map

3.4. Other potential uses of the models developed in this research

Besides estimating dye/oil transport throughout the study areas, the models developed in this study could be used to simulate scenarios of oil spill occurring in the Northern Gulf of Mexico. NOAA reports that 3,858 oil and gas platforms existed in the Gulf of Mexico in 2006 (see Figure 17).

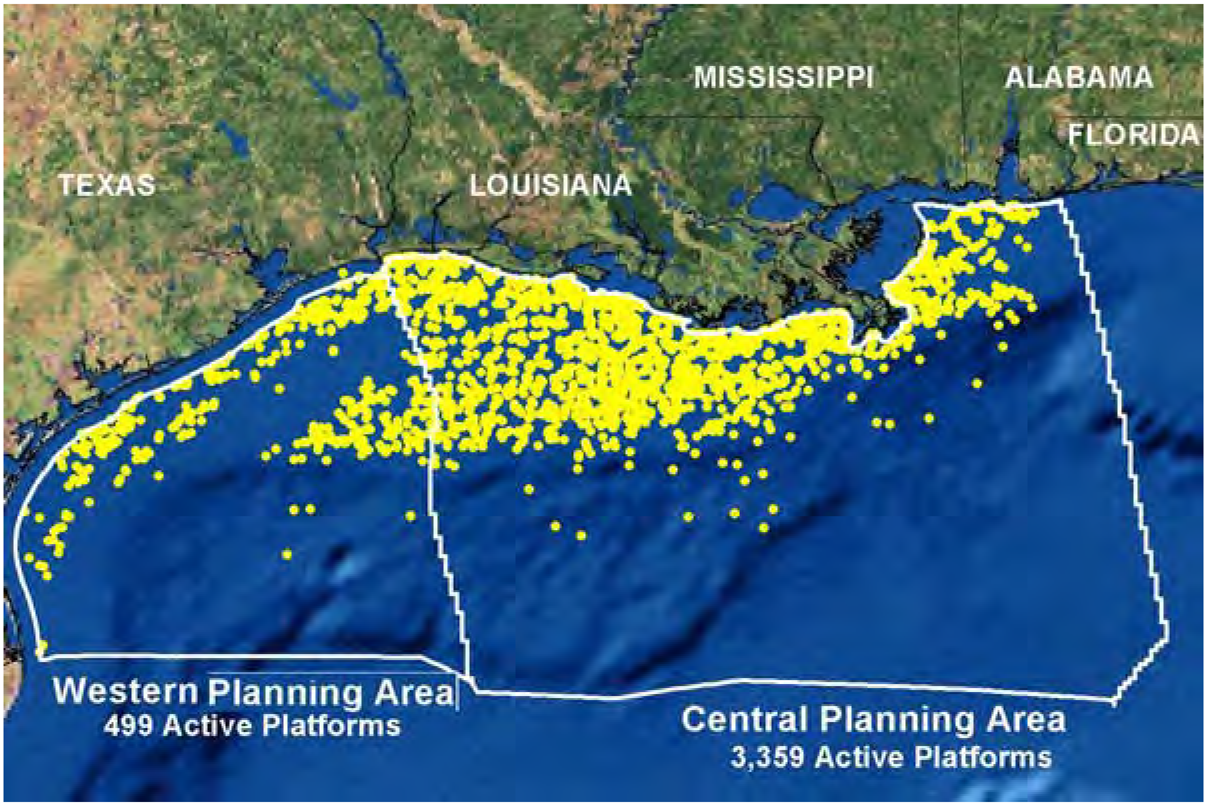


Figure 7. Oil and gas platforms in the Gulf of Mexico (after NOAA, 2010)

If the Deep Water Horizon incident is to be taken as a probabilistic event, the region will surely face a similar event in the future. The models developed in this study (for estimating hydrodynamics and contaminant transport in the region) will be easily modified for accommodating a different location of oil-spill and hence will constitute an initial rapid response system for estimating potential risk areas. In fact, a set of models such as the one proposed in this study would be able to simulate a concurrent failure of several oil rigs. Burger et al. (1994) states that the length of time the effect of an oil-spill can be detected depends not only on the magnitude of the original oil spill and hydrodynamics of the tidal estuary but on the occurrence of other spills (particularly critical in the Arthur Kill oil spill that occurred in New jersey, during year 1990).

3.5 Dissemination of results

Alarcon, V. J., McAnally, W. H., Martin, J., & Xiong, Y. (2010). Computational Water Resources at the Northern Gulf Institute, Mississippi State University. SC10. International

Conference for High Performance Computing, Networking, Storage and Analysis, New Orleans, LA, November 13-19, 2010.

4. Conclusions

An operational hydrodynamic model for Grand Bay MS was developed and used to produce hypothetical dye transport simulations throughout the estuary. The model was set up with ocean boundary conditions from existing NOAA tidal stations and fresh boundary conditions from in- house existing hydrological models (for year 2010). For producing this model, the GEFDC grid generator code was modified and recompiled to ingest 5202 active EFDC cells. Also, the EFDC code was modified and recompiled to be able to manage the high-resolution computational grid produced for Grand Bay. Alternatively, the EFDC input files were modified for use of the EFDC_DS version of the EFDC code. This version was ultimately used to produce the simulation results (movies, charts, etc). An existing EFDC model of Perdido Bay was updated to simulate hydrodynamics and dye transport for year 2010. The EFDC hydrodynamic models resulting from this research can be linked (in the future) to WASP water quality models for explorations on oil-related contaminants.

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Attachment C: Integrated Assessment of Oil Spill – Task C. Natural Systems

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General focus of this task area:

Assessing Early Responses of Natural Coastal Systems to Oil and Dispersant Contamination Along the Northern Gulf of Mexico

Period of Performance of Research:

Start: *June 16, 2010*
End: *December 31, 2010*

Contents

Executive Summary:

Coastal habitats potentially impacted by oil spills include beaches, barrier islands, shallow water habitats (seagrass beds and other submersed vegetation), and coastal marshes and estuaries. Although obvious negative effects of oil and dispersant contamination in coastal habitats has been observed, the more subtle effects of these chemicals cascade throughout coastal ecosystems, and unfortunately, little is known regarding those complex, ecosystem-level impacts (Peterson and Estes 2001). This lack of information has been attributed to the rarity and unpredictability of large-scale spills, such as the Deepwater Horizon (Peterson and Estes 2001). By comparison to the estimated 30,000 km^2 of the Gulf covered by oil in July 2010, it was estimated in 2004 that there are only approximately 14,000 km^2 of coastal wetlands along the US Gulf of Mexico coast (Stedman and Dahl 2008). Thus, there presently is a clear and substantial, yet unknown and unpredictable risk to coastal ecosystems.

This task area aimed to address two of the research priorities set forth by British Petroleum Exploration and Production, Incorporated. Namely, we wished to improve understanding of:

- Environmental effects of the oil/dispersant system on shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery, and
- Biological degradation of the oil/dispersant systems and subsequent interaction with the marine and coastal ecosystems.

We addressed these research priorities by investigating two interrelated focus areas, or Subtasks:
Subtask C1 – Assessing early responses of intertidal habitats to oil/dispersant contamination
Subtask C2 – Assessing interaction between oil/dispersant system and soil/sediment microbial assemblages

In ***Subtask C1***, we found that preliminary analyses of the LANDSAT imagery showed visible changes in vegetation-associated biophysical parameters (chlorophyll content, green leaf area index, and percent green canopy cover) in comparisons of imagery from 2008 with that of 2010 (Chapter I). Analyses using hyperspectral AVIRIS imagery showed that broad areas of coastal vegetation can be grouped, based on their spectral signatures, and that some of those signatures (e.g., marsh grasses) are consistent across the study region (Chapter II).

In ***Subtask C2***, we found that additions of readily metabolizable carbon greatly enhanced degradation of tar balls collected from the Alabama Gulf Coast. This degradation was demonstrated by growth of bacteria assemblages and metabolism of tar ball carbon to CO_2. Experimental samples currently are being analyzed for bacterial community diversity, based on molecular DNA analyses (Chapter III). Finally, preliminary results of a pilot study examining potential effects of oil contamination on coastal sediment microbial communities are presented. Factors examined included: elemental profiles within sediments and microbial community metabolism in one contaminated and one uncontaminated site at Marsh Island, MS (Chapter IV).

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I. Quantifying the Impact of the Gulf of Mexico Oil Spill on the Health and Productivity of Louisiana and Mississippi Salt Marshes

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Technical point of contact: Deepak Mishra, Department of Geosciences, Mississippi State University (dmishra@gri.msstate.edu)

Abstract:

This document provides results of the first phase of work on the quantification of the impact of the Gulf of Mexico Oil Spill on the health and productivity of the salt marshes of Louisiana and Mississippi. Salt marshes are the most vulnerable coastal environment to be adversely affected by the oil spill, with the predicted residence times of over 10 years. Saline marshes generally have more oil-sensitive vegetation than freshwater marshes and oil impact on vegetation is most significant in highly organic soils of salt marshes.

Cleaning activities such as skimming, oil collection, burning, flushing, use of dispersants, and plant cutting can also greatly damage marshes. In addition, the effects of oil spills vary with vegetation types season. For example, *Spartina alterniflora* is more sensitive to oiling than *Juncus roemerianus*. Plants are more sensitive to oiling during the growing season than during the pre-dormancy or dormant season. Since the BP oil spill and cleaning up efforts occurring in summer, the growing season for Spartina spp., we hypothesize that short-term impacts of the spill on salt marshes will be detected. Most post-spill assessments of coastal salt marsh status will be limited to habitat delineation and documentation of change in area. However, assessment of marsh health is essential to the evaluation of the short-term impact of the spill and for the prioritization of future restoration actions.

This study will allow the identification of 'hotspots' of early stages of oil spill-induced marsh degradation which can only be delineated by evaluating marsh biophysical characteristics, including distribution of canopy chlorophyll content (Chl), green leaf area index (GLAI) (a ratio of green foliage area vs. ground area), and green vegetation fraction (VF) (percent green canopy cover). These biophysical characteristics are primary indicators of photosynthetic capacity, nitrogen content, and physiological status of vegetation. Monitoring these characteristics through remotely sensed data can help us infer the overall health and productivity of these valuable natural resources on a larger scale so that effective management strategies can be implemented in high priority areas.

In order to quantify the short-term impact of the oil spill on the photosynthetic activity and physiological status of the coastal salt marshes, we initiated field surveys in Mississippi and Louisiana salt marshes. We combined field data with the LANDSAT 30-m datasets to retrieve the described biophysical characteristics in Louisiana and Mississippi salt marshes before and after the spill. By examining the biophysical parameters using remotely sensed data, we can infer the overall health and productivity of coastal marshland. The question addressed through this study was: ***What is the impact of the oil and oil/dispersant on health and productivity of wetlands?*** The proposed research develops scientific products that can be used to assess marsh physiological characteristics at large spatial scales, which will directly inform restoration and conservation decision-making.

Goals and Objectives:

The overall goal of the research was to quantify the short-term impact of the oil spill on the photosynthetic activity and physiological status of the coastal salt marshes. This was achieved by analyzing several biophysical characteristics of marsh vegetation including canopy chlorophyll (chl) content, GLAI, and VF generated through a remote sensing mapping protocol. The products generated through this research will provide restoration decision makers across Louisiana and Mississippi with a practical tool to inform the prioritization of marsh restoration effort to the areas, most affected by the spill. The specific objectives of this project are:

Goal 1 – Application of a novel suite algorithms combining LANDSAT 30m datasets with field data to monitor the biophysical characteristics of coastal salt marshes

Goal 2 - Developing composite salt marsh biophysical products including distributions of canopy chlorophyll content, GLAI, and VF before-during-after the spill.

Background:

Salt marshes are the most vulnerable coastal environment (vulnerability index of 10 from a 1-10 scale) to be adversely affected by the oil spill, with the predicted residence times of over 10 years (Gundlach and Hayes 1978). Saline marshes generally have more oil-sensitive vegetation than freshwater marshes (Lin and Mendelssohn 1996) and oil impact on vegetation is most significant in highly organic soils of salt marshes (Lin and Mendelssohn 1996; Pezeshki et al. 2000). Direct and immediate physical impacts of oil on plants through the coating of the plant and soil surfaces cause temperature stress and reduced photosynthesis due to blockage of stomata and transpiration pathways (Pezeshki et al. 2000). Petroleum hydrocarbons adversely affect the salt marsh plants and their ability to tolerate salinity (Gilfillan et al. 1989). Cleaning activities such as skimming, oil collection, burning, flushing, use of dispersants, and plant cutting can also greatly damage marshes. In addition, the effects of oil spills vary with vegetation types and season. For example, *Spartina alterniflora* is more sensitive to oiling than *Juncus roemerianus* (Pezeshki and DeLaune 1993). Plants are more sensitive to oiling during the growing season than during the pre-dormancy or dormant season (Pezeshki et al. 2000); and it is advised that summer burns be avoided if possible (Lindau 1999). Flooding following burning adversely affected plant growth in many species (Pezeshki et al. 2000). Since the current oil spill and cleaning up efforts occurred in summer, the important growing season for *Spartina* spp. and the active storm season, we expected to see severe short-term impacts of the spill on salt marshes and changes in plant community composition due to species' sensitivity to fouling and physical disturbance associated with the clean-up.

Chlorophyll is one of the most important foliar biochemicals and the content within a vegetation canopy that is related closely to both the productivity and health. Due to the synoptic view provided by airborne and space-borne sensors, remote sensing has the potential for estimating Chl on a regional basis. Two other key variables required for estimating coastal salt marsh status are green leaf area index (GLAI) and Vegetation Fraction (VF). Remote estimations of these characteristics can be performed using transforms of spectral reflectance, called vegetation indices (VIs) (e.g., Rouse et al., 1974). A physically based algorithm for estimating LAI from NDVI observations has been developed (e.g., Myneni et al., 1997) and proposed that yield more linear relationships between remotely sensed data and VF, LAI, and green biomass (e.g., Chen and Cihlar, 1996; Gao et al., 2000; Gitelson et al., 2003a and b).

The LANDSAT instrument holds considerable potential for advancing our capabilities to estimate and monitor the biophysical characteristics of salt marshes across large geographic areas. LANDSAT provides a fortnightly coverage of moderate resolution data in the visible and the near infrared regions of the spectrum that are well calibrated, and have reasonable geolocational accuracy.

Study Area

Salt marsh locations of Louisiana (in and around Dry Bread Island) and Mississippi (Marsh point) were chosen for the present study. Both the areas have considerable uniform vegetation patches of *Spartina alterniflora*, *Spartina patens* and *Juncus roemerianus*, with occasional presence of *Salicornia virginica*, *Disticulus spicata* and *Batis maritima*. The region experiences tropical - sub tropical climate, with hot summers and moderately cold winters. The region is greatly affected by tropical cyclones in late summers. Average annual precipitation ranges around 60 inches.

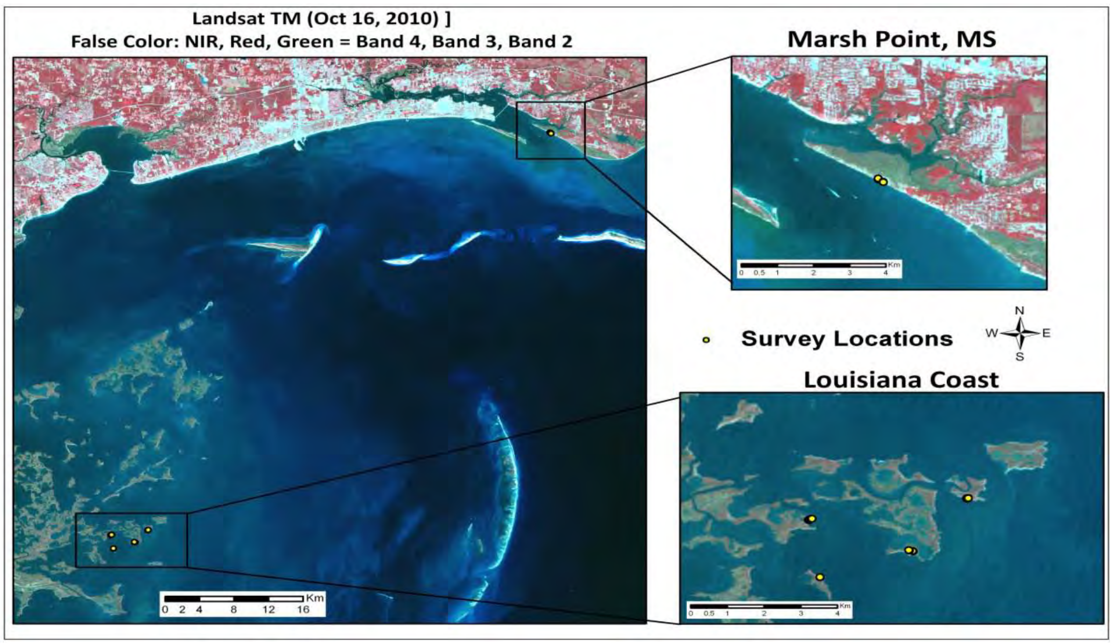

Fig. 1: Survey locations on a LANDSAT 5 (Thematic Mapper) False Color Composite.

Methods:

An airplane survey was conducted in the region to look for traces or signs of oil residues, followed by which field surveys were conducted although the field surveys were not confined only to the regions of contamination; non contaminated sites were also sampled along with. A total of 24 sample plots were studied (19 in Louisiana and 5 in Mississippi). Reflectance spectra of different marsh vegetation types (2.2m×2.2m plot) were collected in early October. The reflectance was acquired using inter-calibrated dual fiber enabled USB4000 Miniature Fiber Optic Spectrometers (Ocean Optics Inc.), mounted on an iron frame. The spectrometers were calibrated using a 12 inch 99% reflectance Barium Sulfate panel. The USB 4000 spectrometers are capable of capturing reflectance from 350 to 1050 nm wavelength range with a spectral resolution of 1.5 nm. A total of three to four scans were taken in each individual plot, with the median of the scans being considered for estimating remote sensing reflectance (R_s).

Leaf Area Index readings were taken in the individual scanned plots using LAI 2000 plant canopy analyzer (LICOR Bioscience Inc.). For each plot, readings were taken in each of the four corners, with one above and four below canopy readings. The median of the four LAI readings were taken for analysis.

Fig 2a – 2d: Field Survey, (a) Ocean Optics Setup, (b) Calibration using 99% panel, (c) Acquiring LAI and Chlorophyll readings, (d) Reflectance Measurement.

Leaf chlorophyll concentration was measured using SPAD 502 chlorophyll meter (Spectrum Technologies Inc.). The chlorophyll readings from SPAD chlorophyll meter were converted to analytical chlorophyll using the following equation

$$y = e(x+25.085)/11.239,$$

where x = chl concentrations measured by SPAD 502 chlorophyll meter and y = analytical chlorophyll (mg/sq. m). Canopy level chlorophyll content was derived as a product of analytical chlorophyll and the leaf area index.

Vegetation Fraction (VF) was measured from a circular section of the plot photographs taken vertically using an OLYMPUS E502 digital camera, also mounted on the iron frame. Vegetation fraction is calculated as the ratio of the green pixels in the circular section of the photographs to the total number of pixels in the circular section.

Cloud free LANDSAT imageries of the study area acquired early October 2010 and October 2008, were atmospherically corrected. Reflectance values were then extracted from these atmospherically corrected LANDSAT imageries, based on the GPS location of the sites sampled. Imageries acquired by LANDSAT in October 2009 was not considered for analysis on account of excessive cloud cover.

Analysis:

In-situ reflectance

Based on the visual estimation of the contamination levels in the sample plots, the entire reflectance data were classified as low, medium and high contaminated plots. The reflectance data acquired from different plots were smoothed out using a running average with a 7 nm window. Remote sensing reflectance for each sample plots were derived from the downwelling irradiance and upwelling radiance using fiber specific calibration coefficients using the following equation:

$$R_s = M_\lambda / E_\lambda \times C,$$

where, R_s = Remote Sensing Reflectance, M_λ = upwelling radiance, E_λ = downwelling irradiance, C = Ocean Optics calibration coefficient.

The reflectance spectra for each plot were analyzed and compared among plots with almost similar biophysical parameters (species composition, vegetation fraction, LAI and chlorophyll in order of preference) across different levels of contamination. As different species have different spectral response in the electromagnetic region of the spectrum, assessing the effects of oil in the spectral response may lead to confusion.

Biophysical parameters like vegetation fraction, leaf area index, and chlorophyll content can affect the spectral response as well (Gitelson et al, 2002). Since we could sample only 24 plots in the region, the variance in the field data was not too high. However, plots having homogenous distribution of a single species (*Spartina alterniflora* in this case) could be identified across different levels of contamination. The reason for choosing *Spartina alterniflora* was due to its relatively high sensitivity to oil contamination (Pezeshki and DeLaune 1993). Vegetation fraction was considered as the standard biophysical criteria (range selected 38 – 46%), followed by Leaf Area Index and analytical chlorophyll content (mg/sq. m).

LANDSAT Reflectance

Vegetation Indices NDVI, WDRVI, CI_{green}, $CI_{red-edge}$, VARI, $VARI_{green}$, and EVI, were calculated based on the reflectance values extracted from LANDSAT imageries and regressed against bio-physical variables leaf area index, canopy chlorophyll and vegetation fraction. First order polynomial regression performed marginally better than linear regression. While NDVI proved to be a better index in predicting Leaf Area Index (r^2 = 0.618) and Vegetation Fraction (r^2 = 0.552), CI_{green} proved to be the best predictor for canopy level chlorophyll (r^2 = 0.523) [see Table 1]. RMSE values observed for predictions for LAI, VF and canopy level chlorophyll (chl) were 2.393, 18.8% and 37.37 mg/m^2.

R^2	**LAI**	**VF**	**Canopy Chlorophyll**
NDVI	**0.618**	**0.552**	0.522
WDRVI 0.1	0.609	0.544	0.516
VARI Green	0.068	0.125	0.036
VARI	0.04	0.129	0.039
EVI	0.482	0.318	0.428
CI Green	0.589	0.38	**0.523**
CI Red Edge	0.608	0.537	0.516

The polynomial regression models were applied to the individual sets of imageries (for Louisiana and Mississippi, 2010 and 2008) to predict Leaf Area Index, Vegetation Fraction and Canopy Chlorophyll.

State-wise subsets were generated from the output images based on the estuarine and marine wetland areas delineated by the National Wetland Inventory.

Results:
Fig. 3a shows the reflectance spectra of *Spartina alterniflora*, with almost similar biophysical characteristics across different levels of contamination. Clearly, the variation in the reflectance at red and NIR region is quite significant with decrease in the increased reflectance in the red region and decreased reflectance in the NIR region with increasing level of contamination. Also similar trends can be observed in other plots as well to varying degrees (Fig. 3b – 3d). A few low contaminated plots showing high reflectance at the red region of the electromagnetic spectrum, might be attributed to the natural browning of the leaves towards the end of the growing season. The results are somewhat concordant with findings of Li et al. (2005) so far.

Leaves are found to lose photosynthetic pigments progressively with increase in physiological stress. In the process they change their color from green to pale-green, yellowish-green, yellow and ultimately red. The stems too become darkened as well. This discoloration (chlorosis) is also accompanied by progressive defoliation, litter fall and stunted growth of seedlings, due to reduced germination rates. Chlorosis due to the loss of both chlorophyll a and b has been observed after an oil spill and in green house experiments (Hutchinson & Hellebust, 1974; Ustin, 2002).

Oil contamination leads to disruption of plant and seed water balance and affects plant and seed metabolism (McCown & Deneke, 1972). Oil pollution also favors the spread of invasive species, which are tolerant to oil contamination against species which are not (Hutchinson & Hellebust, 1974; McCown et al., 1977; Scholten & Leendertse, 1991). Effects of oil contamination are found to be diverse because of the variation in the chemical compositions of the oil compounds.

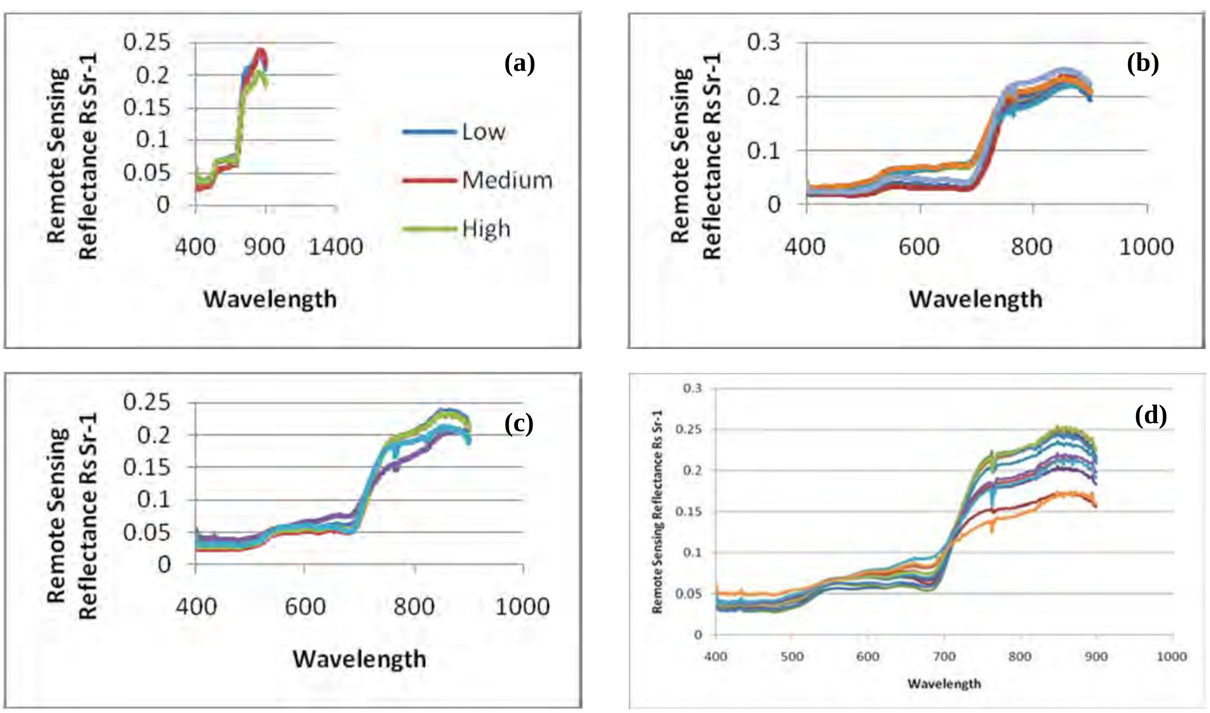

Fig 3a – 3d: Reflectance Spectra of vegetation (a) comparing varying degree of contamination across plots with similar species and biophysical characters (b-d) Spectra of low, medium and high contamination plots respectively

Vegetation response to the electromagnetic radiation is the basis of remote sensing of vegetation stress. In spite of morphological, physiological, phonological and climatic differences, the response of vegetation towards the solar radiation remains similar overall. Healthy plants have characteristic high reflectance in the near-infrared region of solar radiation, due to intense internal scattering of incident light from cell walls and intercellular spaces. However, with increased stress or senescence, these mesophyll cells become degraded accompanied with the collapse of their cell walls, thereby leading to reduction in intercellular spaces. This actually leads to higher reflectance at the red region and reduced reflectance at the NIR region in stressed plants compared to the healthy counterparts. Greater reflection of red light is due to the loss of chlorophyll, resulting in less absorption, in addition to increase of concentration of different other non photosynthetic pigments in the leaves. The results shown here too follow a similar pattern.

As is evident from Fig(s) 4 & 5, there is significant difference in the all the biophysical parameters- Leaf Area Index, Vegetation Fraction and Canopy level Chlorophyll values observed in the pre and post oil spill Landsat imageries, indicating a visible decline in the values post oil spill period due to reduction in photosynthetic activity.

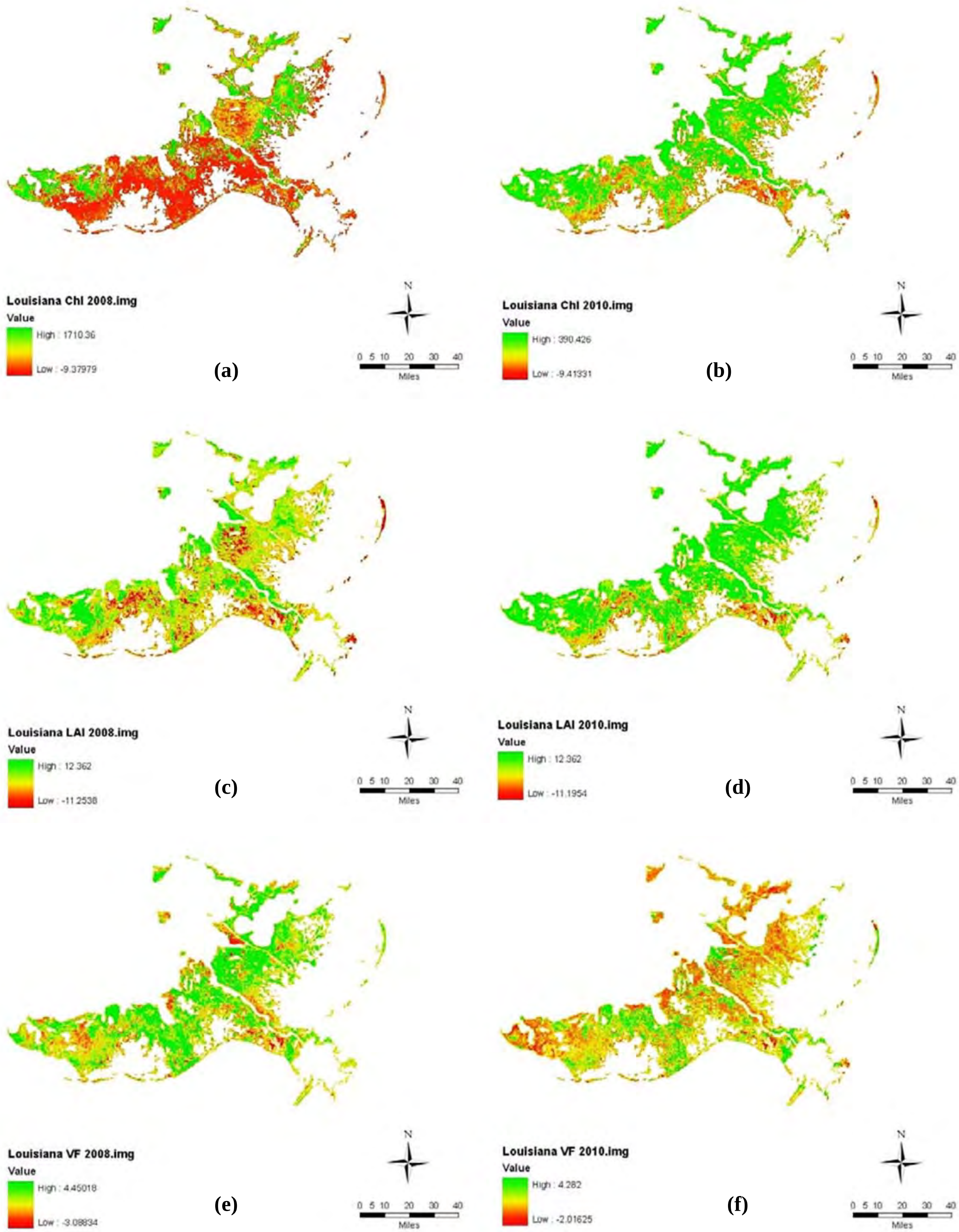

Fig 4a – 4f: Biophysical parameters predicted for Louisiana – Canopy Level Chlorophyll for 2008 (a) and 2010 (b), Leaf Area Index for 2008 (c) and 2010 (d), and Vegetation Fraction for 2008 (e) and 2010 (f)

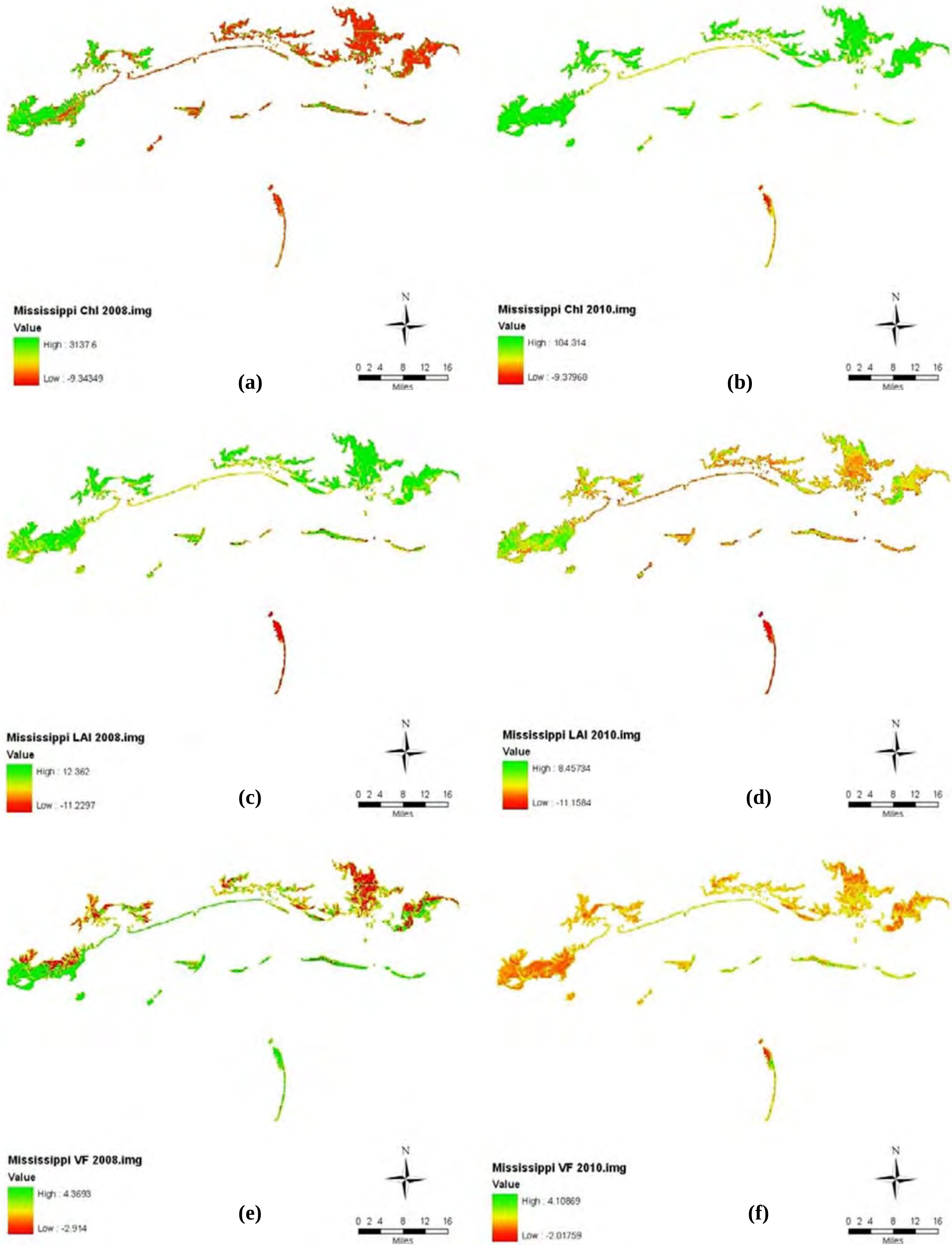

Fig 5a – 5f: Biophysical parameters predicted for Mississippi – Canopy Level Chlorophyll for 2008 (a) and 2010 (b), Leaf Area Index for 2008 (c) and 2010 (d), and Vegetation Fraction for 2008 (e) and 2010 (f)

Conclusions:

From the analysis of the in-situ reflectance data, the fact cannot be denied that significant differences have been observed in the vegetation as is evident from their spectral response pattern, across different areas with varying levels of oil contamination. The results suggest this approach has significant potential as a tool for diagnosing areas subjected to oil-induced stress, although a more thorough investigation is required to confirm the effects of oil contamination on the salt marsh vegetation.

It could not be verified whether the said spectral response patterns are entirely due to oil contamination or there is some contribution of the phenology of the vegetation. A comparison of data across various seasons is currently in progress. In addition, development and testing of different vegetation indices along with their performances in assessing the health of the vegetation is underway.

The preliminary results obtained from the analysis of the LANDSAT imageries as mentioned earlier clearly show a visible change in the biophysical parameters pre- and post-oil spill. However, it should be kept in mind that the study area has experienced severe tropical storms in 2008, the effect of which might have influenced the model outputs of the said year. A more detailed time series analysis including multiple years is required in order to substantiate the effects of the oil spill on the estuarine wetlands of the studied region. In addition, optimizing the models for quantifying biophysical parameters would probably result in a more robust prediction.

Acknowledgements:

We acknowledge Dr. Hyung Jung Cho, Philemon Kirui and Nicholas Jackson, collaborators from Jackson State University, Phil and Mike from University of New Orleans and Scott and Tom from Gulf Coast Research Laboratory, for helping with the field work and Northern Gulf Institute and National Science Foundation, the grant providers for this study.

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II. Image Analysis for Mapping/Monitoring affects of Oil Spill on Sensitive Coastal / Estuarine Vegetation

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Abstract:

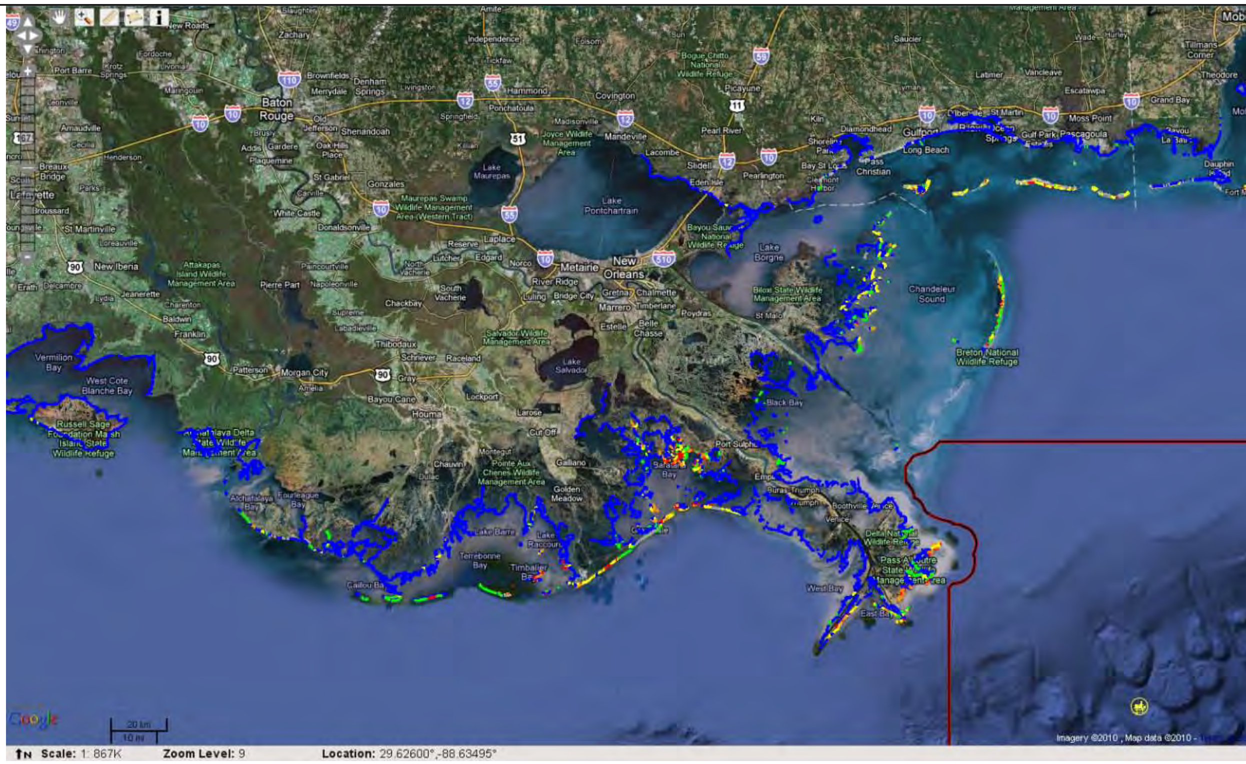
In this work, we studied the applicability of cutting edge hyperspectral and/or multispectral imagery products to visualize and detect stress induced in sensitive estuarine vegetation. AVIRIS imagery available publicly was employed for these preliminary (Phase-I) studies. We attempted this analysis from multiple aspects, such as - looking at simple vegetation indices, looking at broad spectral characteristics as well as fine-scale spectral characteristics, analyzing the remotely sensed imagery over time to do before/after analysis. The goal of these studies was to provide valuable insight into the affects of the oil spill on sensitive vegetation along the gulf coast. This study will serve as a pilot study, enabling us to identify and focus on developing more advanced algorithms tuned for such problems for a wider study (Phase two). Phase one activity included image analysis products, including processing and preparing imagery for analysis and preliminary maps identifying potentially stressed vegetation.

Data Preparation:

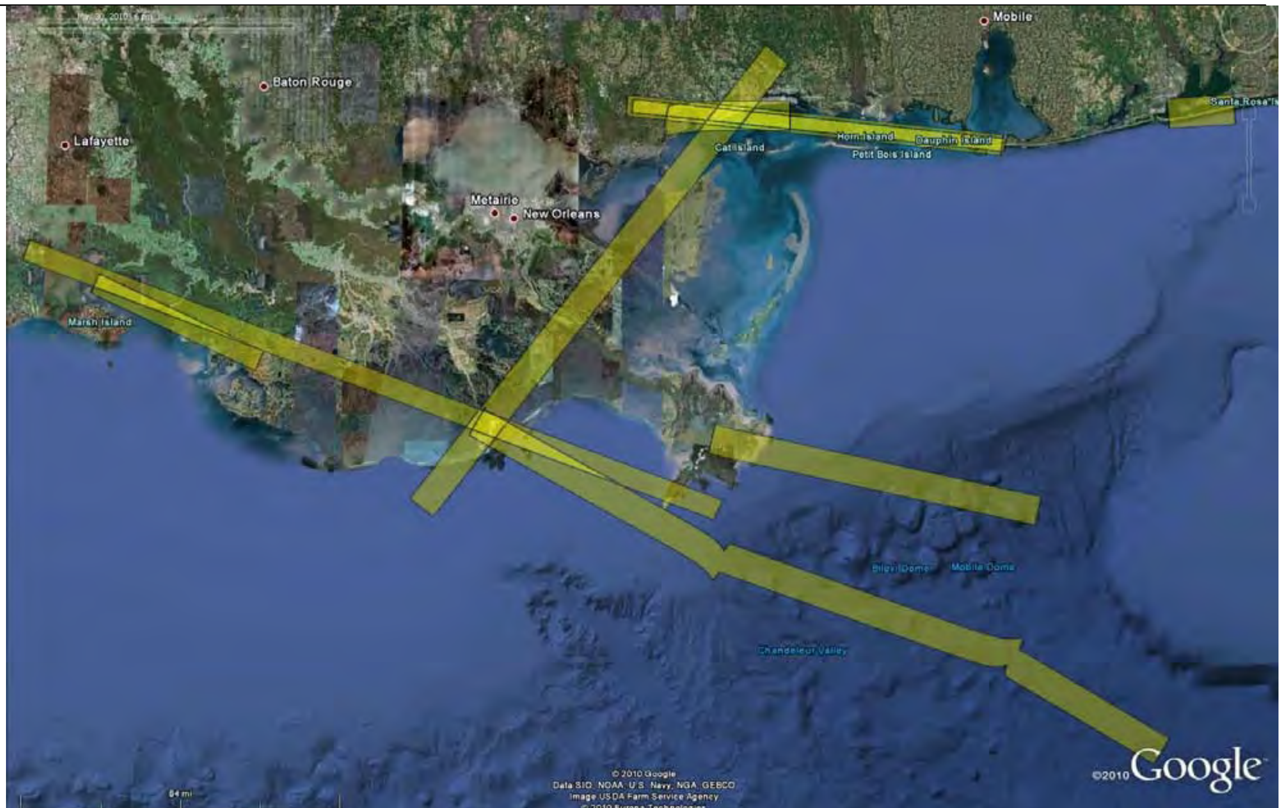
In response to the Deepwater Horizon Gulf of Mexico (GoM) oil spill disaster, NASA acquired and released hyperspectral imagery products (acquired using its AVIRIS sensor) to enable the scientific community study its impacts on the region. For every aerial flight-line, two data products were provided: (i) Calibrated AVIRIS Radiance Data (IMG), (ii) Input Geometry File (IGM). The IGM file contains the *x*, *y* and *z* map coordinates for a specified map projection for each pixel in the uncorrected data cube. The IGM file hence provides the pixel location data for the corresponding radiance data cube. This contains three parameters: (i) WGS-84 longitude (X-Band in Degrees), (ii) WGS-84 latitude (Y-Band in Degrees), (iii) Estimated ground elevation at each pixel center (Z-Band in meters). The data is in IEEE 64-bit double format. The calibrated AVIRIS data is a 16-bit signed integer in IEEE and contains 220 spectral bands.

The IMG file is not readily suited to perform any meaningful analysis without appropriate preprocessing. The first step in such a preprocessing is to perform geo-referencing. For this, we map a coordinate point to every pixel in the AVIRIS radiance cube. This can be performed by using the latitude and longitude information available in the IGM file. The IGM file contains parameters of the external orientation of the AVIRIS sensor, e.g., correction factors for positioning, time and attitude of the push broom sensor per row used to perform geometric correction of the cube. To geo-reference an image, one needs to establish control points, input the known geographic coordinates of these control points, choose the coordinate system and other projection parameters and finally minimize residuals. Residuals are the difference between the actual coordinates of the control points and the coordinates predicted by the geographic model created using the control points. They provide a measure of the level of accuracy of the geo-referencing process. For the datasets we have for this task, there is no need for predictions as the IGM file contains the unique location information of every pixel. The ENVI™ tool is used in this work for performing this geo-referencing.

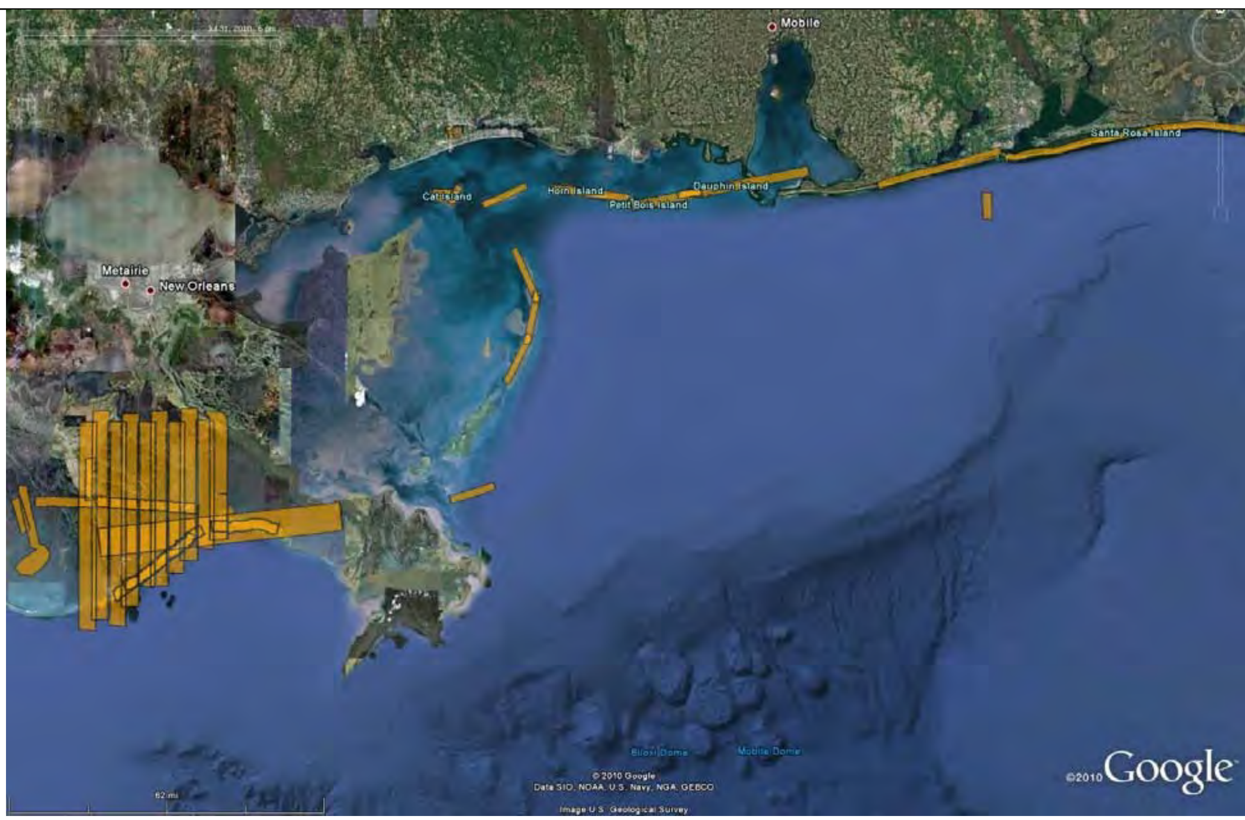
For this research, AVIRIS imagery from the GoM from the period May 2010 to October 2010 was downloaded and prepared for analysis. The geo-referencing process took 30-45 minutes for AVIRIS data cubes having an approximate size of 6000 x 600 x 220 (approximately 2.2 GB per cube). The total number of AVIRIS cubes we now have available thus far (as of November 2010) for analysis is 150.



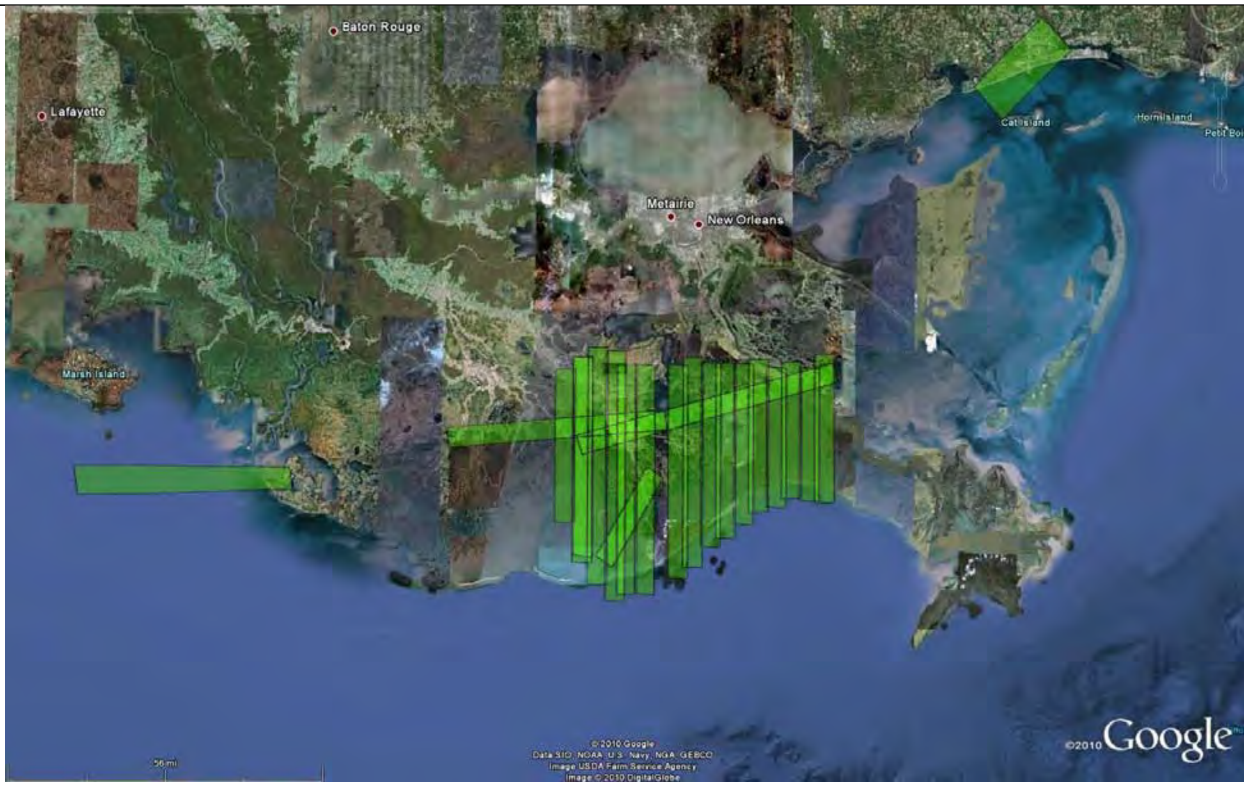
Map illustrating Louisiana and Mississippi coastal areas affected by the oil spill – the key focus area for our initial study



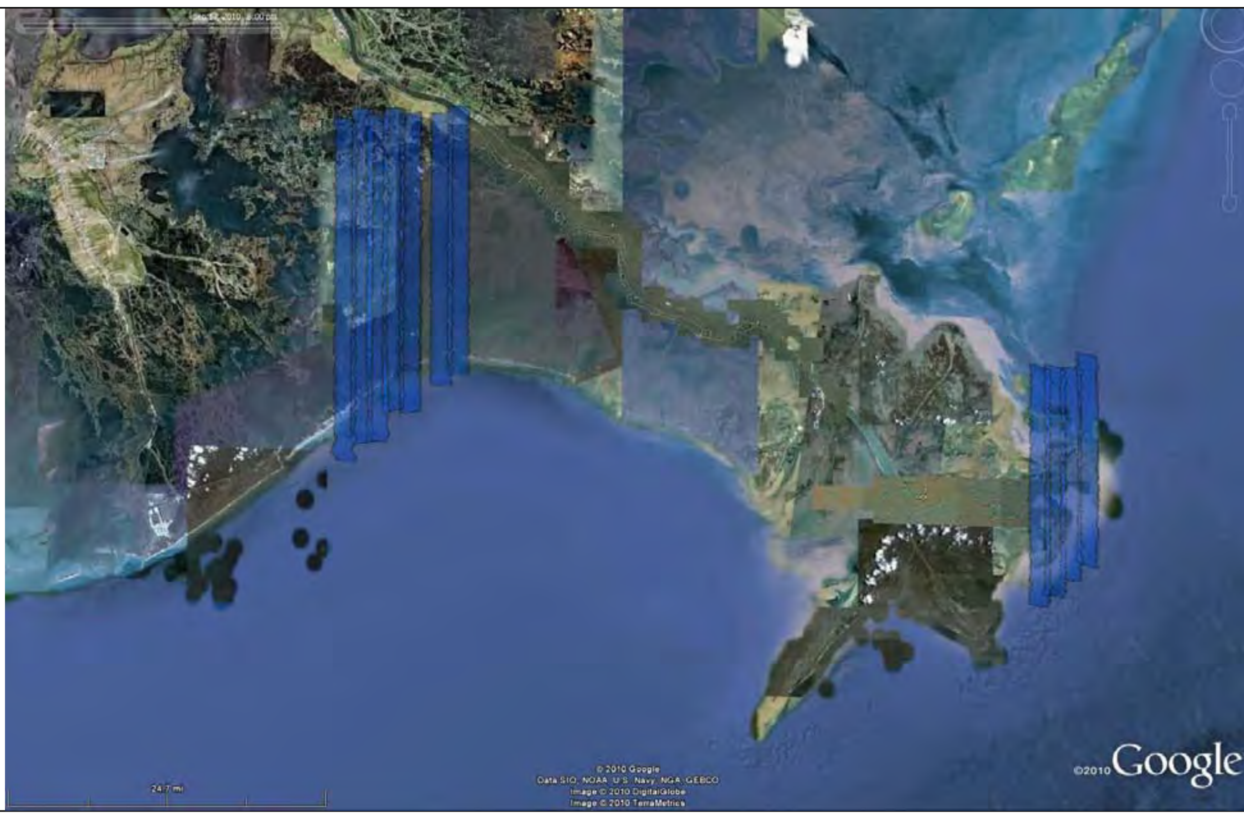
Map of Geo-Referenced HSI cubes for the month of May 2010



Map of Geo-Referenced HSI cubes for the month of July 2010



Map of Geo-Referenced HSI cubes for the month of August 2010



Map of Geo-Referenced HSI cubes for the month of September 2010

Preliminary Data Analysis:

The main goal of this work is to identify and detect any spectral changes in vegetation and soil in regions affected by the oil spill. The AVIRIS radiance cubes provide rich spectral information about the area under study. The flight lines have a significant spatial overlap across different dates – this enabled us to study any detected changes/vegetation stresses over time. Owing to the size of the data cubes, performing analysis over entire cubes is time consuming. For preliminary studies in phase 1, we used the map of potentially affected areas provided by NASA Environmental Response Management Application to extract a few subsets (that we expected to be affected by the spill) from the available imagery for analysis. The predominant vegetation cover in these subsets is marsh-grasses – an important component to the GoM ecology. In phase 1, our preliminary studies focus entirely on unsupervised analysis methods. In phase 2, we planned to extend this analysis to exploit available ground-truth information for a supervised analysis and to validate our unsupervised analysis methods.

Preliminary unsupervised image analysis: *K*-means clustering is an efficient and popular technique to examine the natural groupings in a dataset. The algorithm attempts to partition all the observations into *k*-clusters such that each observation (pixel with a particular spectral profile) belongs to the cluster with closest spectral mean. The two key parameters of *k*-means is the distance metric used and the choice of *k*. The value *k* is varied from 5 to 15 and a Euclidean distance metric was employed for clustering. It is hoped that changes to these clusters over time can reveal possible spectral changes from the vegetation cover on-ground.

Analyses:

Note that in all of our research efforts related to this work, our underlying goal was to be able to detect, map and quantify any changes in the health of marsh-grasses and other vegetation along the GoM in months following the oil spill disaster. Our team was specifically focused on the following key tasks:

1. **Change Vector Analysis** (CVA): CVA attempts to extract features from sets of co-registered imagery acquired at different times. Such an analysis should be able to detect spectral changes between images acquired early on into the oil spill disaster, and more recent ones. These change vectors can then be passed to various classifiers to detect anomalies and areas of potential interest. This algorithm was coded in Matlab™.

2. **Supervised Classification**: GRI researchers have made field trips to the Marshlands in areas where we are focusing our current studies. Data acquired from such trips include geographical coordinates of areas where visually light, moderate and severe oiling could be seen. We hope to exploit this information to train various pattern recognition algorithms and study if other areas for which we have HSI imagery can be classified into such categories.

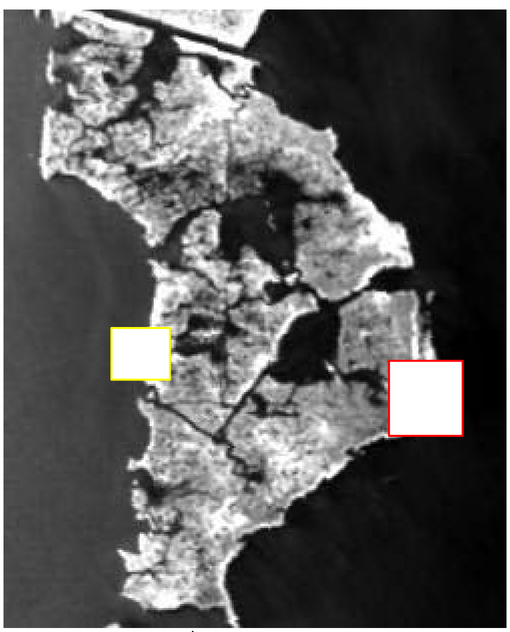
3. **Advanced Unsupervised Classification**: In addition to the efficient, yet simple *k*-means clustering algorithm described above, we can apply more advanced clustering techniques to be able to detect subtle anomalies that might go unnoticed when using simple clustering methods (e.g., vegetation under stress due to oiling). We also can study spectral similarities and dissimilarities between various relevant clusters identified by this process.

4. **Classification after Clustering**: Unsupervised clustering provides areas with similar spectral properties. In supervised classification, we call these sets/clusters as classes. Hence, crudely we can assume the cluster groups as classes. To perform change detection by making use of these clusters, the problem can be defined as a classification problem with clusters obtained from two different dates being different classes. If there is no change in the data of a particular class between the two dates, the classification will result in total confusion between those pair of classes and vice-versa. The amount of confusion can hence be directly related to the amount of change.

Note that since our phase-II funding was not approved, we are unable to proceed with all of the planned items above. We hence have focused our research efforts on item (3) in particular, i.e., studying carefully the unsupervised *k*-means clustering of marsh-grasses, and studying spectral similarities and dissimilarities between potential healthy and stressed vegetation.

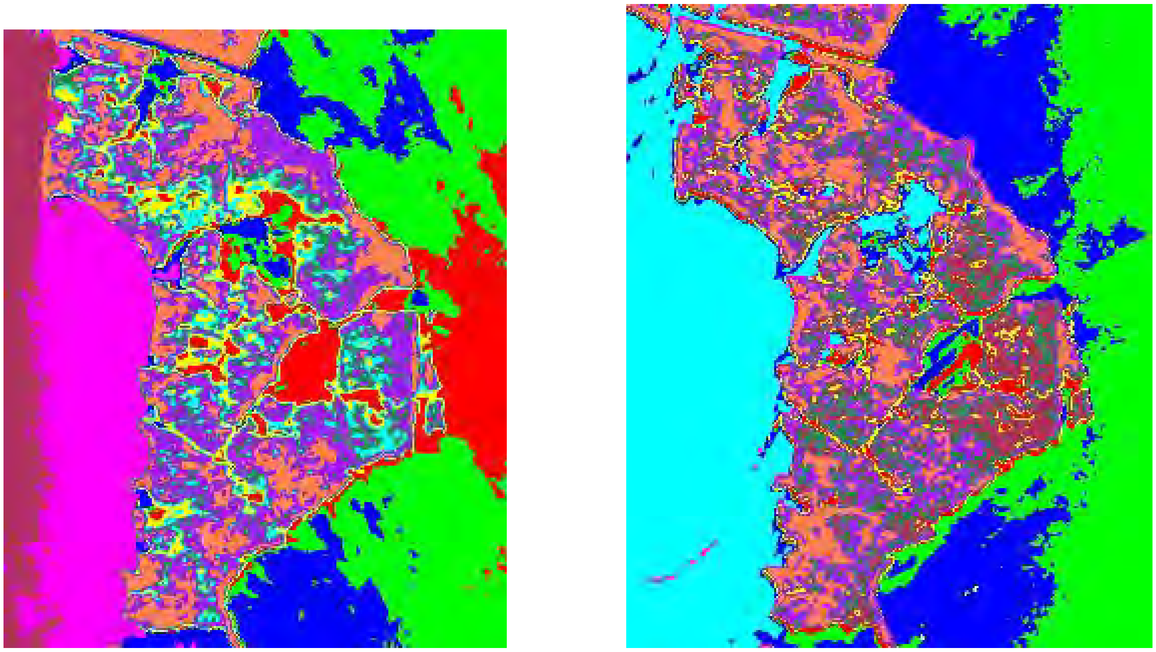
Preliminary Results:

Subset of an AVIRIS Radiance Image

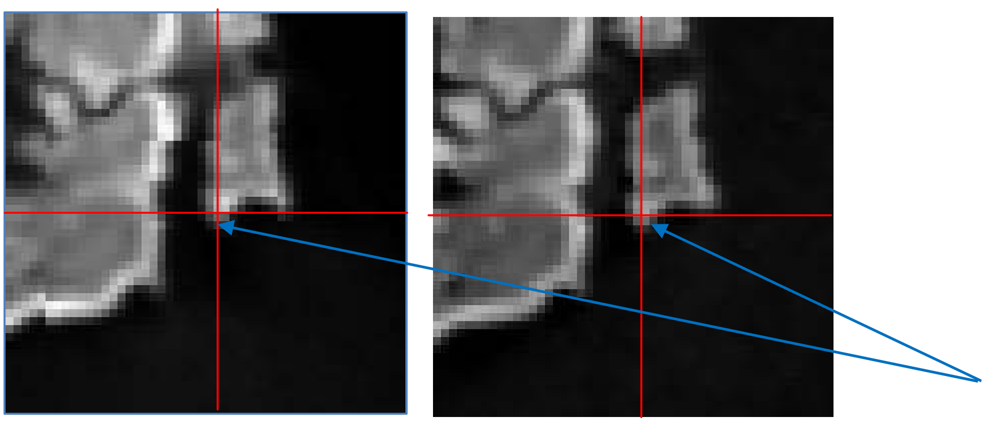


From July 31st (Cube Number r13)

From August 24th (Cube Number r15)

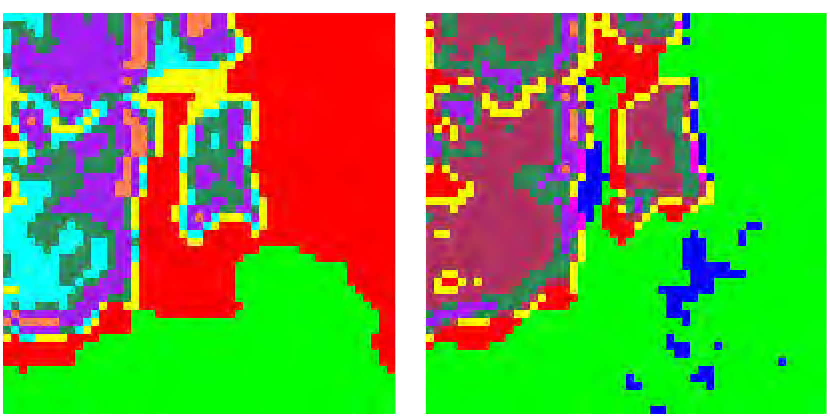


Result of *k*-Means Clustering (*k*=10)

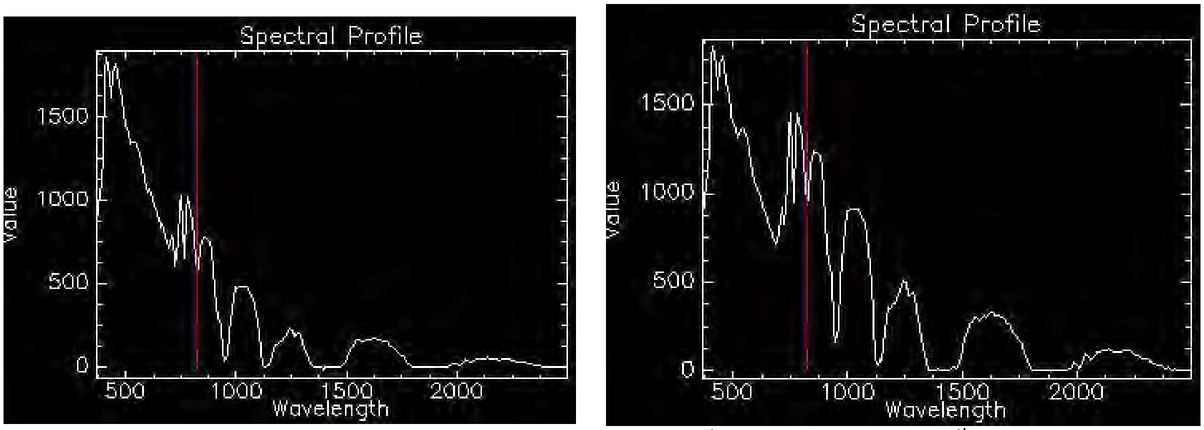


Area 1 Zoom of (Cube July 31 r13)   Area 1 Zoom of (Cube August 24 r15)

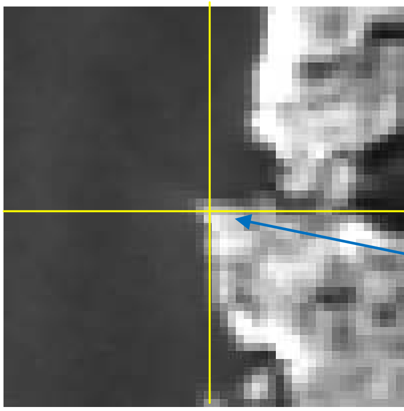
Spectral Profiles for these points are shown below – Note the resurgence of the "red-edge" from July 31, 2010 to August 24, 2010.



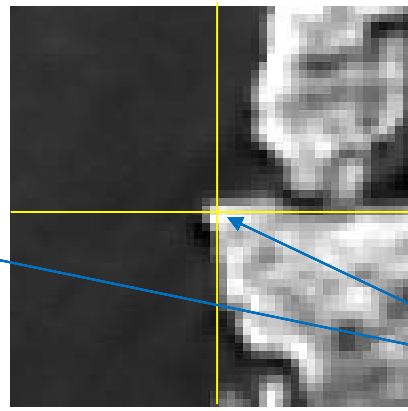
Result of *k*-Means Clustering (*k*=10) for Area 1



Spectral Profile at the points illustrated above on July 31st (*left*) and August 24th (*right*) respectively

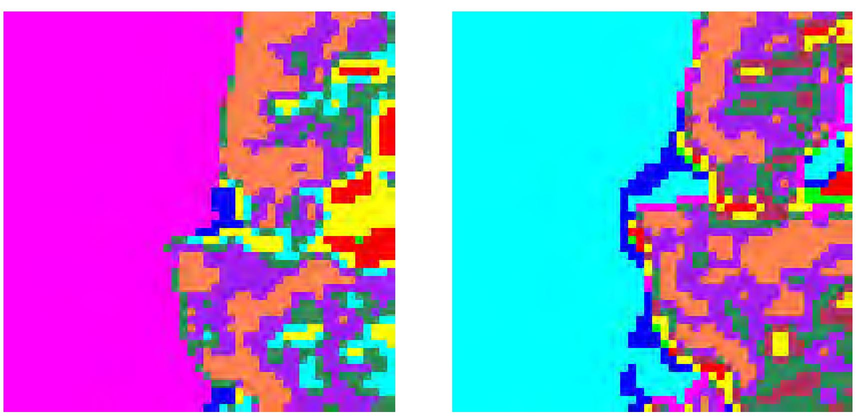


Area 2 Zoom of Cube July 31 r13

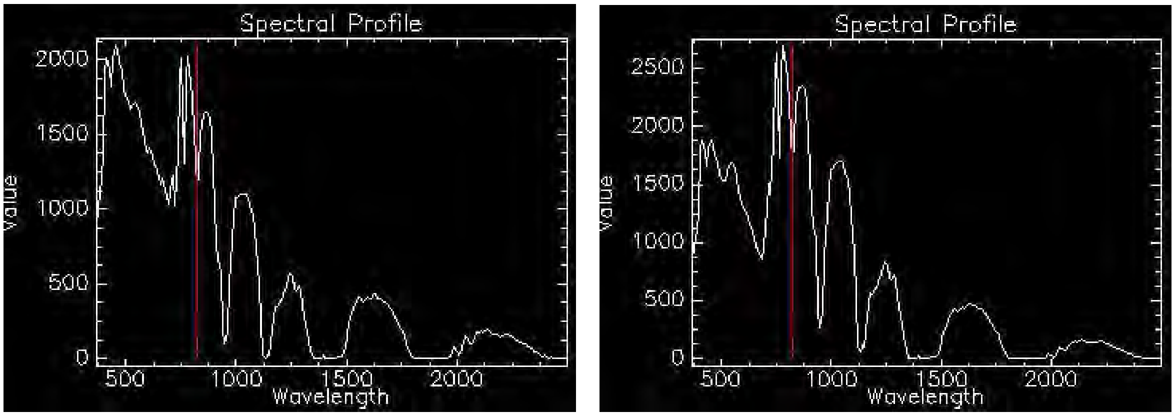


Area 2 Zoom of Cube August 24 r15

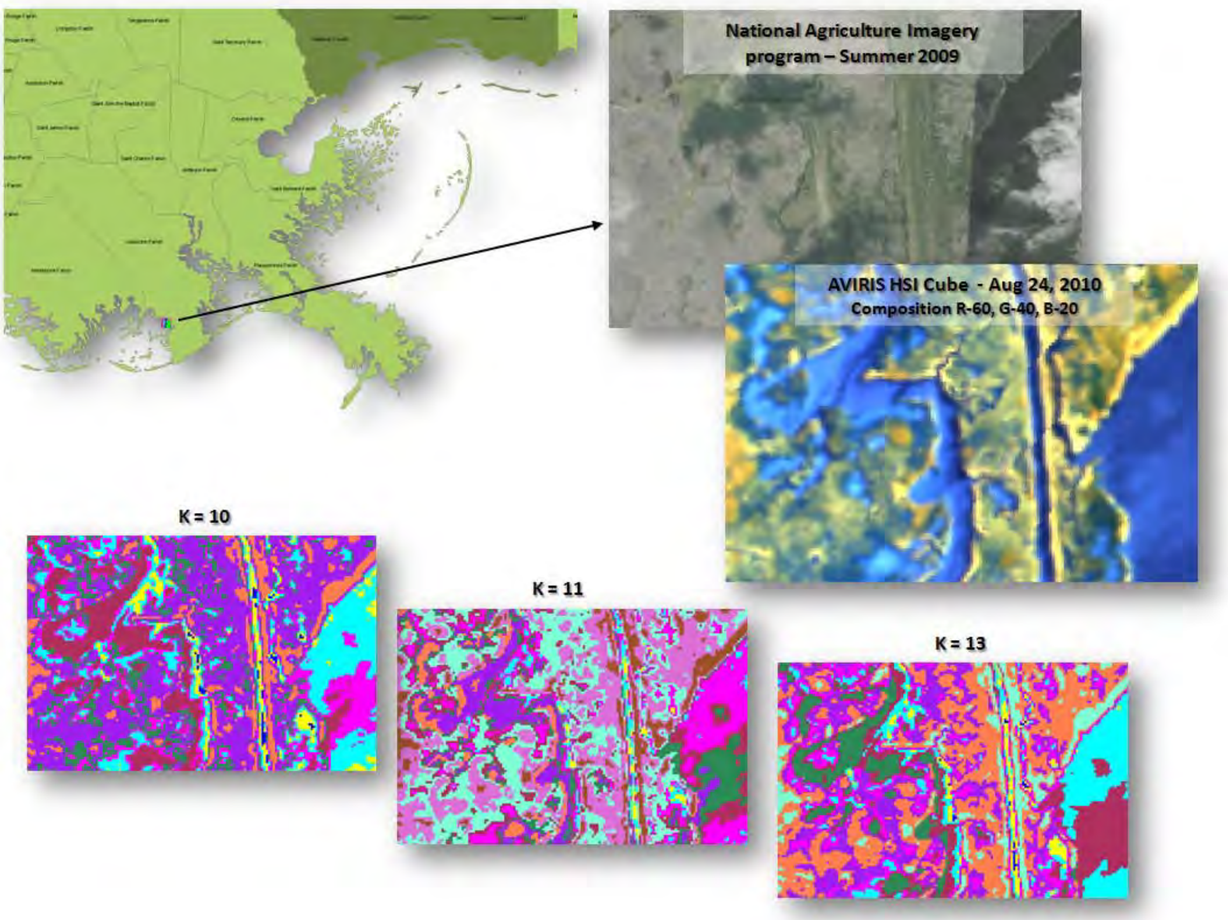
Spectral Profiles for these points are shown below



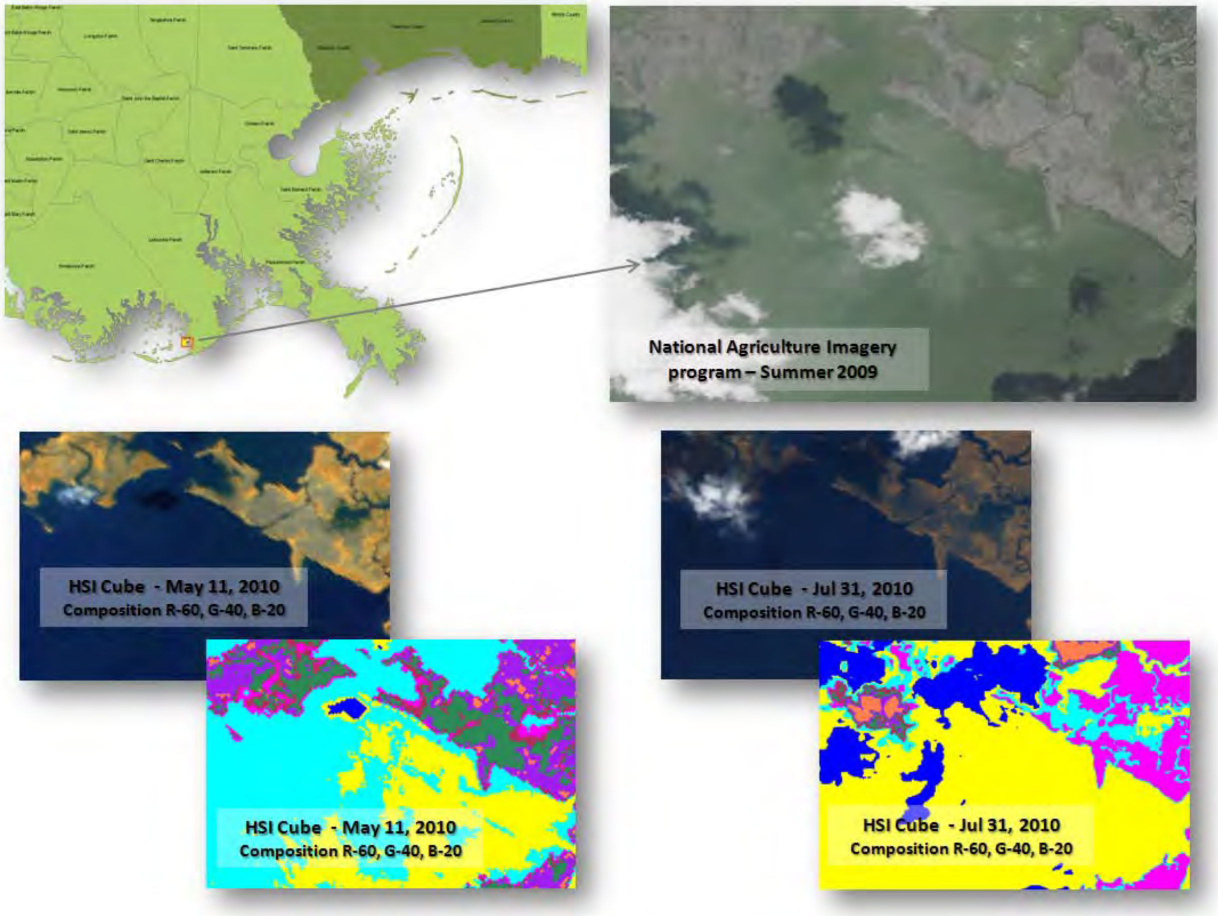
Result of *k*-Means Clustering (*k*=10) for Area 2



Spectral Profile at the point on zoom July 31st and August 24th respectively

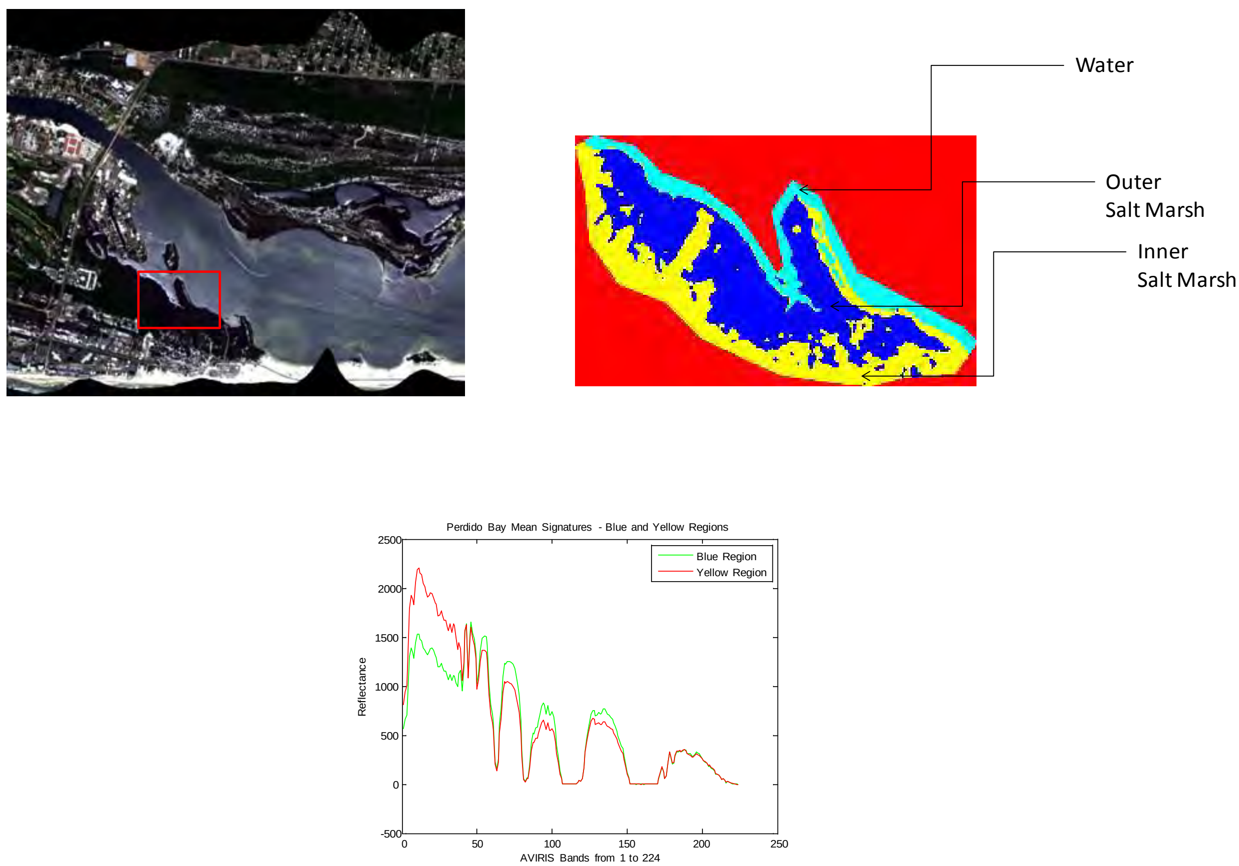


Preliminary clustering results

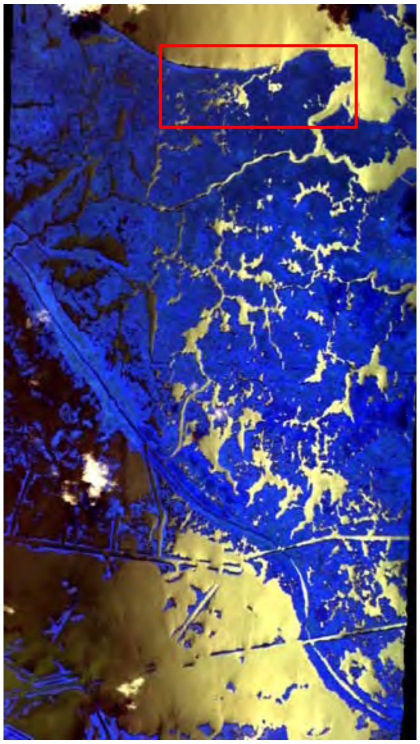


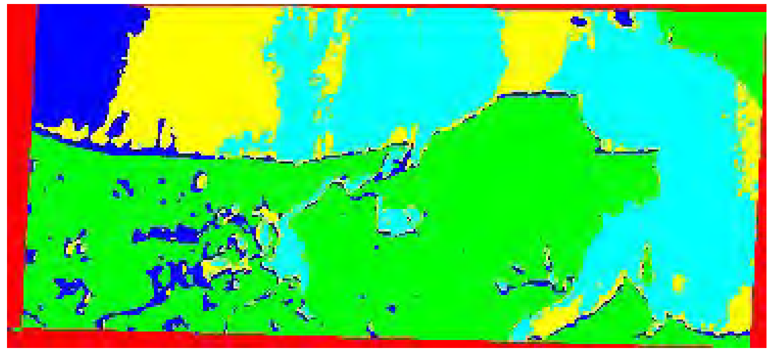
Preliminary clustering results

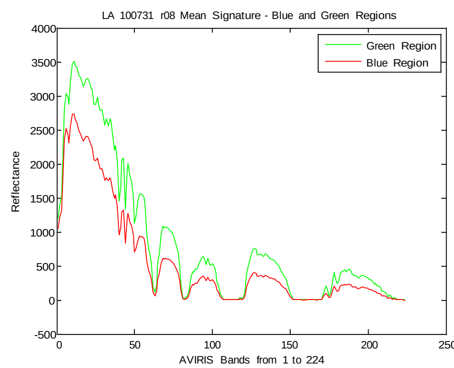
Spectral Clustering Results over Salt-Water Marsh Grass Covers:
As mentioned above, we performed a *K*-means clustering on AVIRIS imagery over regions in the Perdido Bay (Florida) area, as well as the marsh-lands in Louisiana.



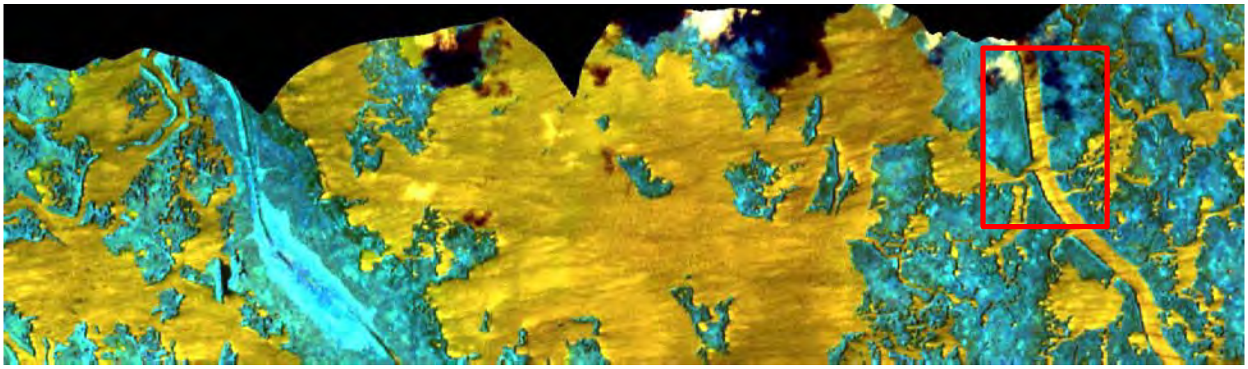
(Left) Optical image of the Perdido bay area; (*Right*) *k*-means clustering results from the Perdido bay area ; (*Bottom*) Spectral signatures of the two clusters identified within the marsh grass stands. From this figure, one can see that the salt water marsh grasses that are more "inland" (closer to the land) are identified as different clusters from those more exposed to the ocean water. Studying the mean spectral reflectance signatures (bottom figure), one can see that the reflectance values in the Near-Infrared region of the spectra is more suppressed for vegetation more exposed to the ocean water (away from the land). This could reflect various stresses on the vegetation, such as salinity, tidal action, or, potentially, greater exposure to pollutant contamination.

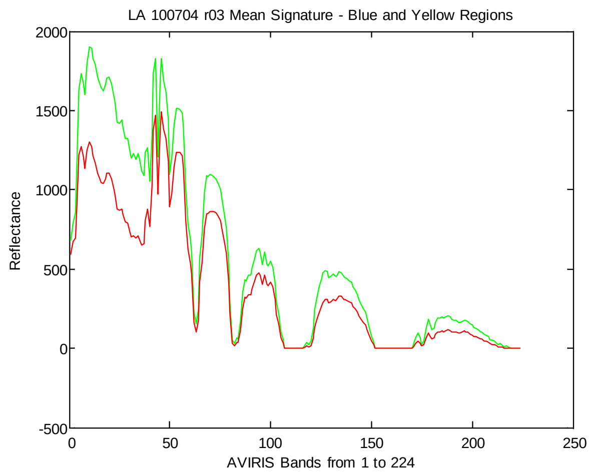


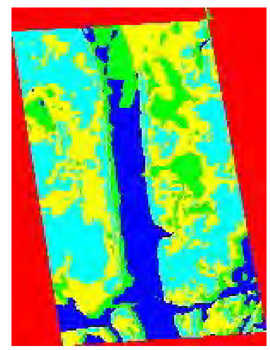




(Left) Optical image (false-color) of a Louisiana salt-water marsh cover; (*Right*) *k*-means clustering results from a subset of the image; (*Bottom*) Spectral signatures of the two clusters identified within the Marsh-grasses cover. Once again, notice a suppression in spectral reflectance values of "outer" vegetation cover. Possible reason for this suppression were discussed on the previous page. Further ground-truth would be necessary to help verify this analysis and attribute the observation to the cause.







(Top) Optical (false-color) image of a Louisiana salt-water marsh cover; (*Bottom Right*) *k*-means clustering results from a subset of the image; (*Bottom Left*) Spectral signatures of the two clusters identified within the marsh grass areas. Once again, notice a suppression in spectral reflectance values of "outer" vegetation cover. Note, however, the spectral similarities in the cover types of the marshes in all the figures above (including the one from Perdido Bay, where we have confirmed the presence of salt-water marsh grasses). This indicates a similar ground cover type in these areas. Further, a similar trend (reduction in spectral reflectance values) in outer-bands of this cover is indicative of potential plant stress, that is resulting in the algorithm clustering this cover into two distinct clusters.

III. Biodegradation of Tarballs Remaining on the Shorelines after the Deep Horizon Oil Spill

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Abstract:

Tar balls were collected in the intertidal zone from a beach near Fort Morgan AL on September 4th 2010. Studies of microbial communities during tar ball degradation were coupled with a suite of chemical analyses to determine changes in microbial metabolism, species assemblage composition, and responses to different enrichment treatments to enhance petroleum degradation.

Objective:

The objective of this study was to determine conditions that would degrade the mousse (tar balls) left on the Mississippi and Alabama shores during and after the Deep Horizon oil spill. Treatments included three different substrate additions (nitrogen, phosphorus, carbon), as well as controls.

Collection of Materials:

Tar balls were collected in the intertidal zone from a beach near Fort Morgan AL on September 4th 2010. These were transported to MSU and held in seawater in a refrigerator until used. Fresh seawater was collected off of Dauphin Island, AL on October 16th/ 17th 2010, transported to MSU and held in the refrigerator until used.

Experimental Setup:

Tar balls were merged into one container, mixed and then distributed into 3 containers. Approximately 0.5g of tar balls were weighed and 3 of these = 1.5g were placed into each 50ml clear serum bottle. Bottles were labeled by number and the exact amount of tar ball in each bottle recorded. Treatments and controls are listed below. There are 4 reps for each treatment/collection time. For nitrogen (N) & phosphorus (P) additions, P was added as ammonium phosphate at 0.003 g P/ 1.5 g tar ball and N was added part from ammonium phosphate and the rest from ammonium nitrate at 0.03 g N/1.5 g tar ball. For carbon additions: 4 ml sugar cane molasses was added to 200 ml of N&P seawater;
400 ul of naphthalene stock and 10ul hexadecane was added to 200 ml N&P seawater (= 200 ppm naphthalene & 50 ppm hexadecane); 0.4 g switch grass (*Panicum virgatum*; wet mass) was added per bottle plus N&P seawater. 10 ml of seawater -/+ additives was added to each bottle. Bottles were capped with stoppers and crimped with aluminum caps. Total headspace is estimated at 59.3 ml including neck.

Bottles were crimped @ 4 pm on Wednesday October 27th 2010 and placed in an incubator shaker at 150 rpm and 23 C. Every 2-3 days, CO_2 was removed from the headspace and the samples were uncapped and aired for 5 min before re-capping. On day zero, tar ball dry weights were obtained by oven drying six tarball samples overnight at ~ 65C. One sample of switch grass was also dried. The average percent moisture of tar balls 9.1% and the percent moisture of switch grass was 3.3%.

Treatments & Controls:
Seawater Only Control
Tarball + Seawater Control
Tarball + Seawater + N&P
Tarball + Seawater + N&P + Molasses
Tarball + Seawater + N&P + switchgrass
Tarball + Seawater + N&P + naphthalene & hexadecane

Analyses:

Four replicates from each treatment were sacrificed on days 12, 25, and 50. CO_2 was measured for all replicates prior to sampling. Bacteria were enumerated from each replicate sacrificed at each sampling date in order to determine bacteria populations. Water from each bottle was plated onto R2A media made with seawater and the colonies counted.

Gas samples (10.4-mL) were taken from the headspace of the serum bottles using luer lock syringe housing a 26-gauge needle. The gas sample was injected into a 10-mL evacuated vaccutainer, and the puncture hole covered with silicone gel. One set of gas samples were analyzed for carbon-dioxide and another set was submitted to the Oregon State University Stable Isotope laboratory for analysis of ^{13}C-CO_2. Isotope analysis data is expected to be finished by Feb 24th, 2011.

For each replicate sacrificed at each sampling date, 0.5 g of tar ball and 3.3 ml of water were extracted for DNA and terminal restriction fragment length polymorphism (tRFLP) analysis run to determine bacterial community richness and how it changed with treatment and time. DNA was extracted from the tarball using MO BIO PowerSoil™ DNA Extraction kit and from water samples using the Metagenomic DNA Isolation Kit for Water. These were combined and concentrated. A ~500bp 16S rDNA region was amplified through polymerase chain reaction (PCR) using forward primer 27F labeled with CD4 and the reverse primer used was 519R. The PCR products of 2 duplicate PCR reactions were combined and purified. The purified product was subjected to Mung bean nuclease digestion at 30^{o} C for 2h to remove any single stranded products. The digestion product was run on the gel and the 500 bp band was excised and purified from the gel. The purified DNA was subjected to Msp1 digestion for 4h at 37 ^{o}C. The digestion was again purified. The samples are currently being processed for analysis on a CEQ 8000 sequencer for fragment analysis. The software (GenomeLab GeXP Genetic Analysis System) would be used for analysis of bands and MICA (http://mica.ibest.uidaho.edu/trflp.php) will be used for correlation of data with RDB database for identifying bacterial species

GC/MS analysis will be run on a selection of replicates for each sampling date in order to determine what types of polycyclic aromatic hydrocarbons and linear aliphatics remain in the tar balls over treatment and time.

Results:

Bacteria populations increased over time in all treatments, including seawater alone. The largest populations were found in the treatment with molasses which were three orders of magnitude higher than the switch grass treatment at day 50. The switch grass treatment contained the next highest populations but these populations leveled off somewhat after day 12. The naphthalene and hexadecane treatment increased until day 25, but decreased at day 50 indicating loss of substrate. The N+P treatment only differed from tarball plus seawater at day 12, but after day 12 these populations remained similar.

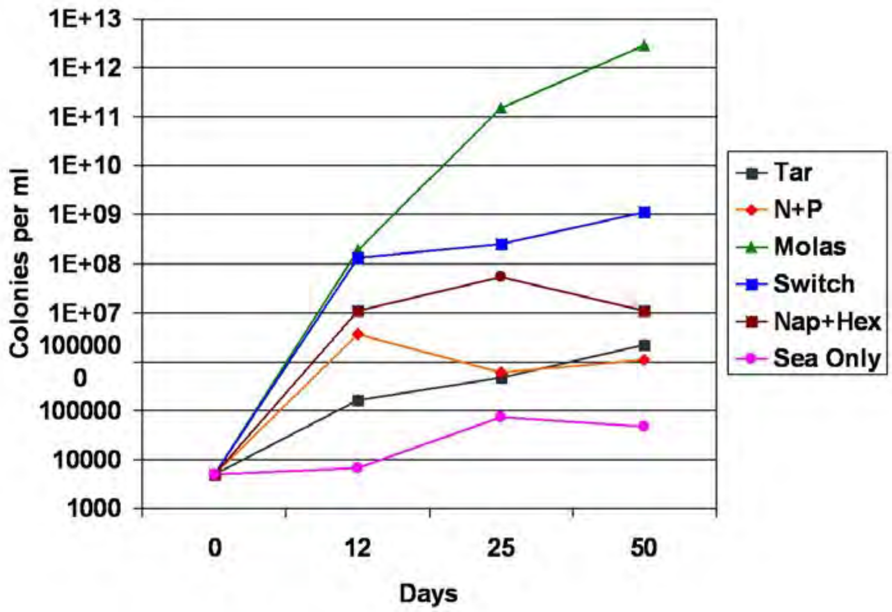


Figure 1. Bacteria enumeration plotted for each treatment and time. Each point is an average of 4 replicates x 2 plates per replicate. Treatments include: Seawater +tarballs (Tar); Seawater + tarball+N+P (N+P); Seawater+tarball+N+P+Molassas (Molas); Seawater+tarball+N+P+Switchgrass (Switch); Seawater+tarball+N+P+Naph+Hex (Nap+Hex); Seawater only (Sea Only).

The amount of tarball-carbon that was mineralized to CO_2 was estimated based on the mass of the tarball and the relative contributions of C-based amendments to the accumulation of CO_2 in the headspace of the serum bottles. In the case of the switchgrass addition, it was known that 9.8% of the straw residue mass was mineralizable by a mixed microbial community over a 48-d period (data not shown). It was assumed that molasses-carbon was completely mineralized during the incubation. Because estimates for microbial biomass growth associated with tarballs have not been fully analyzed, estimates of tarball mineralization and degradation were probably underestimated by as much as 50%. Nevertheless, it is clear that a considerable amount of microbial growth took place on the tarballs, as shown indicated by the bacterial enumeration shown in Figure 1.

Table 1. Influence of amendments on the mineralization of tarball-C to CO_2.

Amendment	**Percentage**
No addition	0.35 a^
Nitrogen and phosphorus	8.7 b
Molasses +N+P	18 c
Switchgrass+N+P	17 c
Napth/Hex +N+P	7 b

^Treatments with different letters are statistically different based on an analysis of variance ($p<0.05$).

Clear trends in the transformation of tarball-C to CO_2 can be seen in Table 1 and in Figure 2. It is notable that without amendment of the mousse with nutrients or an additional carbon source, very little mineralization took place. While it is not known for certain whether other transformations of the tarball took place, visual examination of the tarball through the incubation were in line with the data shown in the Table1. Addition of N and P resulted in significantly increased mineralization of the mousse and strongly suggest that lack of available nutrients in the environment is a key of limiting factor for tarball breakdown. Carbon, in addition to nutrient amendment, in the form of easily mineralizable sugars and carbohydrates as found in molasses and switchgrass further increased the mineralization of the mousse. Visual examination of these treatments further corroborated the relatively strong impact of these carbon sources, but also indicated that these amendments were important in dispersion of the mousse into the seawater solution. It seems plausible that the mousse was being transformed into a number of different chemical forms. While it is notable that almost 20% of the mousse was mineralized, the degradation and mineralization of the remaining tarball and its byproducts would likely take place at a much slower rate. This latter conclusion is based on the declining rate of CO_2 production that took place during the last several weeks of the study (data not shown).

DNA was isolated from all the samples (Figure 3) collected with varying yield. PCR products were obtained from some DNA samples. These samples were processed by PCR (Figure 4) and subsequently for T-RFLP. We are still trying to get products from the remaining samples by varying the PCR conditions. At present we are standardizing the T-RFLP protocol. Comparison to the RDB (Ribosomal database) will be done after obtaining the fragment analysis results.

The GC/MS results are pending and have not been completed.

Figure 2. Photograph of a sample from each treatment at day 50. Treatments are from left to right: Seawater +tarballs (41); Seawater+tarball+N+P (48); Seawater+tarball+N+P+Molassas (52); Seawater+tarball+N+P+Switchgrass (56); Seawater+tarball+N+P+Naph+Hex (58); Seawater only (71)

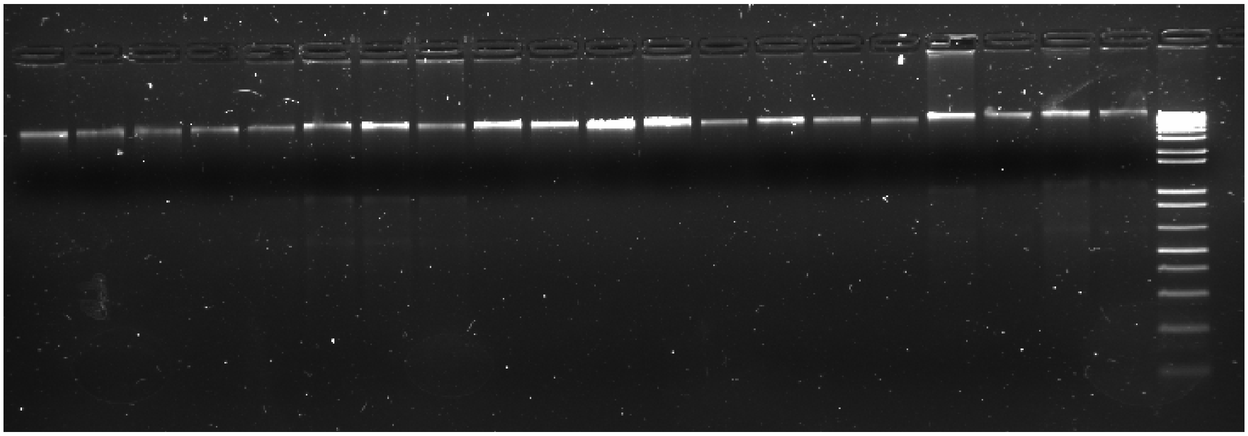


Figure 3. Agarose gel electrophoresis of DNA extracted from some of the tar ball and water samples.

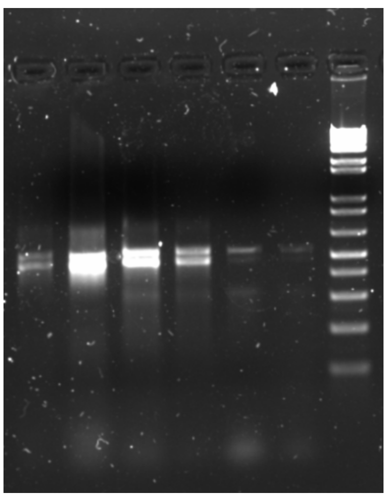


Figure 4. Result of PCR products obtained from few of the samples. The products are ~500 bp in size.

IV. Preliminary study of impacts on sediment biogeochemistry

Technical point of contact: Dr. Karen McNeal, Department of Geosciences (ksm163@msstate.edu)

Preliminary study - a comparison of the sediment biogeochemistry at salt marsh sites vs. salt marsh devoid sites at previously contaminated and non-contaminated locations at Marsh Island, MS.

Overview:

This study was a preliminary attempt to analyze the impact of the Deepwater Horizon oil spill on sediments and marshlands. Specifically of interest was the response of the sediment geochemistry (O_2 and H_2S), the sediment microbial community, and the total CNS in the sediments.

Methods:

In October 2010 and November 2010, triplicate sediment cores were collected at Marsh Island, MS in either saltmarsh rhizosphere or at barren sediment without saltmarsh present from both previously contaminated and uncontaminated sediments. Sediment cores were analyzed for oxygen and hydrogen-sulfide concentrations immediately after collection using a Unisense microelectrode profiling system. Profiles were made in triplicate from the sediment water interface to down to 5cm depth. Once profiles were completed, sediment cores were refrigerated for further analysis and transported back to MSU. Microbial community analysis using the Biolog substrate utilization profile method was utilized to determine differences in aerobic microbial communities at each location. Cores were sectioned in 2cm segments down to 10cm for the analysis. Sediments were diluted (1:100) and Biolog plates were incubated for 96 hour increments and measured using a plate reader every 24 hours. Remaining sediments not utilized for Biolog analysis were then analyzed for total CNS. At each location, water quality data were also taken.

Results:

Table 1. Salt Marsh, Island Water Quality Data

Site	Latitude	Longitude	Conductivity (ms)	Temp (°C)	Oxygen (mg/L)	% Oxygen	Salinity (ppt)
Contaminated Sediment	N30° 22’ 28.0”	W88° 47’ 19.6”	32.92	18.9	7.69	87.2	19.7
Contaminated Saltmarsh	N30° 22’ 28.0”	W88° 47’ 19.6”	ND	20.9	6.93	89.3	24.0
Uncontaminated Sediment	N30° 23’ 1.6”	W88° 47’ 24.0”	25.96	17.5	799	94	18.9
Uncontaminated Saltmarsh	N30° 23’ 01.9”	W88° 47’ 35.6”	25.5	15.5	7.38	83	19.5

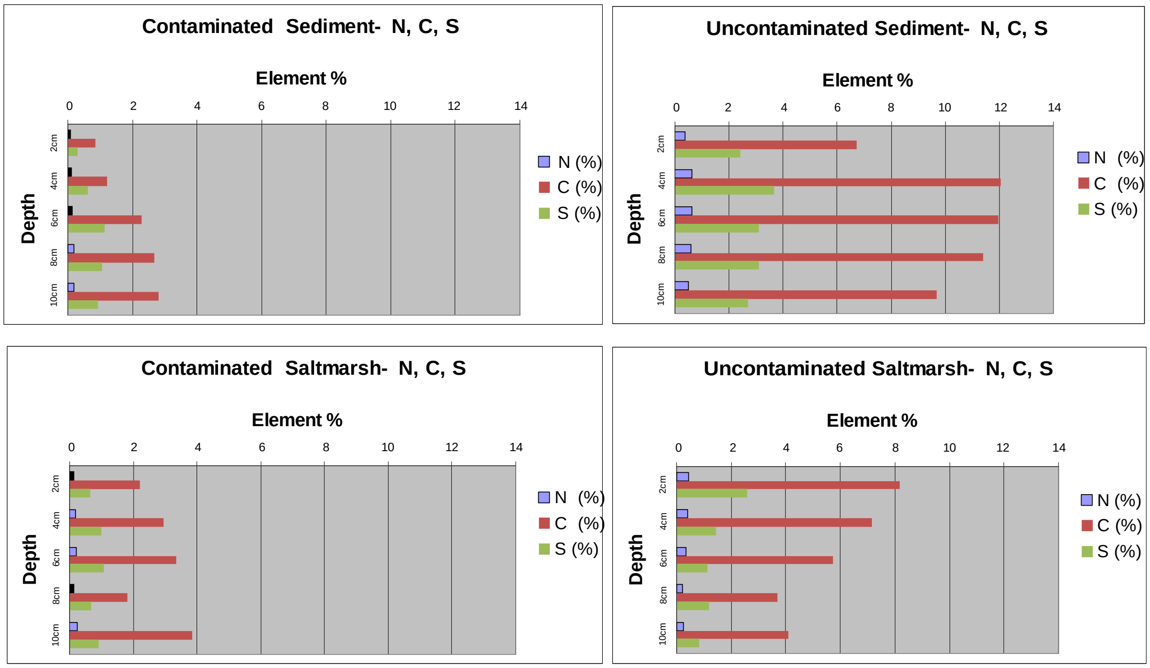
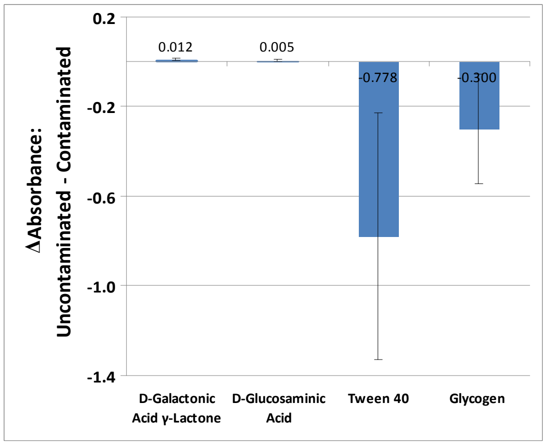


Figure 1. CNS analysis for contaminated and uncontaminated sediment and saltmarsh locations.

Table 2. Average Water Color Development (AWCD) in aerobic microbial communities for each site during the October and November sampling trips.

	Contaminated Saltmarsh	Contaminated Sediment	Uncontaminated Saltmarsh	Uncontaminated Sediment
OCT	0.214	0.289	0.075	0.606
NOV	0.235	0.054	0.080	0.142



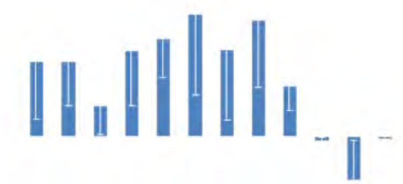
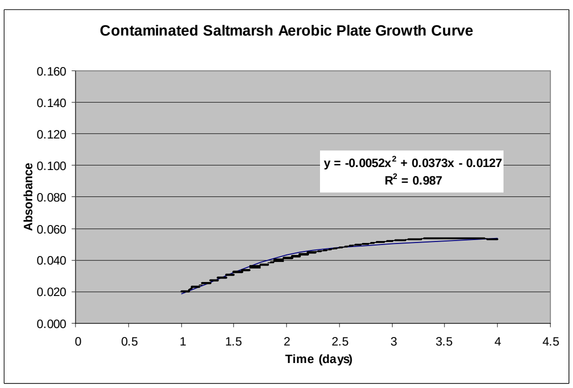


Figure 2. Microbial analyses attempt to form linkages with remote sensing analyses. Here, we see different responses of microbial metabolism to petroleum contamination in marshes (left), versus unvegetated sediments (right) at the Marsh Point, MS. These data represent the relative differences in microbial metabolism of different carbon sources, wherein positive values indicate higher rates in uncontaminated sites.



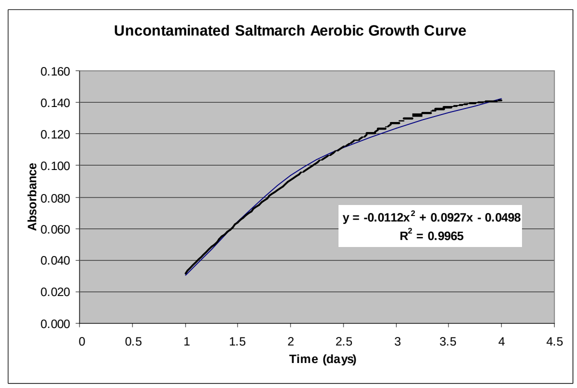


Figure 3. Aerobic microbial community growth rate curves for contaminated and uncontaminated saltmarsh sediment. Notice the much higher growth rate curve for the uncontaminated sediment.

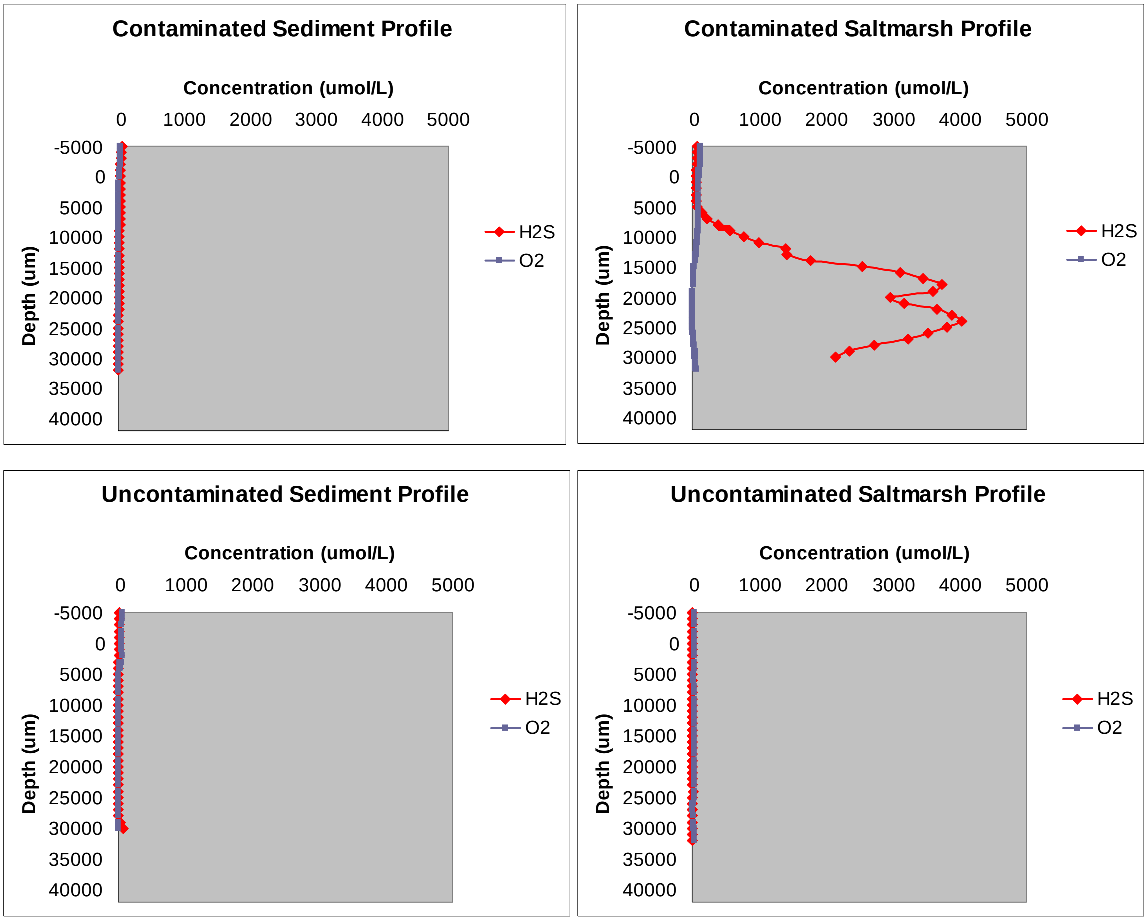


Figure 4. October, 2010 oxygen and sulfide profiles for contaminated and uncontaminated sediment devoid of saltmarsh and sediment at the saltmarsh rhizosphere. Notice that the contaminated saltmarsh profile is much higher than the other locations.

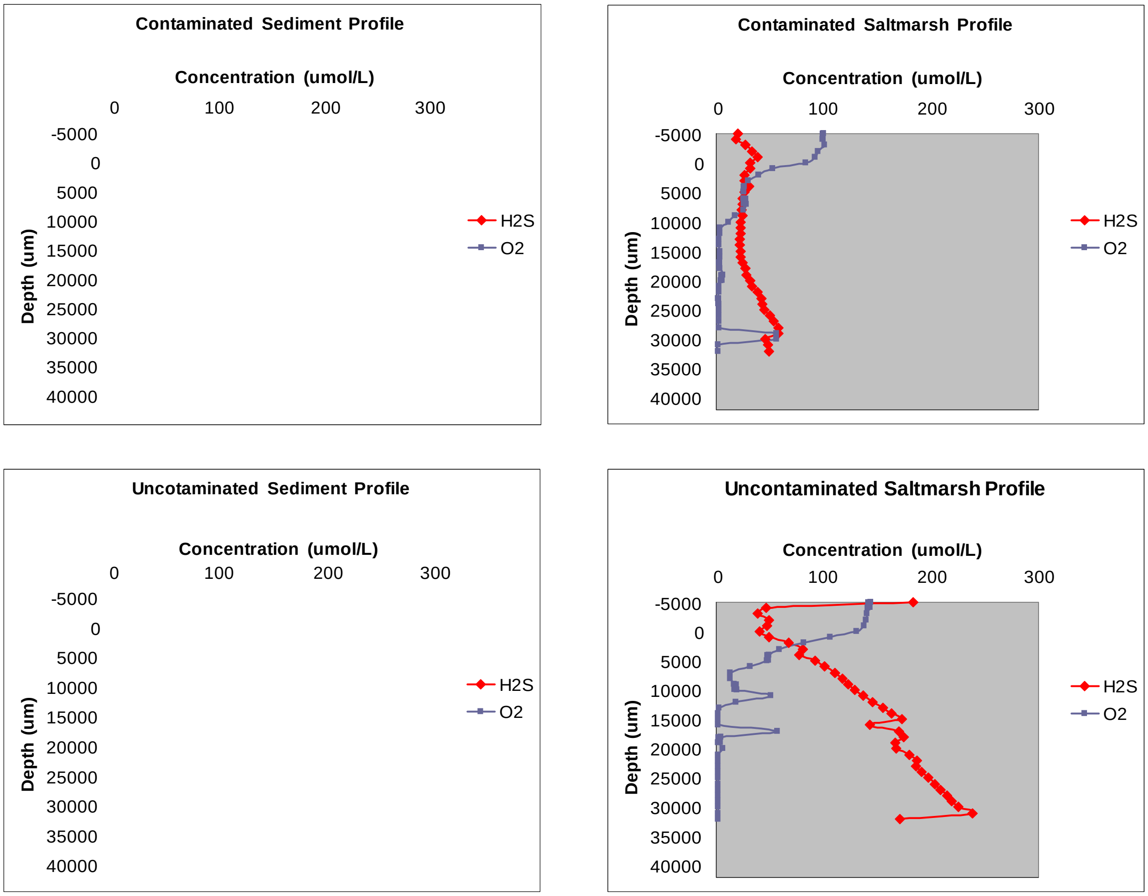


Figure 5. November, 2010 oxygen and sulfide profiles for contaminated and uncontaminated sediment devoid of saltmarsh and sediment at the saltmarsh rhizosphere. Notice that all locations seem relatively similar.

Figure 6. Photographs of field locations and sample collections at Marsh Island, MS.

Summary of Findings:

- Significant increases in sulfide concentrations (~4000 µM) were detected in salt marsh contaminated sediment as compared to contaminated sediment (no salt marsh, ~55 µM) and non-contaminated sediment (30-60 µM, salt marsh and no salt marsh) in October measurements. Sedimentary sulfide has been shown to impact above ground biomass and health and therefore, high sulfide concentrations may increase marshland die-back.
- However, few differences between sites were observed in the November sampling trip indicating that seasonality impacts on saltmarsh growth may be important to consider when determining the role of oil in these regions (e.g., temperatures from October to November were different, impacting the growth of the saltmarsh and potentially the anaerobic metabolism responsible for producing sulfide).
- Total CNS was greater in non-contaminated sediments. It is unclear as to whether the variability between C,N, and S of contaminated and uncontaminated sediments, is part of the natural heterogeneity of these sediments, or due to the contamination.
- Aerobic microbial communities at the non-contaminated sediment location had greater activity and abundance indicating the dominance of aerobic processes at non-contaminated locations, where significant ($p<0.05$) differences were measured. This result indicates an oxygen rich environment prevails in which the microbial community has not de-voided the available O_2.
- The impact of oil contamination also appears to impact the microbial metabolism of different carbon sources and the growth curves of these populations.

- Seasonality, tidal impacts, saltmarsh growth, and sediment heterogeneity strongly influence sediments and further study must take place on a much larger scale in order to determine the overall impact of the oil contamination on the sediment geochemistry, microbial community, and saltmarsh health.
- Future work will include the combination of the geochemical data presented here along with the remote sensing data collected from contaminated and non-contaminated saltmarsh. These efforts to begin in phase II will attempt to determine the impact of the degradation of organic carbon from the spilled oil, the resulting increased H_2S production, and the impact on the biomass and health of the saltmarsh ecosystems along the Gulf coast.
- Further work, specifically in regard to total hydrocarbon analysis is needed to better determine the amount of oil contamination in this area and the potential impacts, as well as the collection of sediments at more locales to confirm these preliminary results. These needs will also be addressed in phase II activities.

Attachment D: Integrated Assessment of Oil Spill – Task D. Technology and Data Integration

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General focus of this task area:

This task makes the results of Tasks A, B, and C accessible and understandable and builds a foundation for future research by providing a platform and mechanism for integration of results.

Period of Performance of Research:
Start: June 16, 2010
End: December 31, 2010

Contents

Executive Summary:

The focus of this task was to take data collected and generated by Tasks A-C and make those data accessible. We used the Sulis[1] toolkit for this purpose. There were three subtasks for Task D, D1 – Data and Metadata, D2 – Extend the Sulis toolkit, and D3 – conduct the Ecological Model Development Workshop. In task D1, we used an Oracle database and developed a new database schema to store both collected and model generated data. We also associated metadata with the data. In task D2, we extended the Sulis toolkit by developing a web interface that provides access to the data in the database, and uses both 2D GIS and 3D visualization to present the data to decision makers. Subtask D3 was a workshop on Ecological Model development, and the results of that workshop are summarized below.

Subtask D1. Data and Metadata

Metadata was written for data collected and generated by Tasks A-C, using the National Coastal Data Development Center's (NCDDC) Metadata Enterprise Resource Management Aid (MERMAid). MERMAid is a web-based tool which allows for the development and management of Federal Geographic Data Committee (FGDC) compliant metadata. As data collection is completed, the metadata will be submitted to the NCDDC for validation and publication. Once the metadata is validated and published, the metadata records will be harvested by the Geospatial One-Stop. The Geospatial One-Stop is a Geoportal where information can be stored, retrieved and exchanged by querying a published metadata record for dissemination of information across a wide range of research topics. Figure D1 is an example of metadata data written for Task A. Tasks B and C metadata follows the same FGDC format.

[1] The Sulis decision support system is described by McAnally, et al., 2010. Sulis: A Framework for Healthy Watersheds, Healthy Oceans, Healthy Ecosystems, Northern Gulf Institute, Stennis Space Center, Mississippi. Sulis was the Celtic goddess of wisdom.

Oil Spill Modeling for Tropical Weather Events Along the Gulf 2010, Northern Gulf Institute, MSU, MS

Metadata:

- Identification Information
- Data Quality Information
- Entity and Attribute Information
- Distribution Information
- Metadata Reference Information

Identification_Information:
Citation:
Citation_Information:
Originator:
Dr. Patrick Fitzpatrick
Publication_Date:
Unpublished material
Title:
Oil Spill Modeling for Tropical Weather Events Along the Gulf 2010, Northern Gulf Institute, MSU, MS
Geospatial_Data_Presentation_Form:
model
Publication_Information:
Publication_Place:
Northern Gulf Institute, Mississippi State University
Publisher:
Northern Gulf Institute
Description:
Abstract:
The simulation is based on a Lagrangian particle tracker with random walk diffusion model. Input consists of latitude and longitude positions of parcels in the oil contaminated area, wind, current, and a large array of random numbers. In addition, new parcels are released at the location of the damaged Macondo rig. Twenty-five parcels are released at each position, and when combined with the diffusion coefficient (set to 10m2/s) results in a natural spread of the parcels with time. The parcel location is based on NASA MODIS satellite imagery, SAR imagery and NOAA oil trajectory maps. The parcels are advected at 80% of the ocean current speed and at 3% of the wind speed. Bilinear interpolation is applied at each timestep to determine the currents and winds at each parcel position. The pseudo-random numbers are uniformly distributed between 0 and 1 and generated by the efficient Mersenne Twister algorithm. The 10-m wind and near-surface ocean currents are provided from an operational, data assimilating forecast system run by the Naval Oceanographic Office called the Navy Coastal Ocean Model (NCOM) in the Intra-Americas Sea domain which covers the Gulf of Mexico and the Caribbean, interpolated to a 3-km Cartesian grid. NCOM assimilates water temperature, salinity analyses, and satellite altimeter data, and the Coupled Ocean-Atmosphere Prediction System (COAMPS) provides the atmospheric forcing. An examination of NCOM data and the oil spill simulation, as well as in-situ data from buoys, weather reanalysis maps, tide gauge data, scatterometer data, and HF radar show that two weather systems altered the currents and water levels such that oil was pushed into the western Mississippi Sound and the Rigolets. An easterly wind fetch from intensifying Hurricane Alex provided the first inland push, followed by a westward-drifting non-tropical low which had formed off the western edge of a Gulf cold front. In both cases, a generally weak pressure gradient was replaced by strong easterly winds which not only switched westerly coastal currents to an easterly direction, but also increased inland water levels by 0.6-0.8 m. These results show that cyclones located west of the oil spill can dramatically alter oil transport.
Purpose:
The Deepwater Horizon oil spill impacted the Mississippi River Delta, Barataria Bay, the barrier islands east of Louisiana, and the Alabama and Florida coast for an extended period of time from May through July. However, the Rigolets and western Mississippi coast were impacted for a briefer period from late June to early July. An important component to understanding the oil transport is to distinguish the influences behind this apex moment. A simulation was conducted for the period 20 June to 10 July 2010 to understand this inland transport.
Supplemental_Information:
NASA MODIS satellite imagery, SAR imagery from http://www.cstars.miami.edu NOAA oil trajectory maps from http://response.restoration.noaa.gov/ NCOMAMESEAS data from http://edac-dap.northerngulfinstitute.org/thredds/catalog/ncom/amseas/catalog.html
Time_Period_of_Content:
Time_Period_Information:
Range_of_Dates/Times:

Figure D1: Task A metadata.

For data stored in the relational database we used the following data schema:

	A	B	C	D	E	F
1	**METADATA Structure**					
2	**Column Name**	**Type**	**Nulls Allowed**			
3						
4	CODE	NUMBER	No			
5	PROJECT_GRP	NUMBER	No			
6	**ORIGIN**	**VARCHAR2(50 CHAR)**	**No**			
7	**TITLE**	**VARCHAR2(2000 CHAR)**	**No**			
8	DATA_DATE	DATE	No			
9	DB_DATE	DATE	No			
10	ABSTRACT	VARCHAR2(4000 CHAR)	No			
11	PURPOSE	VARCHAR2(4000 BYTE)	No			
12	LOCATION	VARCHAR2(500 CHAR)	No			
13	METADATA	VARCHAR2(500 CHAR)	No			
14	NWLAT	NUMBER	No	31		
15	NWLON	NUMBER	No	-92		
16	NELAT	NUMBER	No	31		
17	NELON	NUMBER	No	-85		
18	SELAT	NUMBER	No	26		
19	SELON	NUMBER	No	-85		
20	SWLAT	NUMBER	No	26		
21	SWLON	NUMBER	No	-92		
22	DATA_CATEGORY	NUMBER	No			
23	STUDY_GROUP	NUMBER	No			
24	SERVICE_URL	VARCHAR2(500 BYTE)	Yes			
25	ATTRIBUTE_TYPE	NUMBER	Yes			
26	I_DIMENSION	NUMBER	Yes			
27	J_DIMENSION	NUMBER	Yes			
28	K_DIMENSION	VARCHAR2(20 BYTE)	Yes			
29						
30	**DATA_FORM**					
31	**Code**	**Description**				
32	2	Raster Digital				
33	3	Vector Digital				
34						
35	**DETAIL_FORM**					
36	**Code**	**Description**	**Detail Type**	**Data Form**		
37	1	image	jpeg	2		
38	3	image	gif	2		
39	4	image	png	2		

Subtask D2. Extend Sulis Toolkit

We extended the Sulis toolkit (See FigureD1 below) to encompass products ofTasks A, B, and C. Sulis is a decision supp01t system and toolkit with the purpose of providing users ready access to environmental and natural resources information in a useful form to better understand aquascapes (a complete hydrologic footprint, including a watershed – an area of the earth's surface from which water flows downhill to a single outflow point – plus the water-spread – the coastal and ocean area over which the watershed's flow spreads and ocean forcings affect coastal and upstream waters) and their processes, to evaluate the probable consequences of coastal hazards and management decisions, and to make informed decisions with a holistic perspective. Sulis employs a modular technology, in which individual models can be replaced by others as models evolve and user needs change. As such, it is not a model itself, but a collection of data sources – observations and models (presently hydrologic and hydraulic models) -- from which results can be extracted, viewed, and analyzed.

Tasks A-C include measured data from collection efforts and modeled data generated by numerical models. These data will be collected and cataloged in a single location for further review and analysis. Additionally, much of these data require 2D and 3D visualization for thorough analysis. Task D2 provided 2D visualization through the use of GIS technology and 3D visualization (see examples Figure D2 below) through the use of scientific visualization technology, delivered through Sulis.

Expansion of the Sulis decision support toolkit included the development of a data repository framework for modeled, measured, and analytical products. This repository framework can be thought of as a container for various arrays of data and products that would allow for more informed decisions by managers and agencies. The repository was built on an Oracle relational database management system (RDMS) that utilized an expanded form of Federal Geographic Data Committee (FGDC) compliant metadata. A user can drill down through various types of data based on queried information contained within the metadata (i.e. data type, region of interest, date range, or keywords) via the web interface (Figure D1a). Full metadata information of the queried data can be viewed prior to downloading the specific data set. Additionally data, dependent upon type, may be displayed within the web interface of the repository (Figure D1b).

Figure D1a: Sulis data repository interface with query result for multiple search criteria.

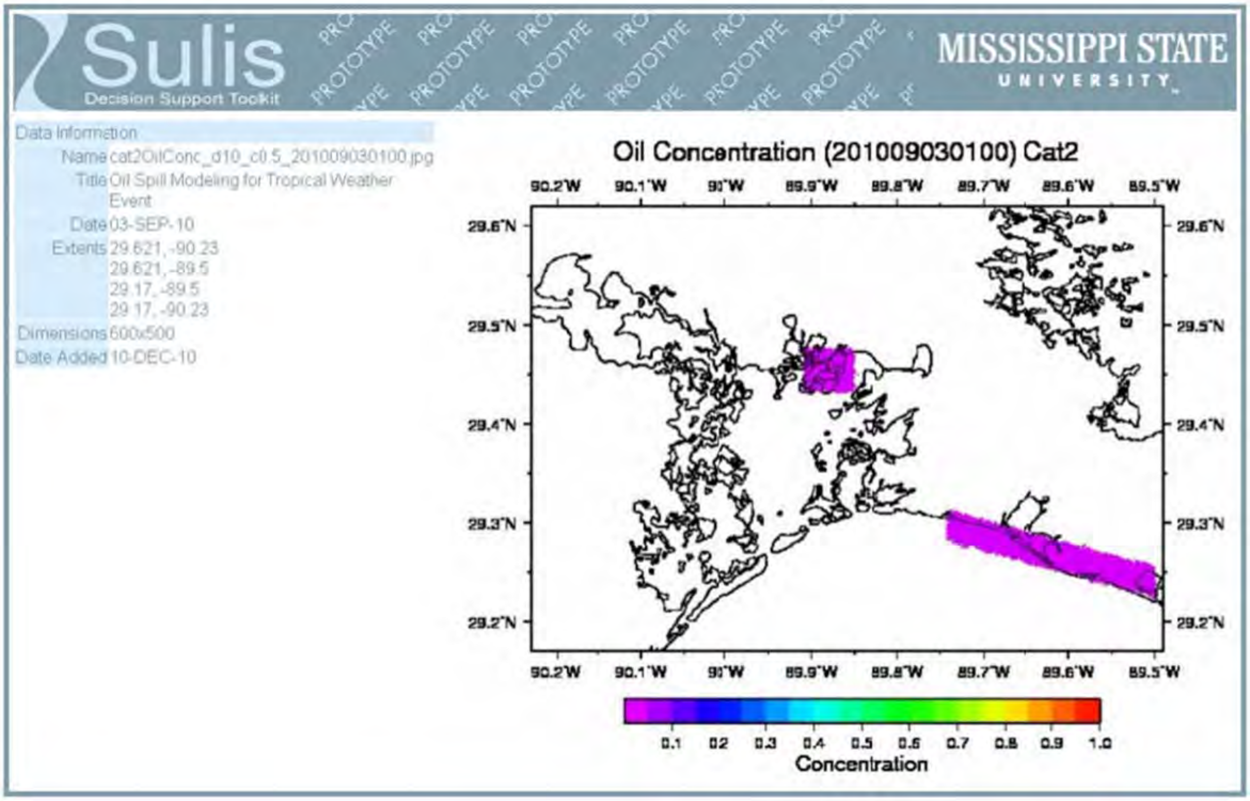


Figure D1b: Detailed data information window for selected data for oil spill concentration modeling during a tropical weather event.

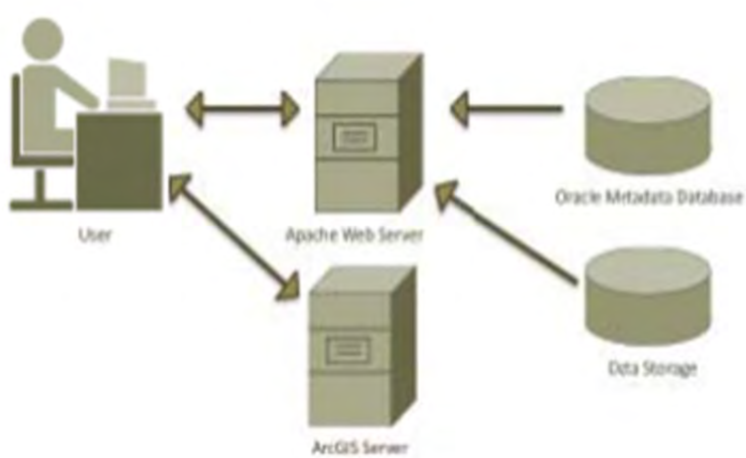


Figure D1c: Network diagram showing relationship between web server, metadata database, and data storage.

Data access for users was increased by generating Open Geospatial Compliant (OCG) services available, as well as standard ESRI map services, for applicable data. This allows for the creation of online viewers for user analysis and visualization (two-dimensional). Current viewers are built with the ESRI ArcGIS API for Flex, allowing users to interact with data with minimal computational requirements or expensive commercial software. Additionally users with more robust technical capabilities may ingest the mapping services for analysis with locally stored data via their GIS software. Sulis map viewers not only utilize services from data within the repository, the viewers also include data from additional map service providers (i.e. NOAA, ESRI, etc…). This allows for data from multiple agencies and sources to be at the finger-tips of a decision maker in the face of an emergency without costly amounts of time lost as they wait for a technology specialist to acquire and assemble data. Figure D2 provides a viewer snapshot of data from field surveys performed by Shoreline Cleanup Assessment Techniques (SCAT) teams with submerged aquatic vegetation (SAV) data for Ship Island in the Mississippi Sound (Figure D2a) and the Chandeleur Sound (Figure D2b).

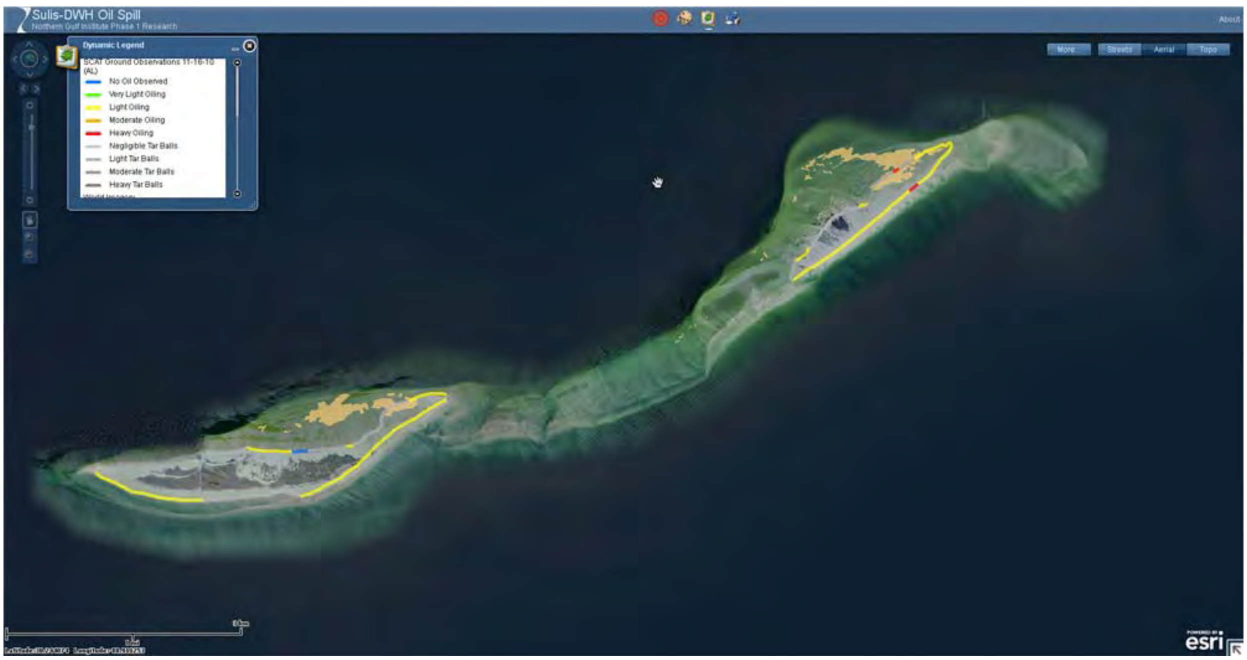


Figure D2ba: Screen shots of the Sulis viewer built with the ESRI ArcGIS FlexViewer and API showing SCAT and SAV data for Ship Island in the Mississippi Sound.

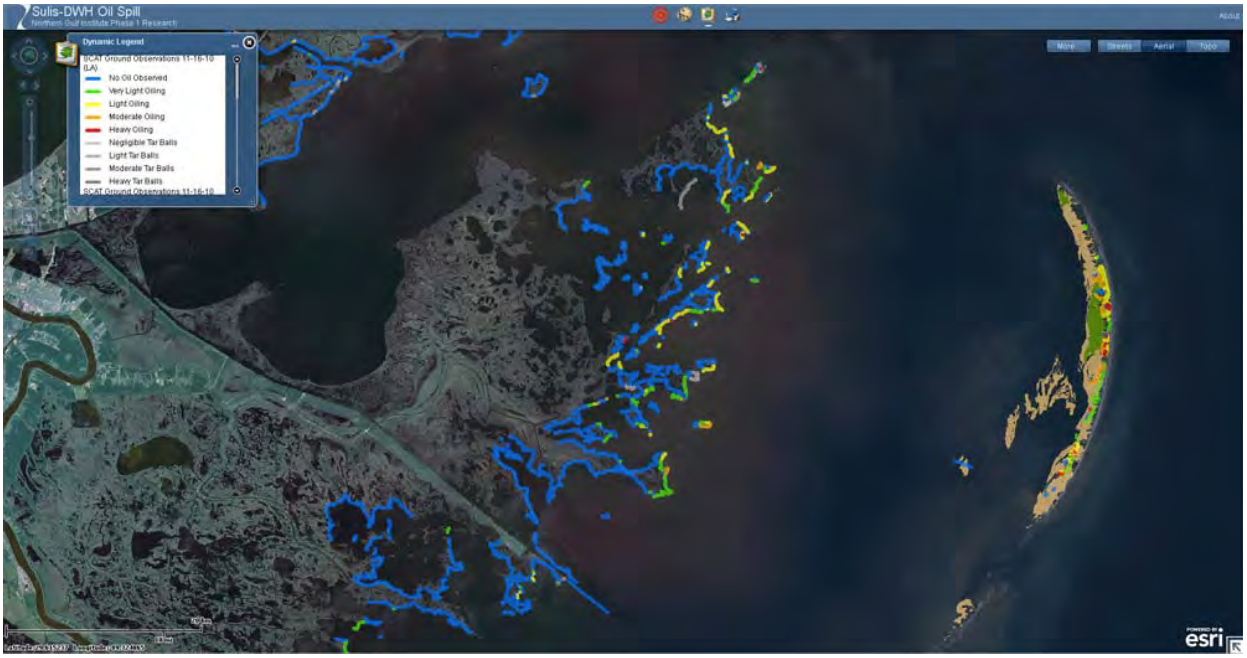


Figure D2b: Screen shots of the Sulis viewer built with the ESRI ArcGIS FlexViewer and API showing SCAT and SAV data for the Chandeleur Sound.

Subtask D3. Ecological Model Development Workshop

The workshop was convened as a starting point for the development of a conceptual ecological model built from existing efforts and mapping the path for an Integrated Ecosystem Assessment (IEA) of the north central Gulf of Mexico. The conceptual model will be used to design a quantitative model based on an energy transfer framework and will be used as a module for a larger Earth Systems Model comprising physical, biological, and social-economic parts.

The workshop was held January 26-27, 2011, at the Gulf Coast Research Laboratory in Ocean Springs, MS and was attended by 43 people from a variety of agencies and backgrounds; nearly all of which are involved in some form of quantitative modeling of living systems. The intent of the workshop was to benefit from the collective experience of the attendees, as well as the core modeling group, to acquire expert input on what needs to go into a general ecological model of a coastal watershed prior to addressing a particular question(s). The workshop's emphasis on discussions by the modeler attendees pulled the focus away from addressing particular ecological issues and directed the workshop towards identifying practical issues of model development such as the model framework, temporal/spatial scale, model complexity, model linking, and computational logistics. The workshop was organized around four small group breakout sessions and the following summary is organized around the questions addressed during these sessions as well as the large group discussions that followed each one.

Breakout 1-Functional/Modular Approach

Breakout session one was intended to discuss a conceptual model framework. For purposes of discussion: the model framework includes functional groups, how they are connected to one another, and how they are connected to input data. We asked the groups to comment on the use of energy transfer as a core model currency and the potential use of 'off the shelf' software such as ECOPATH/ECOSIM and Atlantis for our stated purposes.

Overall, this initial discussion was dominated by the need to identify a specific question and scope from which the conceptual model framework should be discussed. With the vast number questions and scales that could be addressed by the overall model, the group decided to focus on a modular or group of models approach for the rest of the workshop discussions to eliminate perspective complications. The functional groups suggested for modular development were predictable (trophic boxes), but it was also suggested the model be flexible in that shutting boxes on and off be a possibility. One breakout group focused on end user groups as a driving feature of model structure and this facilitated a discussion on whether the model could be 'turned over' to end users with some guidance. Ultimately this question was left open, but the general feeling was that this rarely happens and it is more likely that the model is designed to generate a pre-determined output for digestion by users. An additional discussion point was the need for a developed model inventory for the system in question (i.e., north central Gulf of Mexico) to provide working material for modules. One participant allowed that there is such an inventory of water quality models available from the Gulf of Mexico Alliance (GOMA). A more comprehensive list of multiple model types (e.g. hydrodynamic, water quality, food web, population dynamics, ecological) would be very helpful. Canned modeling tools were discouraged, as this activity may transcend most of them in complexity, although Atlantis was posited as the most promising modeling platform for the project.

Breakout 2 – Scale

The second breakout session was held at the end of Day 1 and addressed the question of the appropriate temporal and spatial scale for the model. Participants were asked to comment on three broad questions: temporal scale and appropriate time-step, spatial resolution and extent, and the use of a watershed level comparative approach (three watersheds) in model development. The overall consensus was that scale will ultimately depend on the question and on the data. We can identify a working scale initially based on a consensus, but this should remain flexible, as it will likely change as the problem develops or changes. Initial scales suggested were a 20-50 year horizon run at an hourly to daily time-step (fish centric). Spatial extent is currently defined by watershed boundaries with recommended horizontal resolution of 1 km and vertical resolution of 1 m. There was a discussion of hydrodynamic conditions and how boundary conditions may drive the scale question. The need for a model inventory was again brought up at this point to reiterate the benefit of utilizing existing models.

Breakout 3 – Input data

The intent of this session was to explore ideas for input to a general model in terms of 'variables that have to be there' vs. 'question specific ones.' The overall response to this discussion was that 'it depends on the question.' However, it was suggested that questions be developed for each watershed (Barataria Bay, Mississippi Sound, Perdido Bay) allowing for more generality in the use of the model while maintaining comparability. Participants also suggested some strategies for converting IEA drivers into model parameters, noting that all drivers should not be model input. It was decided that a more focused approach be taken, and that a pre-analysis may be necessary to identify those drivers in the model and those not considered, but that may be important.

Breakout 4 – Output data

The intent of the final breakout discussion was a consideration of model output. The desire was to consider the model output that would be most useful for comparing across systems AND for linking models together. In some sense this reiterated the 'Input discussion' once again, but there were also specific issues that were considered such as the model output specific to the oil spill. Mainly the discussion within the groups continued along similar lines but several specific suggestions focusing on outputs were made. Links to socio-economic models should be emphasized for crossover appeal and to facilitate the Earth Systems Model framework presented in the introductory presentation.

Key points of the workshop

1) Canned software (even Atlantis) may not do what we want in the long run, but working from scratch may take too long. Consider an amalgam of existing models, such as linked sub- modules.
2) It depends….on the question, on the model, on the use of prior work i)
   We need the model inventory
   ii) We need to flush out some key questions iii)
   We need to map out a modular approach
3) Scale is not fixed and may change across the sub-modules
   i) This is a flexible approach but will require careful examination of feedback mechanisms that cross scales
   ii) Map out functional groups based on relevant scales
   iii) Make maximum use of optimal model approach for each scale (e.g., NPZ model for plankton, MSBio model for inverts and fish)
4) Input –Output variables need to be mapped out for three separate purposes a)
   Address specific questions
   b) Compare outcomes among sites
   c) Allow for linkage between models
5) We should make maximum use of the IEA report, BUT hone it down to a suite of variables we can address and a suite of variables we cannot address (Prioritize)
6) Another important point to add is the need for our models to provide managers with real answers to their questions/problems

Attachment E: Innovations: Interim Status Report

October 1, 2010

This short report summarizes the progress and next steps associated with Task E Innovations component of the GRI/PI project. Specific subtasks included:

1. Subtask E1: Effect of surface oil on Gulf water temperatures (and thus hurricane strengths) (Valentine Anatharaj/Patrick Fitzpatrick)
2. Subtask E2: Use of innovative remote sensing technology to increase oil-spotting accuracy (Robert Ryan/Haibo Yao)
3. Subtask E3: Cleanup Technology
    a. Subtask E3A: Use of wood shavings as clean-up medium (Rubin Smulsky)
    b. Subtask E3B: Supercritical Fluid Extraction of PAH's from Soil and Sand (Ashli Brown)

Subtask E1. Effect of Spill on Gulf Water Temperatures

Project Summary:

Oil on the surface of the water modify some of the physical characteristics of the water surface (particularly surface reflectance, color & fluorescence, albedo, surface emissivity and surface roughness) that are important properties than influence the radiometric measurements from air and space-borne sensors. Hence, these anomalies in the surface properties (due to oil) may introduce further uncertainties in the SST estimates that are (indirectly) derived from radiometric measurements. Proper knowledge and understanding spatial and temporal distribution of SST are vital for many weather, climate and environmental applications, including hurricane predictions, numerical weather prediction (NWP), seasonal forecasting, and ecosystem assessments & monitoring. SST is one of the important forcing variables in NWP where an accurate prescription of SST is important for the proper portioning of energy & moisture fluxes across the ocean-atmosphere interface. Besides, SST is also assimilated into ocean forecasting systems in order to determine the variability of the mixed layer and constrain the circulation of the upper ocean. In fact, the international Global Ocean Data Assimilation Experiment (GODAE) has determined that a level of accuracy of 0.4 K to be the tolerable limit in estimation errors of SST for numerical modeling purposes. Currently, *in-situ* measurements of SST do not provide the spatial and temporal distributions necessary for numerical modeling. Satellite remote sensing is the only viable alternative for meeting these requirements. Hence, it is imperative to understand and characterize the uncertainties in satellite-derived SST estimates. We will use the GODAE High Resolution SST (GHRSST) products investigate the impacts of the DWH oil spill on the additional uncertainties introduced in the operational SST products.

Science Questions:

(1) What are the uncertainties (due to oil in the oceanic surface layer) in sea surface temperature (SST) estimates derived from satellite remote sensing techniques?

(2) How does oil in the surface layer impact surface evaporation rates?

(3) What are the changes in the diurnal variability in the oceanic mixed layer?

(4) What are the implications for numerical prediction (atmospheric & oceanic) and hurricane predictions (intensity)? [Items 2-4 are to be addressed in Phase 2.]

Progress:

- Our initial approach is to examine the anomalies in the monthly mean values and try and correlate the anomalies with area of contamination.
- The SST data are being obtained from a number of sources. For the initial analysis we are using the 4 micron channel data from MODIS (see figure).
- We will then compute the monthly climatology for the area(s) of interest based on nearly 10 years of MODIS SST observations.
- We have also contacted Dr. Lakshmi Kantha regarding the use of his ocean mixed-layer model to understand the diurnal variability of the temperatures.

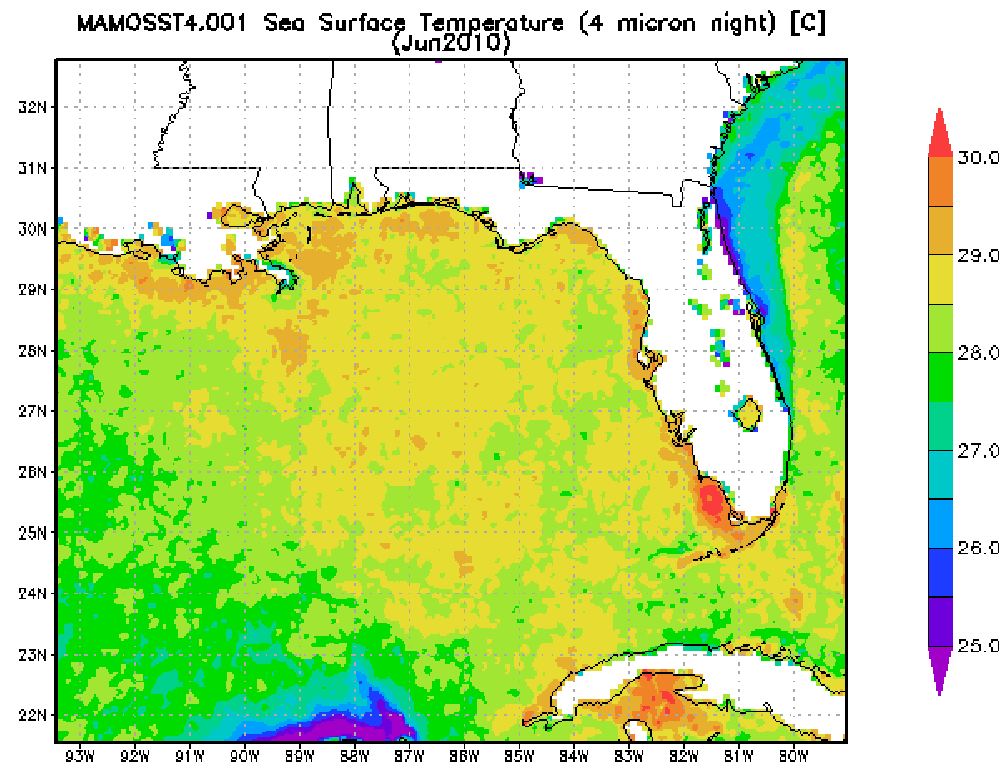
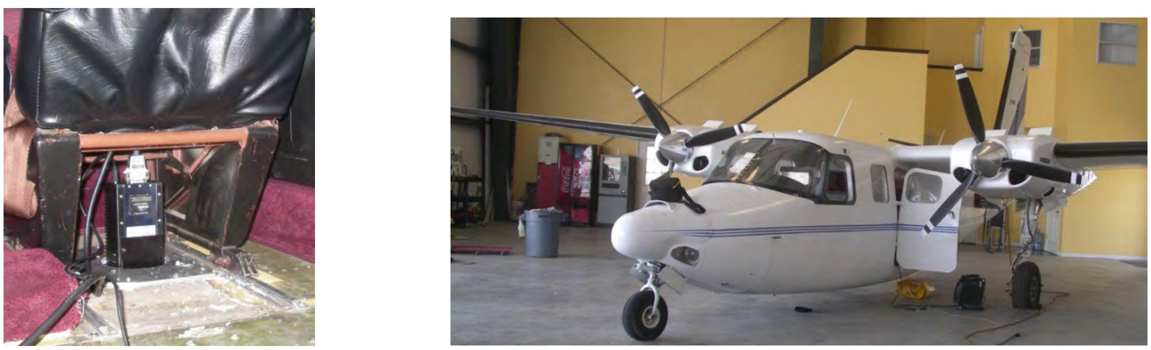


Figure E1.1 MODIS Sea Surface Temperature

Subtask E2 Remote Sensing

Project Summary:

During the Deep Water Horizon event, the ASPECT (Airborne Spectral Photometric Environmental Collection Technology) system was deployed primarily out of Gulfport Airport. The ASPECT sensor suite typically includes a passive Fourier Transform Infrared (FTIR) spectrometer, a long wave 16 band multispectral infrared (MSIR) scanner and a radiological sensor. The FTIR system was used to detect and identify potentially hazardous gas emissions from the crude oil and the oil fires used to reduce the surface oil. The MSIR scanner was found to be an excellent tool for detecting oil and was routinely used to direct oil skimmers. Detecting oil reliability to organize the skimming efforts is a challenging activity. The MSU Geosystems Research Institute Optics group at the Stennis Space Center supported the EPA ASPECT team by supplying a modified (telescope, software and mounting) hyperspectral visible-near infrared (VNIR 400-800 nm) imager to augment the infrared imaging technology being used by the EPA (Figure E.2.1). When the oil is floating on the water, the MSIRLS works well but it cannot detect the oil, if the oil is a mm or less beneath the surface (water is opaque in the infrared). Hyperspectral VNIR data penetrates the water surface and could increase the probability of detection and reduce false alarm rates for oil.



A B

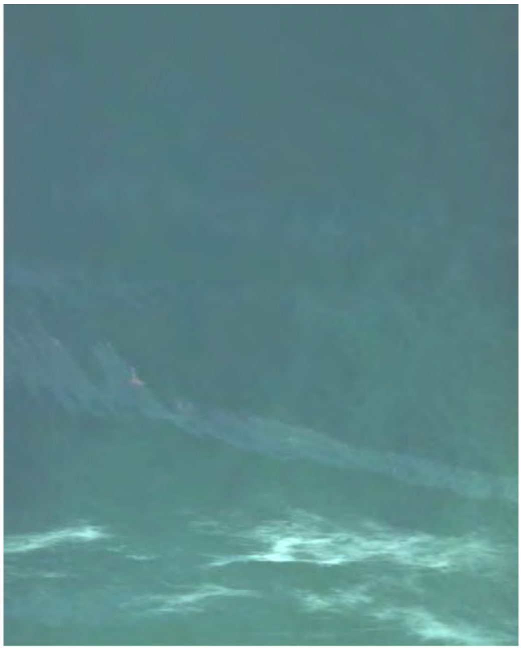
FigureE2. 1. Imaging system setup on the airplane (A);
Aero Commander plane for the survey missions (B)

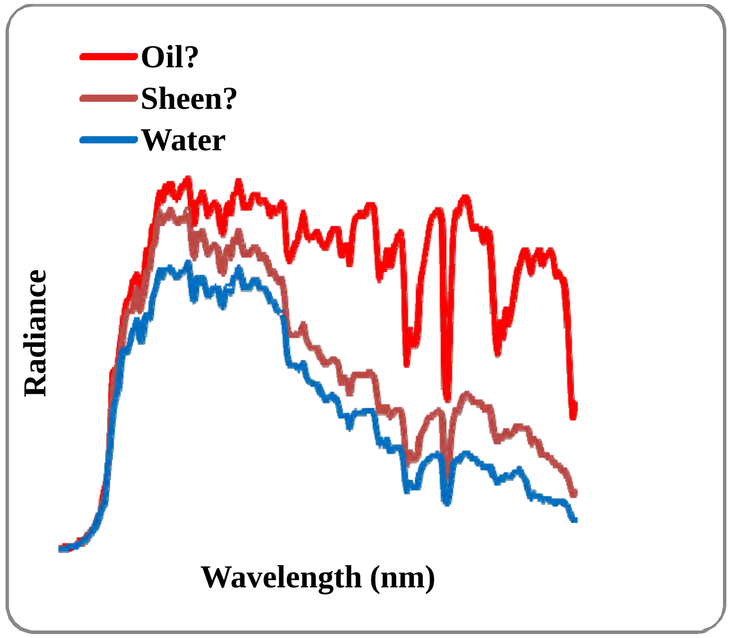
Progress:

- Radiometrically and spectrally calibrated the modified MSU hyperspectral imager
- Developed software to rapidly calibrate data display spectra
- Examined imagery taken and determined some of the oil spills identified by other RS methods were probably sea weed (Figures E.2.2. and E.2.3)
- Developed a poster of results and presented at Ocean Optics Conference (September 27-30, 2010) (See Appendix 1 for Poster)

Future work:

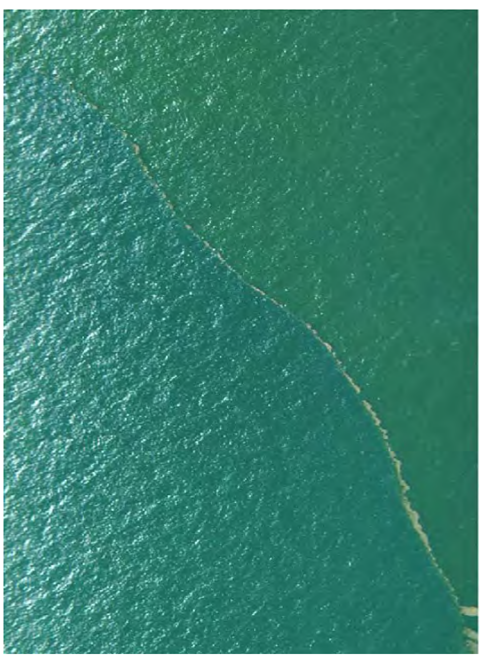
- Examine data fusion algorithms with thermal data to determine if we can improve our detection and reduce false alarms

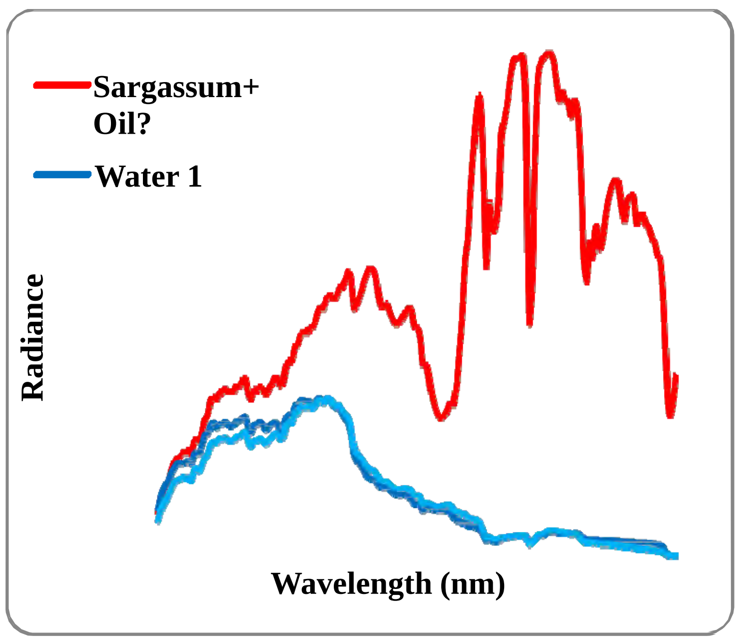




A B

Figure E2.2 A: RGB composite image of the airborne hyperspectral data over possible oil spill; B: Reflectance from water and possible oil slick. The image was taken on 07/23/2010 at 8:34 am CST





A B

Figure E2.3. A: RGB composite image of the airborne hyperspectral data over possible oil spill; B: Reflectance from water and possible sargassum. The image was taken on 07/26/2010 at 10:07am

Subtask E3. Cleanup Technology: Subtask E3A Supercritical Fluid Extraction of PAH's from Soil and Sand

Project Personnel:

PI's: Drs. Ashli Brown and Darrell Sparks, Department of Biochemistry and Molecular Biology; Collaborators: Dr. Rafael Hernandez, Dave C. Swalm School of Chemical Engineering and Dr. Kevin Armbrust, Mississippi State Chemical Laboratory

Current methods for preparing seafood tissue samples for analysis take approximately two days. Therefore, a need exists for a rapid sample preparation method that can aid in quickly determining contamination levels. Currently accepted methods typically utilize either accelerated solvent extraction (ASE) with methylene chloride/acetone or KOH digestion/extraction. Before analysis, the extract is further purified by solid-phase extraction with silica-alumina, which separates lipids from the PAH's.

We are currently investigating the efficacy of utilizing supercritical carbon dioxide with a methanol modifier to extract PAH's in seafood, sand, and soil. Based upon differences in solubility between PAH's and lipids, it could be possible to extract the PAH's and eliminate the solid-phase extraction step. Besides enhancing sample preparation speed, this method would replace the chlorinated solvent methylene chloride with carbon dioxide, a "green" processing media.

Mississippi State Chemical Laboratory (MSCL), one of the primary regulatory testing facilities in Mississippi. The proposed research will greatly enhance the efficiency and accuracy of the regulatory testing sector. MSCL has already received hundreds of oil-spill samples to be tested for PAH's to ensure food and environmental safety. As the spill continues and clean-up begins, the development and implementation of inexpensive, environmentally friendly, rapid, and reliable testing is essential for the fishing industry as well as the general public.

Purchased Items:

1. Pump Maintenance Kit for Supercritical Fluid Extractor: $674.99 (Waters).
2. Deuterated Internal PAH Standards for Analysis: $338.43(Cambridge Isotopes).
3. External PAH Standards for Spiking and Analysis: $201.90 (Sigma Aldrich).

Student Workers Hired:

Ashley Meredith (Senior) Biochemistry
Brigitte Martin (Junior) Biochemistry
William Ford (Sophomore) Biochemistry

Progress:

We have replaced the seals and performed routine maintenance on the Supercritical Fluid Extractor.
The student workers have begun their training for the operation of the Extractor and we have optimized the GC/MS analytical detection methods. Below are the chromatograms for the external PAH standards (Fig E3A.1) and the deuterated internal PAH standard (Fig E3A.2).

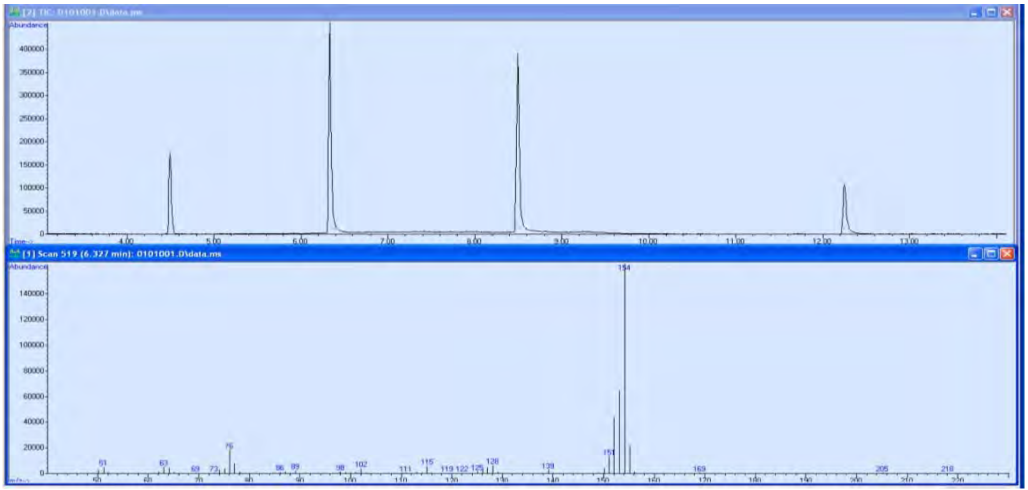


Figure E3A.1: Total Ion Chromatogram of Performance Test Mix on GC/MS showing Spectra of one of the PAH's.

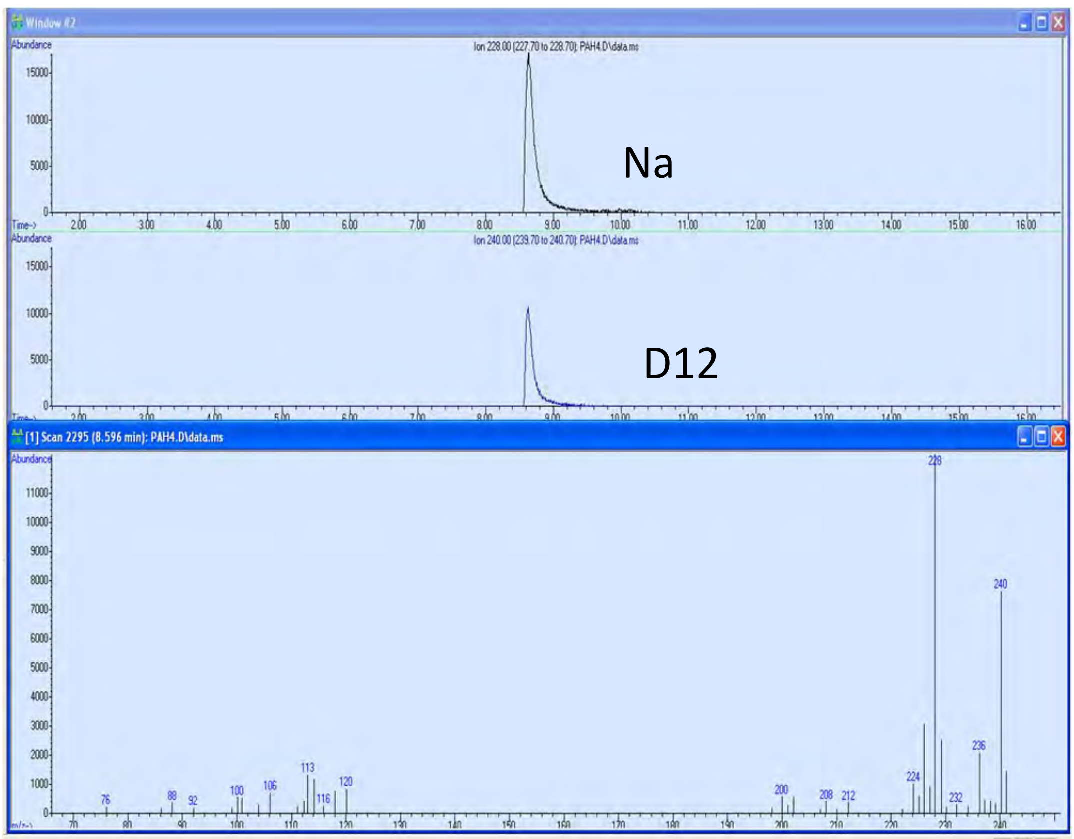


Figure E3A.2: Ion chromatogram and mass spectral fragmentation to show the use of deuterium labeled PAH's for quality control and measurement.

<u>Subtask E3C</u> Use of wood shavings as clean-up medium

Project Summary:

Weeks of cooperative preliminary efforts between MSU and the regional forest products industry, followed by a week of on the ground and water experience has insight regarding opportunities for MSU to provide expertise in addressing and remediating the oil spill and for the forest products industry to assist with rapid and immediate cleanup.

Numerous resources are focused on removal of offshore and landed oil. Cleanup areas include environmentally sensitive marshes and coastal passes. There appears to be at least two different types of oil. One is very light, floats, and can be skimmed from the water. BP has contracted with many small boat operators who are working steadily to clean up and disperse this type of oil. The second type is much thicker and heavier. It travels with the tide into the recesses of the marsh and appears around islands in remote marsh bays. Spotter planes seek and report this oil and then a response is mobilized to lay absorbent boom approximately 15 feet from the marsh grass in the vicinity of the oil. The high viscosity oil appears to render traditional absorbent boom type clean-up efforts only marginally effective, at best. The heavy oil coats the surface of the boom but is too thick to be efficiently absorbed. In impacted areas, it appears that the oil will kill 15-50 feet of perimeter grass protecting the wetlands, particularly at the intertidal zone. Once the grass is killed and the root system removed, that perimeter soil erodes thereby exacerbating marshland habitat and environmental losses.

Pilot tests indicate that clean dry pine wood shavings can be used in conjunction with current response efforts to minimize the negative impacts of the oil spill to the marsh grass. In laboratory tests one pound of wood shavings (a natural and clean product with controlled moisture content) absorbs five pounds of oil. The shavings are low cost and easily applied with leaf blowers which cost approximately $100.00 and are readily available at local hardware stores. Once applied, shavings that contact oil float for extended periods, absorb thick oil, and are recoverable. Oil soaked shavings can also be left in the water or on shore because natural biodegradation will break them. Shavings that contact water sink and can thereby potentially reduce oil deposition and contamination in soil.

Because the shavings are so thin they can rapidly decompose, along with the oil. Another avenue that needs additional investigation is to use shavings as a tool to manage oil loadings for the natural oil-consuming bacteria populations. Shavings can potentially immobilize moving oil in and around shorelines and tie it up until the natural bacteria can consume it. If shavings are applied to clean water the BOD increases. If however shavings are applied to oil and water mixes or combinations, the shavings absorb the oil into the capillaries of the wood. This acts as a water proofing mechanism for the wood and a trap for the oil. By tying up the oil until it can be broken down naturally, the BOD of the oil and water mix is improved. Additionally, toxins in the oil can be contained and immobilized in the wood.

There is currently little or no major clean up option other than application of largely-ineffective absorbent booms to marsh grass areas. Hay has been suggested, but square bales are not packaged for the marine environment, can introduce grass seeds and non-native/invasive species, and the hay supply is finite. Pine shavings are packaged in plastic wrapped bales and are free of invasives. Shavings are also available in bulk and could be packaged in water permeable bio-degradable burlap-type bags. Pine is generally favorable as compared to hardwood as pine is more pH neutral and contains less tannin than oaks or other wood species. Additionally, pine shavings are manufactured in Mississippi and an ample supply – up to thousands of tons - are readily available at any time.

This work seeks to promote the potential of using additives, such as clean pine shavings as a means of rapidly deploying an economical, safe, and large scale means of clean up.

Progress:

- Fabricated testing apparatus. The attached pictures (Figure E3B.1) show dual test apparatus, one with sand and one without that will be used to simulate tidal movement. Using tap water we have tested the apparatus and believe it will replicate tidal reasonably well. There are actually two of these units so we can replicate tests quickly.

- Collected water from behind the bridge at Bay St. Louis as shown in Figure E3B.2 (The Bay St. Louis Bridge can be seen in the background). Figure E3B.3 shows the mechanism used to collect enough water for use in the tidal simulator for the experiments. Some water was collected in clean containers for bacteria counts and chemical analysis.

- Experiments with shavings will begin Thursday October 7th

.

Figure E3B.1 Photographs of Test Apparatus

Figure E3B.2 Photographs of Bay Saint Louis

Figure E3B.2 Apparatus to collect water samples

10-BP_GRI_UM-01: NIUST Deepwater horizon oil spill multi-task research

NGI Project File Number: 10-BP_GRI_UM-01

Project Title: University of Mississippi: NIUST Deepwater horizon oil spill multi-task research proposal –

Raymond Highsmith

SCIENCE ACTIVITIES

1. General Summary:

Task 1: We examined the impacts of oil and dissolved gas derived from the BP oil spill (hereafter BP spill) on microbially mediated oxygen consumption in the waters around MC118, the long term Microbial Observatory Research Site. The proposed research helped understand how natural microbial communities responded to the spill and identified the factors regulating microbial breakdown of spill-derived oil and gas. We quantified rates of methane oxidation and oxygen consumption in three types of water samples collected during research cruises in May/June and August/September: 1) <1 km of the leaking wellhead in a subsurface plume enriched in dissolved gas and oil; 2) 10km W/SW from the leaking wellhead in a subsurface plume; and 3) deep control waters lacking plumes, 25km to the north of the leaking wellhead. Experiments were used to quantify the impact of nutrients, oxygen and carbon substrate concentrations on important microbially mediated processes.

Task 2: - Technology development for improved mitigation, detection, characterization and remediation of oil spills

Physical distribution, dispersion and dilution of contaminants under the action of ocean currents and tropical storms

Chemical evolution and biological degradation of the oil/dispersant systems and subsequent interaction with the marine and coastal ecosystems

Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery

Task 3: Preliminary results from studies near the wellhead indicated that globules of oil are visible both near the surface and in layers (clouds, plumes) at depths below ~1,000m. Near the surface, oil often forms very large aggregates, some exceeding one meter in length, with most on the order of centimeters. This work investigated the distribution of these globules using several novel technologies including camera systems and electronic sensors deployed on instrument packages lowered through the water column. In addition, equipment was purchased and tested that allowed precise sampling of the uppermost sediment layers, which were expected to derive from the sedimentation of these aggregates.

Task 4: Seagrass beds are among the most important coastal marine ecosystems worldwide, providing essential habitat that act as feeding grounds for higher trophic level consumers including birds, finfish, and many commercially important species. In the Gulf of Mexico (GOM), seagrass beds are vital nursery grounds for a variety of fish and invertebrate early life history stages, and also serve as crucial habitat for threatened and endangered species, including manatees and green sea turtles. Seagrasses provide oxygen, filter nutrients and contaminants, and cycle essential inorganic and organic minerals for ecosystem consumer guilds. Since the late 1960s, almost half of the seagrass ecosystem in the eastern Mississippi Sound and the Mississippi Gulf Islands has been lost, largely due to declines in water quality, hurricanes and coastal development. The decline of this crucial nursery habitat has vast socioeconomic implications for coastal fisheries and recreation, and the loss of its vital buffering function can impact coastal environment and human health. In recent years, hurricanes have been a major source of damage to seagrass beds along the Mississippi Gulf Coast. However, even in the wake of Hurricane Katrina, one of the largest natural disasters to ever hit this region, data that we gathered on water and sediment contaminants (including PAHs) indicated a short-term low-level response. Faced with one of the world's worst anthropogenic disasters, we hypothesized that seagrasses will be less resilient than they are to natural disturbances (e.g., hurricanes) due to their evolutionary history of exposure, and due to the fact that natural events are often of shorter duration than anthropogenic sources of disturbance.

We proposed to characterize the impact of a gradient of oil spill contamination on the physiological responses and overall health of seagrass systems in the Mississippi Sound, integrating a combination of molecular biomarker, genetic and chemical biomarker analyses. We identified the current status of these sites, and assessed initial responses to oil contamination when these sites were impacted. We tested the following hypotheses:

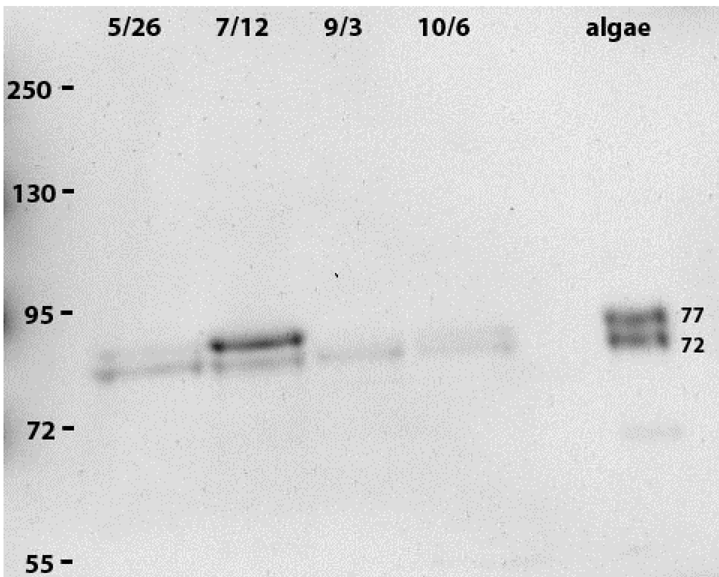
a. Proteomic profiles of the seagrass *Ruppia maritima* will exhibit acute changes that reflect spatial and temporal variations in oil spill contaminants (PAHs and chemical dispersants).
b. Expression of stress-response proteins in seagrasses will exhibit acute changes that reflect spatial and temporal variations in oil spill contaminants.

2. Results and scientific highlights:

Task 2: Overprinting of the Deepwater Horizon (DWH) oil spill was identified at the Woolsey Mound Seafloor Observatory (MC118) in June 2010. At that time, two deep-water plumes of methane were detected using a new suite of sensors on the Station Service Device (SSD) ROV and other profiling platforms. This project was designed to enhance the capabilities of the ROV to better evaluate the impact of the spill by increasing the depth rating of the SSD from 1000 to 2000 meters below sea level (the spill took place in 1500 m and the deepest known impact at that time was 1700 m). The SSD is a proven research ROV that has completed more than 25 dives in the outer continental slope of the Gulf of Mexico (GoM) aboard the UNOLS *R/V Pelican*. The *R/V Pelican* is a reasonably priced vessel that is permanently stationed in the GoM and the SSD ROV has been specially designed to operate from this class of vessel without dynamic positioning. Our launch and recovery system, tether system, and navigation system fits easily into the operating parameters of this smaller class research ship.

A follow-up cruise to Woolsey Mound in September 2011 was conducted to evaluate the evolution of the methane plumes with a suite of sensors on the SSD. The deep-water pycnoclines of methane, however, were not detectable on this cruise. Instead, an unusual flocculated material was identified on the seafloor with the ROV and targeted push cores were collected. Laboratory analysis of the sediment samples indicated significant concentration of petroleum hydrocarbons and the impact of the spill in this area appears to have evolved from water column to the seafloor. Attempts to fingerprint the provenance of the oil have proved inconclusive so the extent of the impact of the spill is still being evaluated. Use of the ROV for this investigation represents a "best practice" and allowed for enhanced site characterization and targeted sampling in areas most likely affect by petroleum contamination.

Task 4: Seagrasses are a difficult group to assess for stress biomarkers; nonetheless our group has developed protocols to prepare seagrasses for HSP70 analyses, and proteomic profiling. Protein blotting indicated that both constitutive isoforms of HSP70 (= HSC72 and 77) are expressed (see below: representative Thalassia testudinum sample). However, replicate samples from specific dates and sites indicate a high level of variability in expression levels. It is currently unclear whether this is due to high variability in seagrass phenotypes, or to contaminant exposure over micro-landscape scales.



Bradford protein for all samples collected between May and October 2010, and at all sites, were also variable between species. Halodule exhibited the greatest variability in ug protein/gm dry wt, although there was no significant effect of date on protein concentration [ANOVA: MS=45408.465, F=1.654, P=0.2623). However, there was a trend (i.e., P=0.08) for reduced concentrations in protein between May-September and October dates (see below)

Date	Mean	Std Dev	Std Error
26 May 2010	314.0	192.3	136.0
12 July 2010	440.3	198.7	114.7
3 September 2010	494.0	169.1	97.6
6 October 2010	218.3	97.6	56.4

Thalassia protein levels were the highest of all three species examined, and there was a high degree of variation within replicates collected at any given point in time. However, there was no significant effect of date on protein concentrations [ANOVA: MS=99975.861, F=0.492, P=0.6975) (see below).

Date	Mean	Std Dev	Std Error
26 May 2010	1347.0	575.8	297.9
12 July 2010	1236.7	443.5	256.1
3 September 2010	929.0	295.6	209.0
6 October 2010	1047.0	198.5	114.6

Two comparisons of Ruppia were conducted, based on collected samples. We were able to assess the effect of time at a single site (=Middle Bay) in Grand Bay NERR; however there was no significant effect of date between May and August [Unpaired t-test: t=1.881, P=0.1331]. We also examined the effect of site (Grand Bay MS vs Grand Bay AL) during September. There was significantly more protein in samples from GBAL than samples from GBMS [Unpaired t-test: t=2.838, P=0.047]. It remains unclear whether these differences between site were due to phenotypic variation or to contaminant exposure.

Date	Site	Mean	Std Dev	Std Error
14 May 2010	Middle Bay, MS	192.3	27.4	15.8
2 August 2010	Middle Bay, MS	150.7	26.9	15.5
29 September 2010	Grand Bay, AL	309.3	28.9	16.7
29 September 2010	Grand Bay, MS	216.7	48.6	28.1

The total number of potential proteins exhibiting temporal variation, in Halodule, based on proteomic profiling techniques is 1001. However, these numbers must be interpreted cautiously since many “unique proteins” within the PLGS database represent isoforms from different species (for example, Heat Shock Protein shows up in our database at least a dozen times, yet a careful analysis of the samples indicate that we can really only identify 3 unique isoforms). Nonetheless, if we assume that database hits are four times more liberal than reality, we still have likely identified 250 proteins that can be used as stress biomarkers. Many of these are important in cellular cascades, and we are currently developing a model of stress functionality in seagrass cells. These proteins vary through time (see below) suggesting seasonal physiological differences. As replicates for impacted vs non-impacted sites become more available we will further assess the unique proteins at each site to determine biomarkers of oil stress.

Date	Total Proteins	Unique Proteins	Common Proteins
26 May 2010	85/91	67/77	18/14
12 July 2010	92/59/134	70/53/106	22/6/28
3 September 2010	162/100/180	124/85/139	38/15/41
6 October 2010	181/73	149/56	32/17

Currently we are working on a paper discussing the use of proteomic profiling in seagrass stress research, and techniques for the optimization/recovery of important biomarkers.

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
R/V Pelican	UNOLS	Ken Sleeper	Spill impact at MC118	9/11-12/10
Station Service Device	ROV		Chemical survey and targeted push cores	9/11-12/10
R/V Walton Smith		SB Joye	Water column sampling	May-June 2010
R/V Oceanus		JP Monotya	Water column and Sediment sampling	Aug-Sept 2010
R/V Atlantis		SB Joye	Water column and Sediment sampling	Nov-Dec 2010
R/V Pelican		A Diercks	Water column and Sediment sampling	May 2010

4. Peer-reviewed publications, if planned

Task 1:

Diercks, A.R., R.C. Highsmith, V.L. Asper, D. Joung, L. Guo, Z. Zhou, A.M. Shiller, S.B. Joye, A.P. Teske, and S.E. Lohrenz, 2010. Characterization of subsurface polycyclic aromatic hydrocarbons at the Deepwater Horizon site. *Geophysical Research Letters*, 37, L20602, doi:10.1029/2010GL045046.

Joye, S.B., and I.R. MacDonald, 2010. Offshore oceanic impacts from the BP oil spill. *Nature Geoscience*, 3:446, doi:10.1038/ngeo902.

Joye, S.B., I.R. MacDonald, I. Leifer, and V. Asper, 2011. Magnitude and oxidation potential of hydrocarbon gases released from the BP blowout. *Nature Geoscience,* 4: 160-164 (doi:10.1038/ngeo1067).

Wade, T.L., S.T. Sweet, J.L. Sericano, N.L. Guinasso, A.R. Diercks, R.C. Highsmith, V.L. Asper, D. Joung, A.M. Shiller, S.E. Lorehnz, and S.B. Joye, 2011. Analyses of water samples from the Deepwater Horizon Oil Spill: Documentation of the Sub-Surface Plume. *Journal of Geophysical Research: Oceans*, Geophysical Monograph Series 195, pp. 77-82.

Peterson, C.H., Anderson, S., G. Cherr, R. Ambrose, S. Anghera, S. Bay, M. Blum, R. Condon, T. A. Dean, M. Graham, M. Guzy, S. Hampton, S.B. Joye, J. Lambrinos, B. Mate, D. Meffert, S. P. Powers, C. Reddy, P. Somasundaran, R. B. Spies, C. Taylor, and R. Tjeerdema, 2011. A Tale of Two Spills. *BioScience,* 62:461-469.

Mendelssohn, I.A., G. Anderson, D. Baltz, R. Caffey, K. Carman, J. Fleegar, S.B. Joye, E. Maltby, E. Overton, and L. Rozas, 2011. Oil impacts to coastal wetland systems: Implications for the Mississippi River Delta Plain Ecosystem after the Deepwater Horizon Oil Discharge. *BioScience*, in press.

Task 4:

M Slattery, S Ankisetty, J Corrales, KE Marsh-Hunkin, DJ Gochfeld, J Rimoldi, K Willett (in prep) Marine proteomics: A critical look at an emerging technology. (for: Journal of Natural Products, expected submission date- May 2012)

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Ocean exploration, research and response.	M Slattery	R Highsmith and V Asper	US Senate	no	4/2011
Resilience of Seagrass Beds to Oil Contamination: Interaction of Physiological Responses and Genetic Diversity	A Boettcher	K Major, A Morris, B Ehman, E Boone, J Corrales, K Willett, D Gochfeld, M Slattery	GNDNERR	no	10/2011
The Detection of Elevated Methane Concentration Indicate the Presence of Deep-Water	Sleeper, Ken	Sleeper, K., Bell, R., Short, T., Chanton, J., Wilson, R. D'Emidio, M.,	American Geophysical Union annual meeting; Special Session on the Oil Spill, San Francisco, CA	Y Abstract OS21G-05	12/2010

Plumes Northwest of the DWH Site		Macelloni, L.			
The Deepwater Horizon oil spill and pelagic foodwebs in the Northern Gulf of Mexico: What do stable isotopes tell us about oil, plumes, and discolored zooplankton?	Montoya, J..	Montoya, J., A. Subramaniam, M. Crespo-Medina*, **S. B. Joye**, A. Bracco, and T. Villareal	TOS/ASLO/AGU Ocean Sciences Meeting, Salt Lake City, UT	no	2/2012
Intense sedimentation to the seafloor following the 2010 Macondo Blowout: geochemical composition, methanisms, and microbial impacts.	Joye, S.B.	**Joye, S. B**., M. Crespo-Medina*, P. Madieros, C. Benitez-Nelson, W. Moore, J. Montoya, V. Asper, A. Diercks, and R. Highsmigh	TOS/ASLO/AGU Ocean Sciences Meeting, Salt Lake City, UT	no	2/2012
Ongoing fluid discharge near the Macondo Wellhead.	Peterson, R.N.	Peterson, R. N., R. F. Viso, I. R. MacDonald, and **S. B. Joye**	TOS/ASLO/AGU Ocean Sciences Meeting, Salt Lake City, UT	no	2/2012
Methane rising from the deep: Hydrates, bubbles, oil spills and global warming.	Leifer, I.	Leifer, I., G. J. Rehder, E. A. Solomon, M. Kastner, V. Asper and **S. B. Joye**	AGU Fall Meeting, San Francisco, CA	no	12/2011
Deepwater Horizon oil and pelagic foodwebs in the Northern Gulf of Mexico: what do stable isotopes tell us about oil, subsurface turbid layers, and discolored zooplankton.	Montoya, J.	Montoya, J., V. Asper, A. Bracco, M. Crespo-Medina*, A. Diercks, **S. Joye**, U. Passow, A. Subramaniam, and T. Villareal.	CERF Annual Meeting, Daytona, FL	no	11/2011

Open Ocean impacts of the Macondo oil well blowout.	Joye, S.B.	**Joye, S.B.**, K.S. Hunter, and M. Crespo-Medina	CERF Annual Meeting, Daytona, FL	no	11/2011
Oil distributions and impacts following the Macondo Blowout.	Joye, S.B.	**Joye, S.B.**, and M. Crespo-Medina	SCMEA-GAME Annual Conference, Savannah, GA	no	10/2011
Undersea impacts of the BP Blowout	Joye, S.B.	Joye, S.B.	Presentation to the UGA Parent's Program, UGA Chapel, Athens, GA	no	9/2011
Undersea impacts of the BP Blowout	Joye, S.B.	Joye, S.B.	Distinctive Voices Lecture Series, National Academy of Sciences, Irvine, CA	no	9/2011
The offshore fate and consequences of hydrocarbon gases and oil released from the Macondo Blowout	Joye, S.B.	Joye, S.B.	Department of Marine and Environmental Biology, University of Southern California, Invited Seminar, Los Angeles, CA	no	9/2011
The offshore fate and consequences of hydrocarbon gases and oil released from the Macondo Blowout	Joye, S.B.	Joye, S.B.	Institute of Marine Sciences, University of North Carolina, Invited Seminar, Morehead City, NC	no	9/2011
The offshore fate of hydrocarbon gases and oil released from the Macondo Blowout.	Joye, S.B.	Joye, S.B.	Presentation to the UGA Government Legislative Retreat, Athens, GA,	no	8/2011
The offshore fate of hydrocarbon gases and oil released from the Macondo Blowout.	Joye, S.B.	Joye, S.B.	Gordon Research Conference, Chemical Oceanography, Andover, NH	no	8/2011
The offshore fate of	Joye, S.B.	Joye, S.B.	Presentation to the Kiwanis	no	7/2011

hydrocarbon gases and oil released from the Macondo Blowout.			Club, Athens, GA		
Pelagic aerobic methane oxidation: natural background and response to a deepwater blowout	Joye, S.B.	**Joye, S.B.,** M. Crespo-Medina, A. Vossmeyer, K.S. Hunter, C.D. Meile, A.R. Diercks, V. Asper, A.M Shiller, D.J. Joung, J.P. Chanton, J.J. Battles, C. Mann, J. Montoya, T. Villareal, M. Wood, and R. Amon	FEMS Annual Congress, Geneva, Switzerland	no	6/2011
The offshore fate of hydrocarbon gases and oil released from the Macondo Blowout.	Joye, S.B.	Joye, S.B.	Presentation to the Bavarian Government Delegation, Athens, GA	no	6/2011
Doing Research Following the Gulf of Mexico Macondo Disaster	Joye, S.B.	Joye, S.B.	Presentation to the UGA Arch Foundation, Athens, G	no	5/2011
Evolution of water column methane cycling after the 2010 Gulf BP oil well blowout	Joye, S.B.	**Joye, S.B.,** M. Crespo-Medina, A. Vossmeyer, K.S. Hunter, C.D. Meile, A.R. Diercks, V. Asper, A.M Shiller, D.J. Joung, J.P. Chanton, J.J. Battles, C. Mann, J. Montoya, T. Villareal, M.	American Society for Microbiology, Annual Meeting, New Orleans, LA	no	5/2011

		Wood, and R. Amon			
The offshore fate of hydrocarbon gases and oil released from the Macondo Blowout.	Crespo-Medina, M.	Joye, S.B.	Presentation to the Alabama League of Woman Voters, Tuscaloosa, AL	no	4/2011
The offshore fate of hydrocarbon gases and oil released from the Macondo Blowout.	Joye, S.B.	Joye, S.B.	Presentation to the UGA Roosevelt Institute, Athens, GA	no	4/2011
The offshore fate of hydrocarbon gases and oil released from the Macondo Blowout.	Joye, S.B.	Joye, S.B.	Plenary talk at the UGA CURO Symposium, Athens, GA	no	4/2011
The offshore fate of hydrocarbon gases and oil released from the Macondo Blowout.	Joye, S.B.	Joye, S.B.	Presentation to OLLI Lunch and Learn, Athens, GA	no	4/2011
The offshore fate of hydrocarbon gases and oil released from the Macondo Blowout.	Joye, S.B.	Joye, S.B.	Presentation to Franklin College Dean's Council, Sapelo Island, GA	no	4/2011
The offshore fate of hydrocarbon gases and oil released from the Macondo Blowout.	Joye, S.B.	Joye, S.B.	UGA Law School, Environmental Law Association/Constitutional Law Society, Invited Seminar, Athens, GA	no	2/2011
Slime, Soot, and Blue Water: The offshore fate of hydrocarbon gases and oil released from the Macondo	Joye, S.B.	Joye, S.B.	Department of Geosciences, Princeton University, Invited Seminar	no	2/2011

Blowout					
The Microbial Slime Highway: An efficient mechanism of oil transport to the benthos and consequences on microbial dynamics in Deep Gulf of Mexico Environments	Joye, S.B.	**Joye**, **S.B.,** M. Crespo-Medina*, K. Hunter, A. Vossmeyer, M. Bowles, V. Asper, A. Diercks, A. Teske, J. Montoya, C. Arnosti, C. Benitez-Nelson, J. Brandes, W. Moore, U. Passow, A. Subramaniam, T. Wade, K. Zeirvogel and R. Highsmith	American Society of Limnology and Oceanography, Aquatic Sciences Meeting, San Juan Puerto Rico	no	2/2011
Subsurface turbid layers in the Gulf of Mexico: Ghosts of the Deepwater Horizon Oil Spill	Montoya, J.P.	Montoya, J.P., A. Subramaniam, V. Asper, A. Diercks, U. Passow, M. Crespo-Medina*, **S.B. Joye** and T.A. Villareal	American Society of Limnology and Oceanography, Aquatic Sciences Meeting, San Juan Puerto Rico	no	2/2011
Slime, Soot, and Blue Water: The offshore fate of hydrocarbon gases and oil released from the Macondo Blowout	Joye, S.B.	Joye, S.B.	American Association for the Advancement of Science, Annual Meeting, Invited Topical Lecture, Washington D.C.	no	2/2011
Oil and Gas in the Gulf of Mexico after the Macondo Blowout	Joye, S.B.	Joye, S.B.	Cedar Shoals High School, AP Oceanography Class, Athens, GA	no	1/2011
Doing science following the Macondo Blowout	Joye, S.B.	Joye, S.B.	UGA Alumni Assembly, Athens, GA	no	1/2011

Oil and gas dynamics following the Macondo Blowout	Joye, S.B.	Joye, S.B.	UGA Oil Spill Science Symposium, Athens, GA	no	1/2011
Open ocean impacts of the BP Oil Well Blowout	Joye, S.B.	**Joye, S.B.,** A. Diercks, A. Teske, and D. Valentine	American Geophysical Union, Fall Meeting	no	12/2010
2010 Documentation of Sub-Surface Oil Plume by Analyses of Toxic PAH in Water Samples from the Deep Water Horizon Oil Spill	Wade, T.L.	Wade, T.L., Sweet S.T., Sericano, J.L., Guinasso, N.L. Jr., Lohrenz, S.E., Shiller, A.M., **S.B. Joye**, Dierks, A.R., Asper, V.L. and Highsmith, R.C.	SETAC 31th Annual Meeting, November 7-11, 2010, Portland OR	no	11/2010

6. Other products or deliverables

7. Data

Task 4: Proteomic profiles are stored at the University of Mississippi Supercomputing Facility, and on external terabyte hard drives. A meta-data file, in excel is copied at each location.

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Marc	Slattery	PI	U Mississippi	slattery@olemiss.edu
Deborah	Gochfeld	coPI	U Mississippi	gochfeld@olemiss.edu
Kristie	Willett	coPI	U Mississippi	kwillett@olemiss.edu
John	Rimoldi	coPI	U Mississippi	jrimoldi@olemiss.edu
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Andy	Gossett	Research Systems Specialist	University of Mississippi	Andy.gossett@gmail.com
P. Matt	Lowe	Research Systems Specialist	University of Mississippi	pmliii@yahoo.com
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Andreas	Teske	Collaborator	UNC-Chapel Hill	teske@unc.edu
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Ian	MacDonald	Collaborator	FSU	Ian.macdonald@fsu.edu
Annalisa	Bracco	Collaborator	Georgia Tech	abracco@gatech.edu

MENTORING AND TRAINING

9. Student and post-doctoral participants

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Jone	Corrales	Post-doc	Oil effects on seagrass	U Mississippi	K Willett	2014
Crystal	Warren	MS	Oil effects on seagrass	U Mississippi	K Willett	2011
Sylvester	Lee	MS	Oil effects on sponges	U Mississippi	Slattery/Gochfeld	2012
LaTina	Steele	MS	Seagrass stress	U South Alabama	Boettcher	2013
Meghan	Dailey	MS	Oil effects on oysters	U Mississippi	Willett/Slattery	2012

Steven	Tidwell	BS	ROV operations	University of Mississippi	Greg Easson	05/2011
Melitza	Crespo-Medina	Post Doc	Methane cycling	UGA	Joye	
Joy	Battles	MS	Methane cycling	UGA	Joye	2014
Chassidy	Mann	BS	Methane cycling	UGA	Joye	2013
Laura	Potter	MS	Microbiology	UGA	Joye	2012
Marshall	Bowles	PhD	Hydrocarbon dynamics	UGA	Joye	2011
Katherine	Segarra	PhD	Methane dynamics	UGA	Joye	2012

10. Student and post-doctoral publications, if planned

Task 1: Crespo-Medina, M., A. Vossmeyer, K.S. Hunter, C.D. Meile, A.R. Diercks, V. Asper, V.J. Orphan, J.P. Chanton, A.M Shiller, D.J. Joung, J.J. Battles[#], C. Mann[#], J. Montoya, T. Villareal, M. Wood, R. Amon, and **S.B.Joye**. The rise and fall of methanotrophy following a deepwater oil-well blowout. *Nature Geoscience* (in review).

1) Student and post-doctoral presentations and posters, if planned (Please provide copies of each)

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
A Proteomic and Analytica Chemistry Approach: Seagrasses and Oil Contaminants	J. Corrales	S. Lee,[2] L. Steele,[3] D.J. Gochfeld,[4] M. Slattery,[2] A. Boettcher,[3] K.L. Willett[1]	Gulf Oil Spill SETAC Focused Meeting, Pensacola, FL	no	April 26-28, 2011
Impact of Oil Contaminanats From the Deepwater Horizon Oil Spill in Seagrasses of the Mississippi/Alabama Coast	J. Corrales	S. Lee,[2] L. Steele,[3] D.J. Gochfeld,[4] M. Slattery,[2] A. Boettcher,[3] K.L. Willett[1]	PRIMO, Long Beach, CA	no	May 14-18, 2011

Assessment of Water, Sediment, and Oyster PAH Concentrations and RNA and Protein Expression Following the Deepwater Horizon Oil Spill	M Dailey	J Corrales, C Thornton, H Patterson, A Boettcher, R Carmichael, M Slattery KL Willett	SETAC, Boston MA	no	15-18 November 2011
Transcriptional Response of Deepwater Bacteria and Archaea to Hydrocarbon Contamination From the Deepwater Horizon Spill	Rivers, A.	Rivers, A., S. Sharma, E. Lindquist, S. Tringe, **S. B. Joye** and M.A. Moran	TOS/ASLO/AGU Ocean Sciences Meeting, Salt Lake City, UT		2/2012
Water Column Methane Dynamics in Response to the Deepwater Horizon Hydrocarbon Spill	Crespo-Medina, M., A.	Crespo-Medina, M., A. Vossmeyer, K. Hunter, J.J. Battles, J.P. Montoya, V. Asper, A. Diercks, T.A. Villareal, and **S. B. Joye**	TOS/ASLO/AGU Ocean Sciences Meeting, Salt Lake City, U		2/2012
Pelagic microbial community composition before, during and after the Deepwater Horizon Oil Spill	Yang, T.T.,	Yang, T.T., L. M. Negro, T. Guitierrez, L. d'Ambrosio, **S. B. Joye**, R. Highsmith, and A. P. Teske	TOS/ASLO/AGU Ocean Sciences Meeting, Salt Lake City, UT		2/2012
Impacts of dispersants on microbial metabolism in Gulf of Mexico sediments	Tinker, K., M.	Tinker, K., M. Crespo-Medina, and **S.B. Joye**	State of North Carolina Undergraduate Research and Creativity Symposium, Raleigh, NC		11/2011
Fate and Consequences of Macondo Methane in	Crespo-Medina, M.	Crespo-Medina, M. and **Joye, S.B.**	Deepwater Horizon Oil Spill Principal Investigator Conference, University of		10/2011

the Water Column of the Gulf of Mexico, 2010-2011			South Florida, St. Petersburg FL		
Impacts of Dispersants on Microbial Metabolism in Gulf of Mexico Sediments	Tinker, K., M	Tinker, K., M. Crespo-Medina*, and S.B. Joye	Microbiology REU Symposium, Athens, GA		7/2011
Patterns of Water Column Aerobic Methane Oxidation Rates in Response to the Deepwater Horizon Blowout	Crespo-Medina, M.	Crespo-Medina, J. Slaughter#, A. Vossmeyer, J.P. Montoya, A. Subramaniam, V. Asper, A. Diercks, T.A. Villareal, and **S.B. Joye**.	American Society of Limnology and Oceanography, Aquatic Sciences Meeting, San Juan Puerto Rico		2/2011
Microbial Community Response to the Deepwater Horizon Oil Spill	Redmond, M.C.	Redmond, M.C., D.L. Valentine, and **S.B. Joye**	American Geophysical Union, Fall Meeting		12/2010

10-BP_GRI-UNO-01: Monitoring of Natural Resources in the Pontchartrain Basin Following the Deepwater Horizon Oil Spill: Processes, Habitats, and Fisheries

1. **NGI Project File Number:** 10-BP_GRI-UNO-01

2. **Project Title:** Monitoring of Natural Resources in the Pontchartrain Basin Following the Deepwater Horizon Oil Spill: Processes, Habitats, and Fisheries

3. **Project Lead (PIs and Co-PIs):**

Name	Project Lead or Co-	Affiliation	Email
Denise Reed	Project lead	University of New Orleans	djreed@uno.edu
Mark Kulp	Co PI	University of New Orleans	mkulp@uno.edu
Martin O'Connell	Co-PI	University of New Orleans	moconnel@uno.edu
Ioannis Georgiou	Co-PI	University of New Orleans	igeorgio@uno.edu
Matt Tarr	Co-PI	University of New Orleans	mtarr@uno.edu
Mike Poirrier	Co-PI	University of New Orleans	mpoirrie@uno.edu
Tom Soniat	Co-PI	University of New Orleans	tsoniat@uno.edu

4. **All Non-Student Personnel funded by this project:**

Name	Category (e.g., PI, Visiting scientist, Co-PI, Post doc, Senior Researcher, Research Associate)	Degree	% Salary funded from this project	Is individual located at a NOAA Lab?*
Dallon Weathers	Research Associate	MS	16%	N
Phil McCarty	Research Associate	MS	8	N
Mike Brown	Research Associate	BS	12	N
Ann Uzee-O'Connell	Research Associate	M.Sc.	2.4	No
Christopher Schieble	Research Associate	M.Sc.	1.0	No
Twyla Herrington	Research Associate	B.Sc.	6.9	No
Phil McCarty	Research Associate	BS	20%	No
Mike Brown	Research Associate	BS	20%	No
Dallon Weathers	Research Associate	MS	5%	No
Ross Del Rio	Research Associate	MSc	25%	No

*If yes, list NOAA lab

5. All Students funded by this project :

Name	Category (i.e., highest degree already obtained: BS, MS, PhD)	Degree program	% Salary funded from this project	Is individual located at a NOAA Lab?*
Sarah King	BS	Ph.D.	100%	No
Aisa Carter	none	BS	100%	No
Jenny Wolff	undergraduate	NA	8.3	No
Chris Esposito	BS	MS	35%	No
Kevin Trosclair	BS	MS	0 %	No
Janice Jacobi	Undergraduate	A.S	9.0	No
Ellen Isbell	Undergraduate	H.S.	34.6	No
Megan Thorne	Undergraduate	H.S.	46.1	No
Alicia Wylie	Undergraduate	H.S.	1.5	No
Patrick Slattery	Undergraduate	B.S.	2.8	No
Elisabeth Trinh	Undergraduate	H.S.	6.0	No
Poinsettia Le	Undergraduate junior	High School	20	No
Stefanie Perez Juanazo	Undergraduate junior	High School	50	No

6. Project Abstract (500 words or less):

This project supported monitoring of the effects and implications of oil on the coastal ecosystem of the Pontchartrain Basin, Louisiana. The monitoring work built on existing monitoring programs addressing important ecosystem processes and functions by specifically seeking to identify oil related changes and the nature and status of the oiling. Monitoring included tracking and assessment of the effects of oiling on submerged aquatic vegetation, benthic bivalves and nekton.

a. For SAV surveys identified the absence of *Vallisneria americana* from the Rigolets and adjacent waters and the shoreline of Lake Pontchartrain except near large streams. Historic data indicates a gradual decline in of *V. americana* and other freshwater SAV in the study area, and severe damage to *Vallisneria* in the Rigolets and Lake Pontchartrain from Hurricane Katrina so this in unlikely to be related to the spill. Persistent higher turbidity and periods of high salinity have occurred since Katrina preventing *V. americana* recovery.

b. Oysters were collected from Lake Borgne and Mississippi Sound in Louisiana. Oysters from the oiled area had a higher gonadal index, a similar condition index, and higher percent females than did oysters from the un-oiled area. This maybe explained as a response to salinity. No Dermo infection was found in oysters in the un-oiled area in contrast to a 43% infection of oysters in the oiled area. There is evidence that Dermo is exacerbated by pollutants such as hydrocarbons or it may simply be a response to the higher salinities at the oiled sites. Chemical analysis shows higher hydrocarbon concentrations in oysters from the oiled area is ongoing.

c. Nekton sampling was conducted at three stations along the Chandeleur Island chain, as well as at Grand Pass, Half Moon Island, and Rabbit Island at the Rigolets. Analysis of fish assemblages in the Pontchartrain Estuary responding to the oil spill is ongoing. We have yet to see significant changes in the numbers of fishes or the species composition of assemblages when we compared 2010 data with baseline data. Our assumption is that when the larval and juvenile stages of organisms are killed by these disturbances, the actual decline in

populations will not be detected until that time when those larval and juvenile organisms should have recruited into the populations.

Field surveys of estuarine circulation showed that toward the Gulf side, some dynamic interaction with the coastal ocean is evident from the thermohaline structure, as well as evidence of dissolved oxygen dynamics in response to wind stress, and resulting mixing and momentum transfer from the atmosphere. Laboratory experiments addressed how exposure to sunlight altered the toxicity of various compounds in crude oil when combined with Gulf waters. Findings showed an increase in toxicity in our studies as expected due to the increase in solubility of the degradation products in the aqueous layer.

Our studies have provided baseline information for the period immediately post-spill and will be valuable benchmark in future assessments of the effects of DWH on the Pontchartrain estuary.

7. Key Scientific Questions/Technical Issues:

This project focused on identifying oil related changes and the nature and status of the oiling within the Pontchartrain basin. This included three main technical issue areas:

a. Tracking oil and oil residue within the estuary in water samples, together with select samples of tissue, vegetation and sediment
b. Assessment of oiling on key ecosystem components including Submerged aquatic vegetation, Bivalves including oysters (*Crassostrea virginica*) and clams (*Rangia cuneata*), and Nekton.

c. Evaluating the transport processes influencing the distribution of oil through the coastal ecosystem.

8. Collaborators/Partners:

None – all work was conducted by UNO personnel.

9. Project Duration: 2 July 2010 – February 15 2011

10. Project Baselines:

Contributions to specific NOAA Goals/Objectives:

This study addresses NOAA Strategic Goal #1 to protect, restore, and manage the use of coastal and ocean resources. Mitigation of potential effects of oil impacts requires that the scope of the impact be established as a time line from the spill event. For example, coastal submerged aquatic vegetation (SAV) is an important marine resource habitat recognized by NOAA to be in a state of global decline with protection, management and restoration efforts needed. The current status of (SAV) and possible effects of the oil spill were evaluated in Lake Pontchartrain, a large stressed urban estuary. This study provides a similar “snapshot” of conditions during Fall/Winter 2010 for oysters and nekton.

Contributions to regional problems and priorities:

The problems of coastal Louisiana and the Pontchartrain estuary are well recognized. The project has addressed the regional need to accurately assess how ecologically and economically important aquatic organisms have responded in the near term to the Deepwater Horizon Oil Spill. For example, Lake Pontchartrain SAV has been in

a state of decline since first surveyed in 1953. Although *Ruppia martima* an opportunistic euryhaline species has at time increased, *Vallisneria americana* and *Najas guadualpensis* have continued to decline and the only Louisiana populations of *Potamogeton perfoliatus* were extirpated from Lake Pontchartrain about ten years ago. A goal of the Lake Pontchartrain Basin Foundation is to restore historic SAV beds. The status of coastal SAV is of concern to the Louisiana Depart of Wild Life and Fisheries because it provides essential fisheries habitat, and food for water fowl, sea turtles and manatees. The study also assesses the effects of diminished water quality on the resilience of oyster populations and helps establish a baseline for oyster reef habitat conservation and restoration in a localized but important area. In addition, understanding the density gradients across estuaries in a deltaic setting, can provide timely knowledge for estuarine dynamics and help discern impacts from rising sea-levels. Estuarine dynamics play also a key role in better linking and understanding ecosystem response and subsequent impacts as a result. With specific reference to the DWH spill and the broader effects of the oil industry on the local environment, the results from this study
provide a better understanding of the fate of oil on the surface of the Gulf of Mexico. Data obtained in this study on the photochemical degradation rates for various components of crude oil will provide important baseline data for modeling of oil fate and transport in the environment.
Priority stakeholders include Louisiana Department of Wildlife and Fisheries, which manages the public oyster grounds and fisheries in the basin; the Louisiana Department of Health and Hospitals, which certifies the health of seafood products; and Louisiana fishermen who harvest the resources. Local
citizens are heavily involved in the environmental quality of the Basin and are represented by groups such as the Lake Pontchartrain Basin Foundation.

Gaps:
The study has filled data gaps from previous studies and has been able to identify certain conditions which have previously been only occasionally monitored:

a. Although we have conducted Lake Pontchartrain SAV surveys from 1996 through 2006, because of lack of funding no formal comprehensive surveys have been conducted since 2006. This survey provides needed temporal information on the current species distribution and abundance in a sensitive area directly and indirectly affected by the oil spill.

b. We have filled gaps in baseline data for nekton species in the middle and lower portions of the Pontchartrain Estuary. These post oil spill data can now be compared to our historical baseline data to determine any impacts on these organisms from the oil spill.

c. Systematic observations showed that regional hypoxia previously observed in Chandeleur and Breton Sounds is episodic.

11. Milestones accomplished during entire project period.
Field excursions were completed as planned for the most part with the exception of the Chandeluer sampling which was hampered by bad weather and initial problems with site access which were eventually overcome.

All three cruises were performed as planned, with concentration on the beginning of the cold-front season, where coastal waters and exchange between coastal bays and the Gulf of Mexico would be expected to be the highest. For each cruise, the RV Fisk started at the CERF field station, and performed 26 casts using a marine grade CTD (Seabird 19plus), employed with a Wetlabs optical backscatter sensor, and a dissolved oxygen sensor. Along side the CTD cage was a Laser In-Situ Scattering and Transmissometer (LISST) from synchronize casts. At least two of the cruises were performed at neap and spring tides respectively.

SAV surveys were conducted from August through December 2010. The area covered was the Rigolets Pass and selected adjacent bayous and ponds. The north shore of Lake Pontchartrain from the mouth of Bayou Bonfouca west to the Mandeville breakwater and ten sites in Bayou Bonfouca were surveyed. Benthic invertebrate samples were collected from three sites near Rigolets for *Rangia cuneata* clams. Oyster sampling was conducted in January 2011.

12. Describe all significant research results, protocols developed, and research transitions. Tracking Oil and Oil residue:

There are several mechanisms for degradation of oil released into aquatic environments. Bioremediation is one of the most important remediation methods; however degradation becomes stagnant in low nutrient waters. Furthermore, larger molecular weight alkanes and polycyclic aromatic hydrocarbons (PAHs) are not readily available for biodegradation. Transformation of these molecules often requires initial photodegradation. We have investigated the photochemical transformation of oil films from the Deepwater Horizon spill. Under simulated sunlight, we observed significant rates of phototransformation of PAHs and moderate molecular weights alkanes (the partially weathered sample had already been depleted of low MW alkanes prior to collection). After 3 hours of irradiation, small, medium, medium-large, and large PAHs were degraded 20, 30, 40, and 50%, respectively. Additionally, 50% of the moderate molecular weight alkanes were degraded. However, the higher molecular weight alkanes showed little or no degradation. After irradiation, toxicity significantly increased. Photocatalyst addition did not increase the overall degradation rate, but toxicity was lower with photocatalysts after 3-6 hours of irradiation.

Crude oil collected from the surface of the Gulf of Mexico was weighed and dissolved in a mixture of pentane and toluene and sonicated to fully dissolve. The dissolved oil was then poured into a jacketed beaker that contained Gulf water and the solvents were allowed to evaporate. The samples were exposed to simulated sunlight. After irradiation the samples are either extracted with dichloromethane (DCM) for GC-FID and fluorescence analysis or the aqueous layer was used for Microtox analysis.

Oil extracts were analyzed on a Hewlett-Packard Agilent 6890 GC coupled to an auto sampler with an flame ionization detector and a 30 m X 0.32 mm (i.d.) AT-1 capillary column. Synchronous fluorescence scans of diluted oil extracts were collected from 250 to 500 nm with a delta lambda of 25 nm and excitation and emission slits set to 2.5 and 5.0 nm, respectively. Microtox analysis was performed using a Microtox 500 analyzer. Comparison tests were performed to analyze the toxicity of the water exposed to the oil.

Crude oil was deposited onto the gulf collected water to mimic the interactions of the components in the water with those of the oil and degradation products. 100 mg of the oil was used which produced a film of oil that was approximately 60 µm in depth. Photographs were taken before and after each irradiation time to document the physical changes in the oil layer throughout irradiation, Figure 1. After 6 hours of irradiation the oil layer became leathery in appearance and upon movement the oil layer cracked. After 24 and 48 hours significant physical degradation of the oil was observed.

Synchronous flourescence scans were performed on the DCM extract, Figure 2a. For our 3 hour irradiated samples the emission maximum was at 306 nm and decreased 72, 58, and 68% for no oxide, TiO_2, and Fe_2O_3, respectively.

The extent of degradation of alkanes was studied via GC-FID, Figure 3. Identification of the major peaks was accomplished by analyzing a number of n-alkanes. From the results it was observed that samples that were exposed to 3 hours of simulated sunlight exhibited extensive degradation for the lower molecular weight alkanes. In comparison to the no oxide samples, the TiO_2 samples exhibited an increase in the degradation for the lower molecular weight alkanes. In contrast, lower degradation rates were detected for the Fe_2O_3 in comparison to the no oxide.

The aqueous fraction of the irradiated sample was analyzed to evaluate the toxicity of the samples over time. To examine the toxicity of the oil and degradation products, the emission intensity of the luminescent bacteria, *Vibrio fischeri*, was monitored for water from oil/water mixtures that had been irradiated for various times. The % Effect correlates to a decrease in the emission in comparison to a control thus representing the extent of toxicity. Our studies have found that after 24 hours, the toxicity of the dark controls did no increase (data not shown); however, all irradiated samples presented an increase in the toxicity, Figure 4. The increase in toxicity in our studies was expected due to the increase in solubility of the degradation products in the aqueous layer. Samples irradiated for 3 and 6 hours with photocatalysts showed lower toxicity compared to samples that contained no oxide. After the samples were exposed to 24 hours of irradiation, all the samples had almost equivalent toxicity.

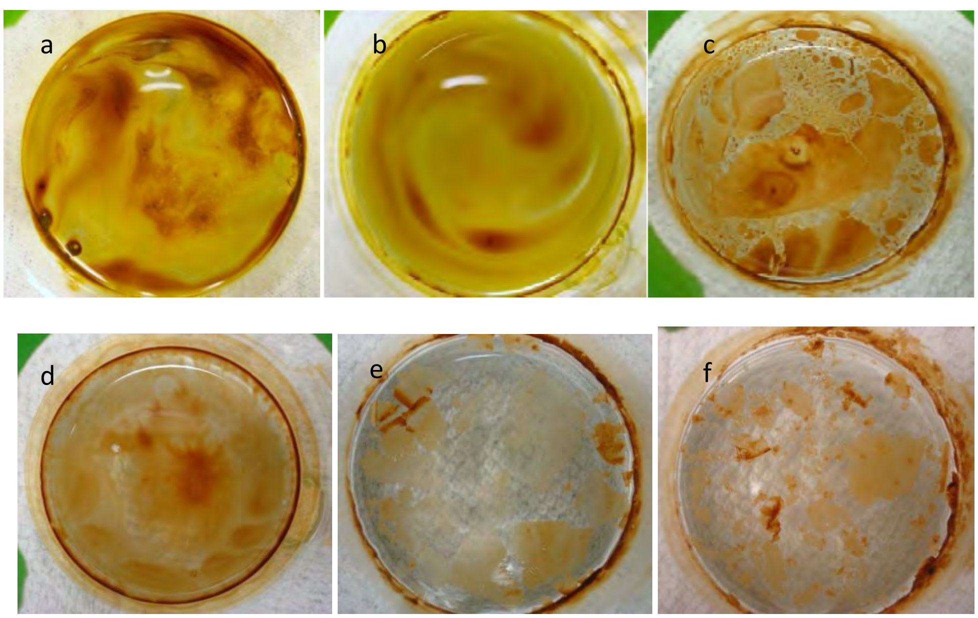

Figure 1. Appearance of oil as a function of irradiation time: (a) before irradiation, and after (b) 3 hours, (c) 6 hours, (d) 12 hours, (e) 24 hours, and (f) 48 hours irradiation.

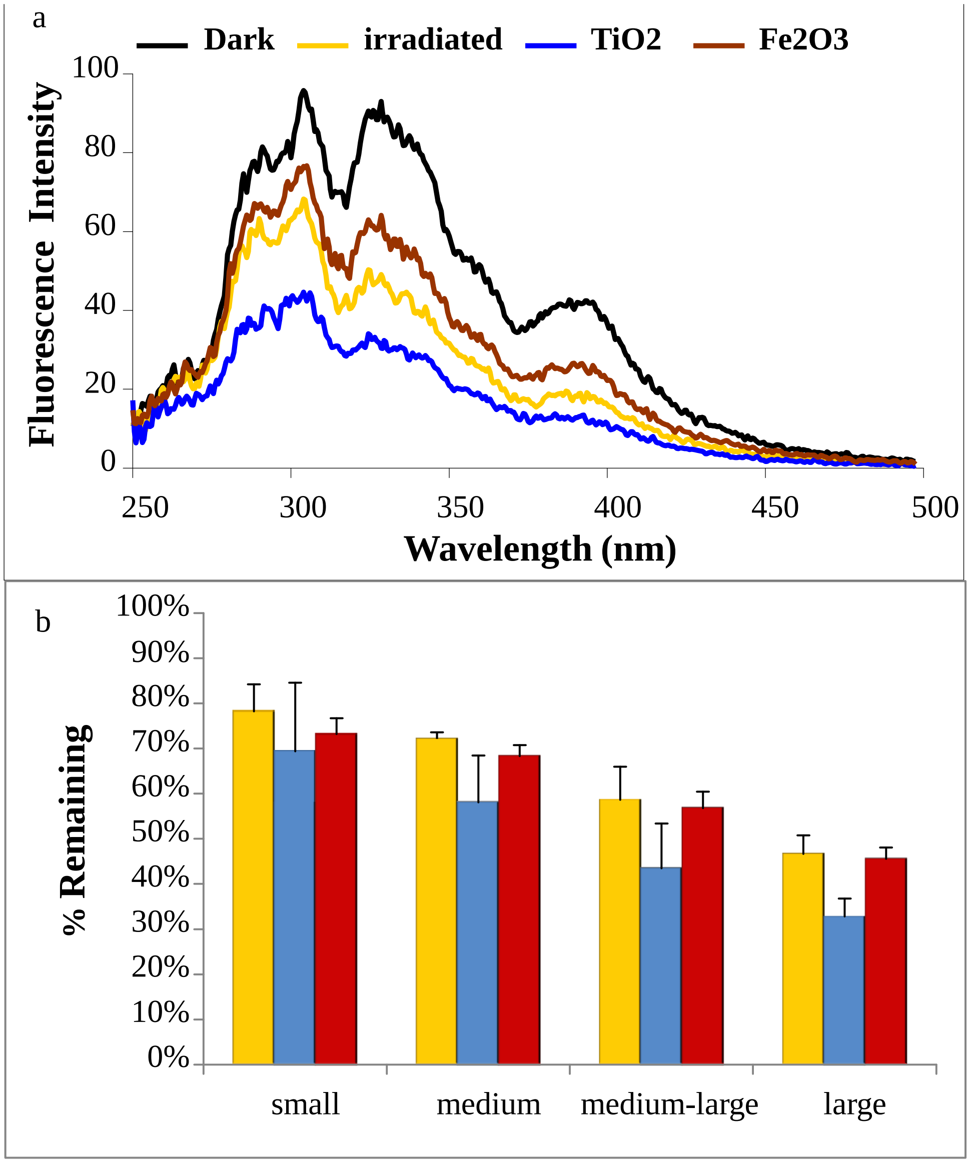

Figure 2. Synchronous scan of the (a) 3 hour irradiated samples with Δλ= 25nm. The percent remaining of PAH (b) after 3 hours for small (290 nm), medium (305 nm), medium-large (326 nm) and large (390 nm) molecules.

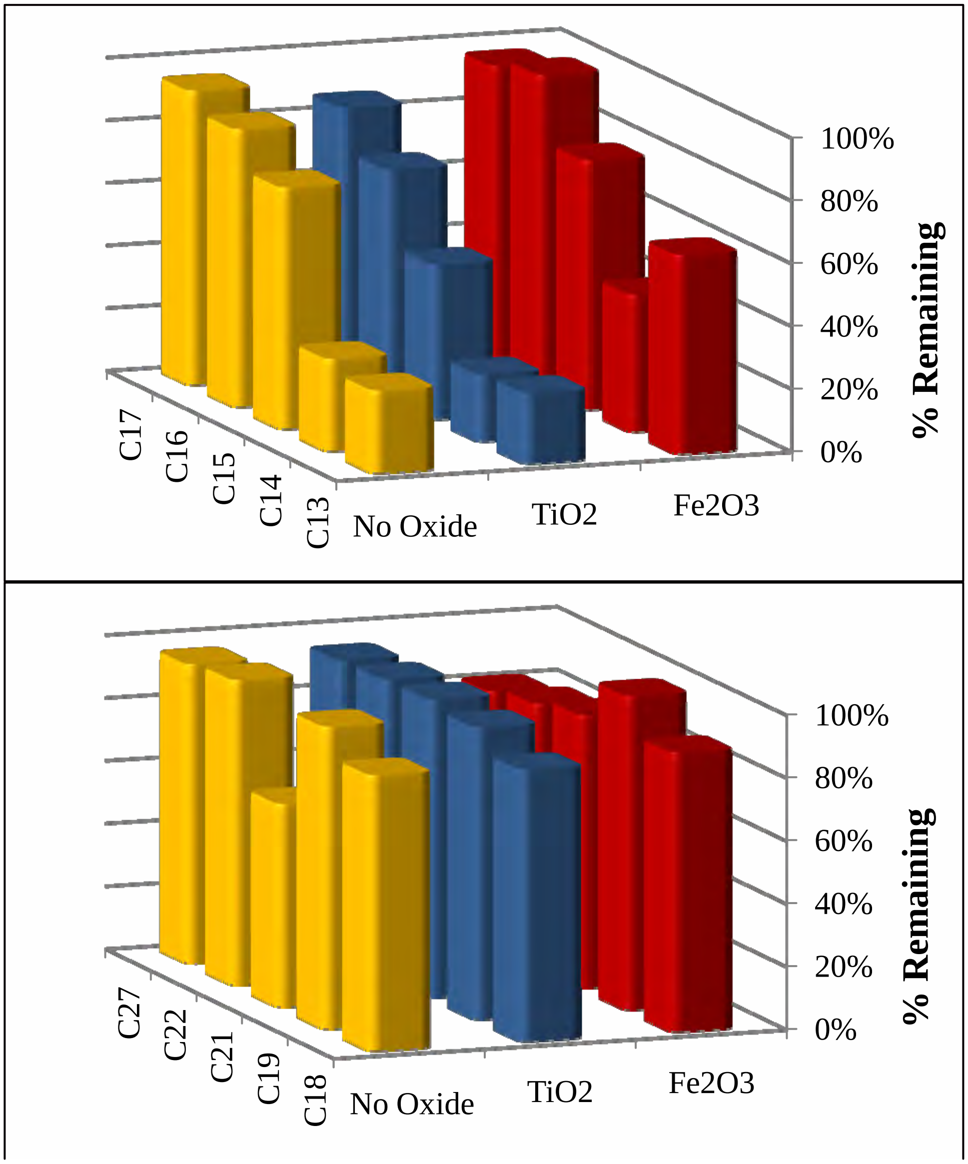

Figure 3. The GC-FID analysis of oil exposed to irradiation for 3 hours.

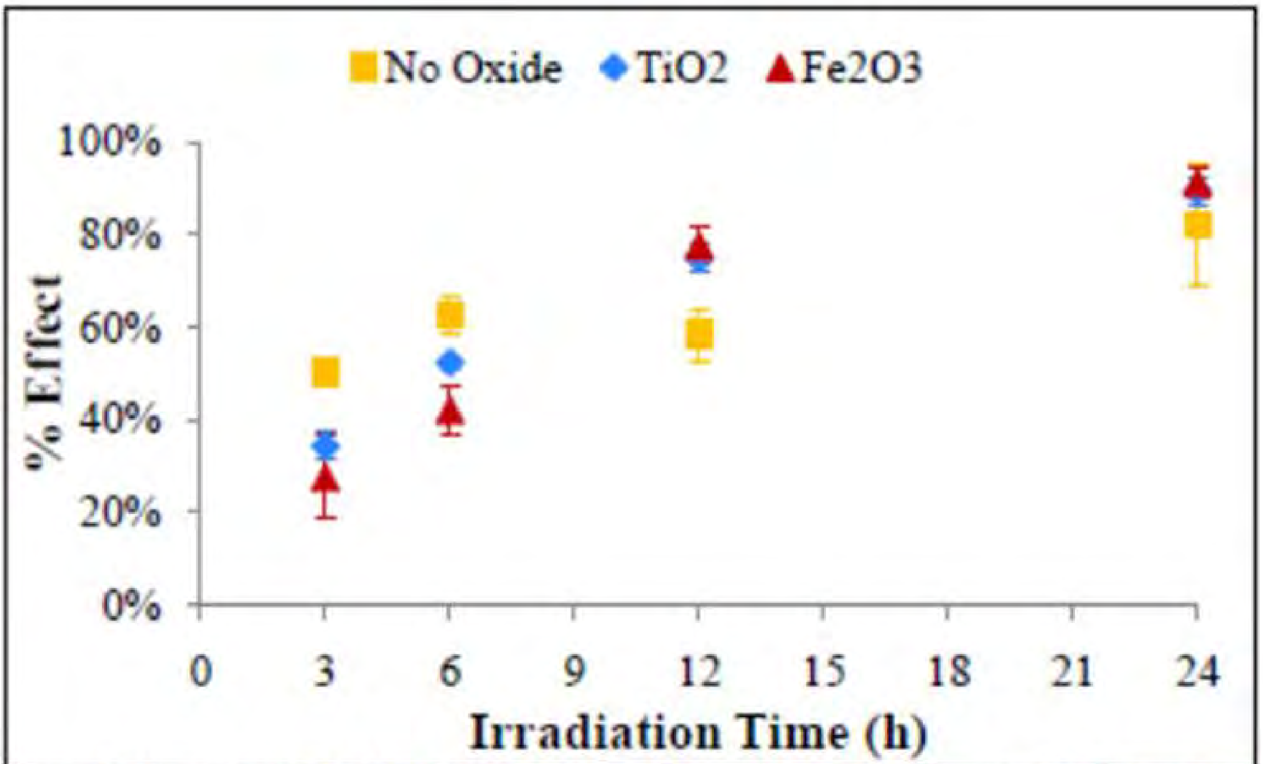

Figure 4. Microtox data of the toxicity of the aqueous layer of the irradiated samples. Results displayed were outcome from the comparison test for marine samples

Monitoring Key Ecosystem Components

Submerged Aquatic Vegetation

In the Rigolets and Lake Pontchartrain surveys *Ruppia maritima,* was present in most of the area sampled. However, *Vallisneria americana*, the historic dominate SAV species in Lake Pontchartrain, was only found in small beds west of the mouth of Bayou Bonfouca and *Najas guadulapensis* and *Potomogeton perfoliatis* were absent. *Ceratophyllum demersum, Potamogeton pusilis, Najas guadulapensis, Vallisneria americana, Zanachellia palustris* and *Ruppia maritima* were found in Bayou Bonfouca. *Vallisneria americana, Ruppia maritina, Najas guadulapensis*, and *Ceratophyllum demersum* were abundant behind the Mandeville breakwater near the mouth of Bayou Castine. An obvious difference between these data and historic data is the absence of *Vallisneria americana* from the Rigolets and adjacent waters and the shoreline of Lake Pontchartrain except near large streams. One might quickly conclude that this change was caused by oil damage. However, historic data indicates a gradual decline in of *V. americana* and other freshwater SAV in the study area, and severe damage to *Vallisneria* in the Rigolets and Lake Pontchartrain from Hurricane Katrina. Persistent higher turbidity and periods of high salinity have occurred since Katrina preventing *V. americana* recovery. The presence of healthy populations *Vallisneria* in streams, such as Bayou Bonfouca, which flow into the Lake should provides source populations for recovery if and when historic salinity and water clarity conditions return. No large Rangia clams were obtained from the three east Lake samples for the proposed condition index analysis. The absence of large clams is consistent with other benthic invertebrate studies currently being conducted in Lake Pontchartrain. It appears to be related to damage from severe hurricanes.

Oysters and Clams

Oysters were collected from Lake Borgne and Mississippi Sound in Louisiana on 4 January 2011 from two areas -- an area (Stations 1-3) that was affected by oil and an area (Stations 4-6) that was unaffected. A minimum of three dredge samples were taken at each station; if insufficient numbers of oysters were obtained, additional dredges were taken until at least 15 adult oysters (>75mm) were collected. Oysters were divided for subsequent analysis -- some for oil content (Tarr) and others for oyster population and condition metrics (Soniat). Ten oysters from each station were used to determine oyster condition, *Perkinsus marinus* (Dermo) infection, percent female and gonadal condition. The height of each oyster was measured. The oysters were shucked and the adductor muscle diameter (AMD) was measured. Shell weight and wet meat weight were measured for each oyster and used to calculate condition index (CI, meat weight/shell weight *100). Gonadal width (GW) was measured and a gonadal index (GI) was calculated as GW/AMD*100. Each oyster was sexed as female, male, or unknown and percent female was calculated for each site. A small tissue sample was taken for Dermo analysis and was incubated for one week using Ray's thioglycolate technique (Ray, 1966). After incubation, Dermo infection was rated from 0 (uninfected to 5 (heavily infected). Results of the statistical tests are not complete and the analysis of oil content is in progress, and thus the interpretation of the results should be considered preliminary.

A comparison of top (10.7 ^{O}C) and bottom (10.7 ^{O}C) temperatures, top (16.8 ppt) and bottom (18.0 ppt) salinities, and top (9.7 ppm) and bottom (9.5 ppm) oxygen concentrations, showed no evidence of stratification of the water column or depletion of oxygen. The mean salinity of the oiled area was higher (23.6 ppt) than the salinity of the un-oiled area (11.3 ppt). Oxygen concentrations were similar in the oiled (9.3 ppm) and un-oiled areas (9.9 ppm); likewise, water depths were similar at sites in the oiled (3.1 m) and un-oiled (3.0 m) areas. No observable oil was detected in any of the samples.

No live clams (*Rangia cuneata*) were found; however, recently-dead clams (organic periostracum intact) were found at lower-salinity, un-oiled sites. The dredge survey was designed to evaluate wholesale mortalities, and the presence and relative abundance of spat (0-25mm), seed (26-74mm), and adult (≥ 75 mm) oysters in oiled and un-oiled areas. Oyster spat, and seed were more abundant in the oiled area, whereas more adult oysters were collected from the un-oiled area. No boxes (articulated shells) of spat or seed were found in either area and only one adult box was found in each area, indicating that mortality was similarly low in the two areas.

Oysters from the oiled area had a higher gonadal index (7.8 vs.5.6), a similar condition index (9.45 vs. 9.42), and higher percent females (73% vs. 57%) than did oysters from the un-oiled area. Thus, the results from these sub-lethal measures of stress can be explained as a response to salinity and not pollution. No Dermo infection was found in oysters in the un-oiled area in contrast to a 43% infection of oysters in the oiled area. There is evidence that Dermo is exacerbated by pollutants such as hydrocarbons (Chu and Hale, 1994; Bushek et al., 2007), but the higher levels of Dermo at oiled sites may simply be a response to the higher salinities at the oiled sites. If chemical analysis shows higher hydrocarbon concentrations in oysters from the oiled area, then interpretation of the Dermo results are equivocal; however, if hydrocarbon concentrations are not higher in oysters from the oiled area, then it can be reasonably concluded that the distribution of disease follows the well-known pattern of enhanced levels of disease at higher salinity and is not a response to hydrocarbon pollution.

Nekton

The Nekton Research Laboratory (NRL) at the University of New Orleans has been conducting fisheries independent scientific surveys of the fish assemblages at the Chandeleur Islands, Biloxi Marsh, and Lake Borgne since 2003. We are in the process of comparing these data with post-oil spill data collected for the current NGI project. The NRL conducts scientific sampling at three stations along the Chandeleur Island chain, as well as at Grand Pass, Half Moon Island, and Rabbit Island at the Rigolets. These stations were sampled for 24 months straight from 2003-2004 and from May through October from 2005 through 2008 using triplicate samples with standard Louisiana Department of Wildlife and Fisheries gear types: beach seines, gillnets, and trawls. These gear types are specifically tailored to sampling small juvenile and young of the year (YOY) fish species because they utilize small mesh sizes of 2 inches down to ¼ inch.

While we are still in the process of analyzing all of the data, we can report some initial findings here regarding how fish assemblages in the Pontchartrain Estuary responding to the oil spill. We have yet to see significant changes in the numbers of fishes or the species composition of assemblages when we compared 2010 data with baseline data. Please note that not all of these analyses are completed, but we include here three examples that suggest assemblage change has not occurred to this point. Post-oil spill beach seine collections taken in December from Goose Point in the northeast of Lake Pontchartrain did show some compositional separation from baseline data (Figure 5) but these differences were not significantly different (ANOSIM, Global R = 0.169, p = 0.22). Similarly, November seine collections from Grand Pass in the Biloxi Marshes taken from before and after the oil spill were not significantly different (ANOSIM, Global R = 0.037, p = 0.40). Trawl samples from Half Moon Island in Lake Borgne were also not significantly different over time (ANOSIM, Global R = 0.074, p = 0.58). Although these results appear to be encouraging about the recovery of nekton species in the Pontchartrain Estuary, we reiterate here that we still need to analyze all the data and that the long-term impacts of the oil spill will have to be properly assessed. As we have seen with nekton responding to other recent impacts on the Pontchartrain Estuary (i.e., Hurricane Katrina and the 2008 Bonnet Carre Spillway opening), initial responses to disturbance are not that noticeable. The assumption is that unlike less mobile benthic organisms (e.g., Rangia clams), fishes, crabs, and shrimp can for the most part swim away from potential threats. The less obvious threat, though, is when the larval and juvenile stages of these organisms are killed by these disturbances. When this happens, the actual decline in populations will not be detected until that time when those larval and juvenile organisms should have recruited into the populations. This is typically on the scale of a few years. If we are going to effectively understand how this latest disaster has impacted the nekton, we need long-term sampling to compare post-oil spill data with our historical baseline data.

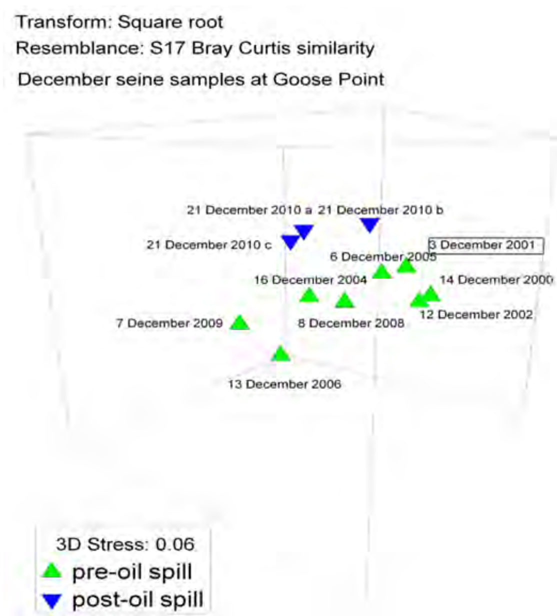

Figure 5. Three dimensional MDS plot of pre-post oil spill beach seine collections of fishes from Goose Point, Lake Pontchartrain. While post-oil spill collections from 2010 appear separate from baseline data, assemblage composition was not significantly different from baseline data collected from that site (ANOSIM, Global R = 0.169, p = 0.22).

Evaluating Important Estuarine processes

During each cruise, 26 casts (Fig. 6) were performed, documenting the estuarine gradient in terms of salinity, temperature, dissolved oxygen, and particulate properties. The cruises performed started in late fall, during which time, temperature in the estuary was relatively higher. Following the end of November, and through some frontal weather, the cruises capture the winter cooling of the estuary along the estuarine axis. Toward the Gulf side, some dynamic interaction with the coastal ocean is evident from the thermohaline structure, as well as evidence of dissolved oxygen dynamics in response to wind stress, and resulting mixing and momentum transfer from the atmosphere. Other interesting results observed were mainly in regards to the particle size distributions in the water column. Field data show rather large variations in the distributions in suspension between cruises, and show in some cases relatively mixed conditions. This could be in part due to the shallow nature of the estuary or due to wind-induced mixing. However, optical water properties vary little with depth, except for surface waters, which tend to produce higher acoustic backscatter intensity, suggesting higher sediment concentrations. Some stratification was observed, especially in deeper channels and inlets, but generally the largest gradients contributing to horizontal (along estuary) density gradients were largely related to temperature.

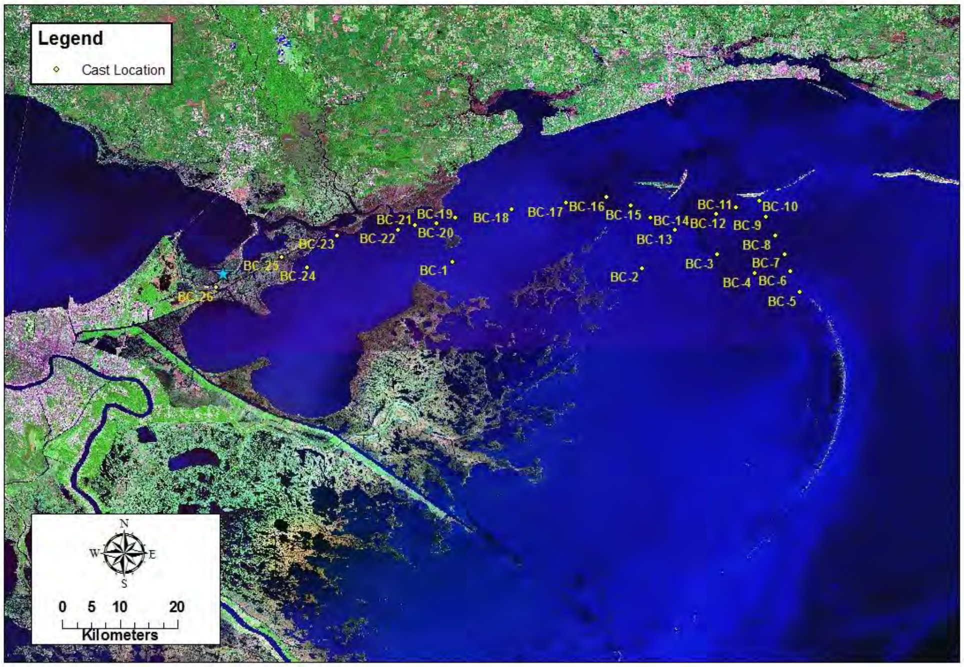

Figure 6. Map of estuarine process field sampling sites.

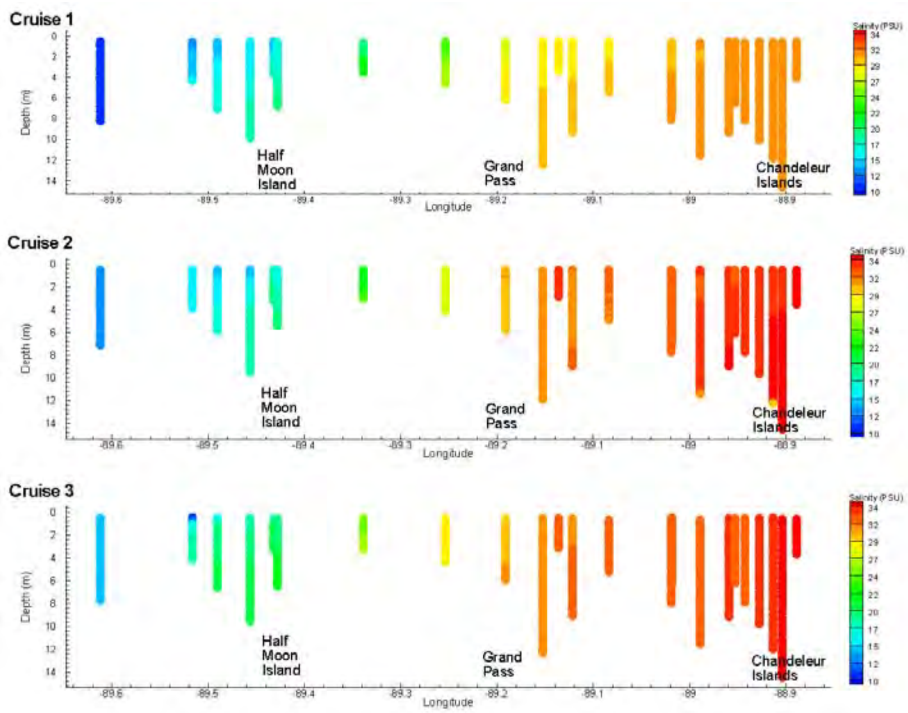

Figure 7. Salinity profile data – see Figure 6 for sampling locations.

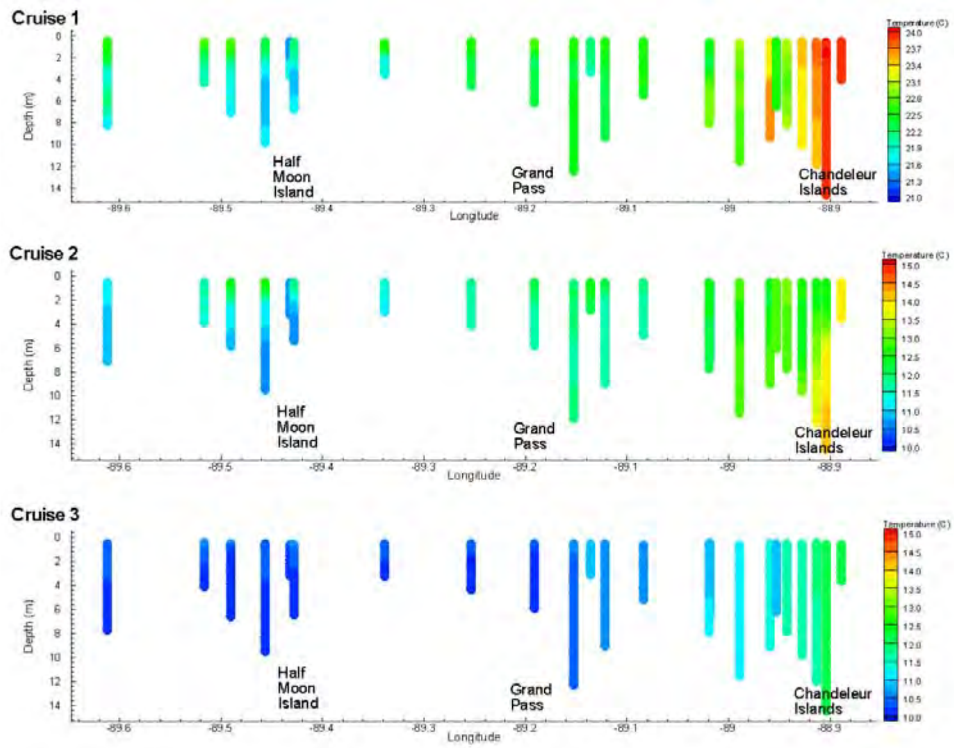

Figure 8. Temperature profile data. See Figure 6 for sampling locations

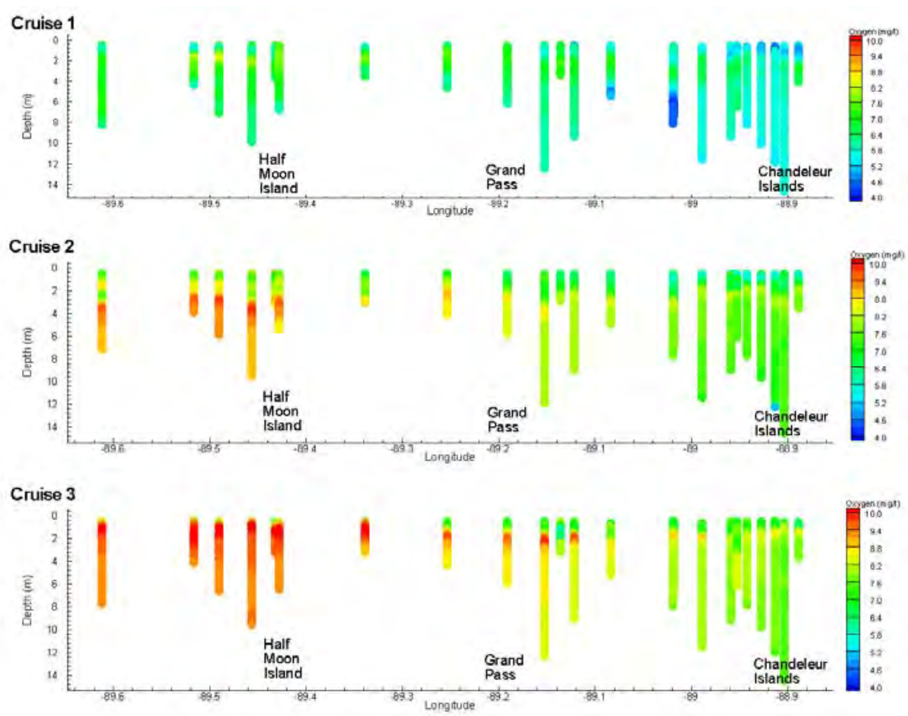

Figure 9. Oxygen profile data. See Figure 6 for sample locations.

13. Outreach activities:

Kulp presented an invited lecture within the Tulane University Law School "**Deepwater Horizon Lecture Series"**. The focus of the talk was the history behind the development of the Louisiana Sand berm construction, the berm significance in preventing the incursion of oil into Louisiana wetlands, and barrier island renourishment issues related to the construction of the berm. Tulane University, September 27, 2010, Tulane University, ~200 student and faculty participants

14. Peer Reviewed Articles:
None at this time.

15. Non-refereed articles and reports for this project:
None at this time.

16. List conference presentations and poster presentations for this project:

"Photolytic and photocatalytic degradation of oil from the Deepwater Horizon spill," S. M. King, P. A. Leaf[‡], A. M. Carter[†], A. R. Whitney[†], E. A. Balga*, and M. A. Tarr, 241st ACS National Meeting, Anaheim, CA, March, 2011.

"Photolytic and photocatalytic degradation of oil from the Deepwater Horizon spill," S. M. King, P. A. Leaf, A. M. Carter, A. R. Whitney, E. A. Balga, and M. A. Tarr, Joint 66th Southwest Regional and 62nd Southeast Regional Meeting of the ACS, New Orleans, LA, December, 2010.

"Photochemical Transformation of Surface Oil from the Deepwater Horizon Spill," M. A. Tarr, S. M. King, P. Leaf[‡], A. Carter[†], A. Whitney[†], and E. Balga, Collaborative Scientific Research Opportunities Relative to the Gulf Oil Spill, New Orleans, LA, November, 2010.

17. Has anyone from this project been hired by NOAA during this reporting period?
No

10-BP_GRI_USM-01: (Overall Summary): A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release

1. NGI Project File Number: 10-BP_GRI_USM-01 (Overall Summary)

2. Project Title: University of Southern Mississippi: a comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release

Stephan D. Howden

SCIENCE ACTIVITIES

1. General Summary: The Gulf of Mexico region is critically important to the U.S. from cultural, economic, natural resource, and recreational standpoints. An integrated and comprehensive strategy is proposed to i) characterize the distribution and transport of the oil in coastal waters of the northern Gulf of Mexico, ii) characterize the chemical form and evolution of oil and dispersant and potential contribution to coastal hypoxia, iii) assess the impacts of oil and dispersant on the coastal and and offshore habitat, food webs, and living marine resources, and iv) assess the impacts of the oil spill on public health and welfare. Within each of these themes, a series of tasks are proposed as follows:

I. Characterize distribution and transport of oil in coastal waters

a. Task 1: Coastal Observation Platforms in Support of Characterization of Oil Extent and Transport (Lead: Stephan Howden)

II. Characterize the chemical form and evolution of oil and dispersant and potential contribution to coastal hypoxia

b. Task 2: Chemical effects associated with leaking Macondo well oil in the Northern Gulf of Mexico (Leads: Alan Shiller and Laodong Guo)

III. Assess impacts of oil and dispersant on the coastal and estuarine habitat and living marine resources

c. Task 3: Monitoring and Assessment of Potential Impacts of Oil Contamination on Coastal and Marine Ecosystems and Food Webs in the northern Gulf of Mexico (Leads: Stephan Howden and Scott Milroy)

d. Task 4: Assessing Possible Impacts of the Deepwater Horizon Oil Spill on Summer Plankton Assemblages of the Inner Continental Shelf in the North Central Gulf of Mexico (Leads: Harriet Perry and Bruce Comyns)

e. Task 5: Responses of Benthic Communities and Sedimentary Dynamics to Hydrocarbon Exposure in Neritic and Bathyal Ecosystems (Leads: Kevin Yeager, Charlotte Brunner, Vernon Asper, Kevin Briggs, Chet F. Rakocinski, Richard W. Heard, Harriet Perry, Don Johnson and Dick Waller)

f. Task 6: Monitoring the impacts of dispersed oil exposure on ecologically and economically important species in the northern Gulf of Mexico (Leads: Joe Griffitt and Robin Overstreet)

g. Task 7: Microbial Response to Macondo Oil and Dispersant (Leads: D.J. Grimes and Kevin Dillon)

h. Task 8: Salt marsh habitat sampling to delineate potential oil impacts from BP Deepwater

Horizon spill (Leads: Patrick Biber, Wei Wu and Mark Peterson)

i. Task 9: Investigation of Juvenile Fishes Associated With Pelagic Sargassum Habitat in the North Central Gulf of Mexico (Leads: Jim Franks, Bruce H. Comyns, and Eric R. Hoffmayer)

IV. Assess the impacts of the oil spill on public health and welfare.

a. Task 10: Public Health Impact of Gulf Oil Spill: Assessment of Risk and Health Education (Leads: Amal Mitra and James McGuire)

b. Task 11: Adaptation and Resilience of Mississippi Residents to the BP Oil Disaster (Lead: Tom Osowski, Tim Rehner, and Alan Bougere)

2. Results and scientific highlights:

Task 1:

- Surface currents in the Mississippi Bight were provided to NOAA OR&R, and other emergency responders, during the project period and are archived for research studies.
- Surface currents are being used to help understand unusual marine life mortality events.

Task 2:

- In the deep plume near 1100 m depth, enriched levels of PAH concentrations, of probable biological significance, were found out to a distance of at least 15 km from the wellhead.
    - We observed fractionations in PAH composition compatible with solubility effects. This includes enrichments in the more soluble methyl-naphthalene component relative to other PAH components near the wellhead followed by a progressive decrease in the percentage of methyl-naphthalenes with distance away from the wellhead.
    - In surface waters, the methyl-naphthalene percentage also decreased rapidly with distance away from the wellhead, probably due to volatilization.
- We observed depletions in nitrate and phosphate in the sub-surface plume, associated with oxygen depletion, consistent with large blooms of oil and gas-consuming organisms.
- Small enrichments in some dissolved metals were observed
    - Co (which has very low background concentrations
    - Ba (likely derived from drilling fluids used in the topkill procedure)
- Distributions of dissolved Fe and Mn appear to have been affected by benthic inputs. Careful examination of our data also suggestions possible Fe limitation of methanotrophic organisms and possible input of Mn from the top kill.
- Elevated DOC concentrations, higher absorption values, and lower spectral slope or higher molecular weight DOM were found in the surface waters during May and early June 2010. Two types of DOM were found in the water column, one with high optical reactivity but low in abundance and the other with low optical reactivity but high in DOC concentration. The fluorescence EEM spectra of both surface oil and seawater samples strongly resemble those of crude oil, with maximum Ex/Em centered on 226/340 nm. Four fluorescence components were identified using multivariate PARAFAC analysis: three of them are oil components and the fourth component is UV humic-like DOM. Based on the dynamic changes between the fluorescence components in the water samples, two components were the degradation products of crude oil and contained mostly lower molecular weight materials, whereas one component was preferentially degraded through photochemical processes.

Task 3:

- 100% of the tissue samples gathered from various species within the MS Sound from 30 Aug – 03 Sep 2010 indicated PAH concentrations (specifically, C_0-Naphthalene) well above background levels:
  - 7,190 – 42,620 ppb C_0-Naph within whole-body *Penaeus aztecus* (Brown Shrimp)
  - 15,670 – 30,340 ppb C_0-Naph within whole-body *Crassostrea virginica* (Eastern Oyster)
  - 31,360 ppb C_0-Naph within whole-body *Anchoa mitchilli* (Bay Anchovy)
  - 570 – 14,700 ppb C_0-Naph within the viscera of *Brevoortia patronus* (Gulf Menhaden)
- In all but one tissue sample from 30 Aug – 03 Sep 2010, C0-Naphthalene was the onlyPAH measured above detection limits; all alkylated forms of PAHs (incl. alkylated Naphthalenes) were absent from all 30 Aug – 03 Sep 2010 tissue samples, indicating disparities between the source crude, potential routes of exposure, and/or preferential sequestration/bioaccumulation of C_0-Naph which require further elucidation.
- Using FDA protocols to establish acceptable "Levels of Concern" (LOC) for PAHs, only one tissue sample from 30 Aug – 03 Sep 2010 (MC4 Shrimp) contained PAHs other than C_0-Naph, and these exceeded the cancer-risk LOC using Benzo(a)Pyrene Equivalents (BaPE).
- Despite C_0-Naph levels within the 30 Aug – 03 Sep 2010 tissues being well above background concentrations, PAHs were below detection limits (<10 ppb) in all sediment samples from 30 Aug – 03 Sep 2010. By contrast, dissolved PAHs (specifically, C_0-Naph) ranged from <0.01-0.14 ppb; PAHs within the particulate fraction ranged from <0.01-1.39 ppb (20-53 μm size fraction) to <0.01-0.24 ppb (53+ μm size fraction) for the 30 Aug – 03 Sep 2010 samples. These results indicate a greater likelihood of PAH exposure (and subsequent bioaccumulation) from the water column and from the ingestion of suspended particulates rather than from the sediments.
- At no time, at any station, were sediment PAHs above detection limits.
- During water sampling within the MS Sound on 27 Sep 2010, dissolved PAHs (specifically, C_0-Naph) ranged from <0.01-0.11 ppb and PAHs among the particulates were below detection limits.
- During water sampling at offshore GIP stations from 11-20 Oct 2010, dissolved PAHs (specifically, C_0-Naph) ranged from <0.01-0.80 ppb.
- By 21 Nov 2010, dissolved PAHs were below detection limits at all stations save that furthest offshore (NGI8), where C_0-Naph was 0.04 ppb.
- By 21 Nov 2010, PAHs within the suspended particulates and all tissues were below detection limits, indicating the complete depuration of C_0-Naph within the biota. However, further analyses of additional petrogenic hydrocarbon biomarkers (*e.g.* hopanes, steranes, triterpanes) and the presence of PAH metabolites (*e.g.* Naphthols) within these tissues is warranted to confirm depuration endpoints (which will therefore enable a calculation of natural depuration rates). Also, the presence/absence and concentration(s) of various PAH metabolites will also help to establish the relative toxicity of PAH exposure (primarily from C_0-Naph) and the residence time of potentially toxic PAH-metabolites.
- The dominance of C_0-Naph, and the absence of alkylated PAHs, will make it more difficult to establish the source of PAH contamination as BP crude without the addition of petrogenic hydrocarbon biomarker analysis (*e.g.* hopanes, steranes, triterpanes). As these analyses were not funded within this project, these analyses were not conducted; however, they represent a great need in the assimilation of the data discussed herein.
- As alkylated PAHs comprised a significant portion of the source oil, it is as yet unknown why none of the alkylated PAHs were measured above detection limits in any of the samples analyzed. This may be due to the reduced solubility of alkylated PAHs (in comparison to parent PAHs); however, a thorough investigation of these dynamics is warranted.

- Analyses of Total Organic "C-band" content within the biota indicated the whole thorax ("head") of *Penaeus aztecus* (Brown Shrimp) could contain up to 97.2% of the total organic content of the whole organism when compared to the shelled abdomen ("tail"). Hence, the FDA seafood safety protocol of analyzing only shelled tails for PAH contamination may be warranted for organisms choosing to ingest only the shelled tails of shrimp. Therefore, any organism ingesting the entire shrimp may be receiving a much larger PAH dosage than the FDA protocol would suggest.

Task 4:

- Although the sample collections were small due to limited funding, it appears that densities of anchovy larvae two months after the Deepwater Horizon oil spill was capped were lower than during the five or six year period before the spill. This would be of ecological importance because anchovies are a primary food source for many species of fish. Red snapper larvae were actually more abundant in post-spill bongo collections than in pre-spill collections, but this might be the result of small sample sizes and patchy distributions of larvae. More credence is given to the disparity in anchovy abundances before and after the oil spill because of the large and consistent differences.
- No evidence of hydrocarbon or dispersant presence was detected in zooplankton or pelagic prey fish as a part of this study. Molecular analysis was not completed due to sample loss in a faulty freezer but this portion of the study will be extended into Phase II in order to further examine molecular responses of plankton and fish to dispersed oil and dispersant.

Task 5:

- We currently have total, sedimentary PAH concentrations for 7 of 19 bathyal sites. These data compare favorably to the spatial trend of total, sedimentary PAH concentrations provided in the Operational Science Advisory Team's (OSAT) first report (2010) (Fig. 2). While we have identified some stations where the concentrations of total PAHs at the sediment surface (1 cm) are above background (Fig. 3), we have not yet determined if the composition, or "fingerprint," of the hydrocarbons in these samples is, or is not, consistent with Macondo oil as a source.
- In the context of the question about whether hypoxia in the Mississippi Bight has been exacerbated, extended, or reduced under where the oil slick occurred, qualitative observations showed that the abundance of fish in trawls and plankton tows and live macrofauna from the hypoxic floor of the Chandeleur channel were dramatically lower than elsewhere in the Mississippi and Chandeleur Sounds. Quantitative results and interpretation will require the integration of data from water column instrumentation, discrete water samples, organic geochemistry, sedimentology, radiochemistry and benthic ecology. No surface water slicks of oil were observed at any station during the August-September sampling.
- We continue to work on understanding the impacts to and responses of benthic meio- and macrofaunal communities that have been exposed to hydrocarbons derived from the Deepwater Horizon spill in the environments sampled. Qualitative observations show that live meio- and macrofauna survived in noticeable numbers in all samples collected, includes sample GIP-16, which had the highest concentration of PAH measured to date in our collection.

  The one exception was samples collected from the deep Chandeleur channel, which was hypoxic in early September 2010.
- While water column hydrocarbons were suggested at some stations whee sampling of bottom sediments were performed, based on fluorescence data collected using a Chelsea Aquatracka, discrete water samples are still being analyzed to definitively address this.

Task 6:

- The assemblage of croaker parasites from the 2010-2011 collection consisted conservatively of 29 species. The assemblage present between 1970 and 2008 consisted of approximately 31 species. Of these during the 2010-2011 sampling period, 12 species of parasites showed at least some possible evidence of exposure to petroleum hydrocarbons. These parasites included four species of external ones with direct life cycles, five additional adult ones from the digestive tract, and three species of larval parasites that inhabit the body cavity and mesentery of the host croaker.
- Sections through gill tissue stained with hematoxylin and eosin revealed a variety of signs. Hyperplasia, a condition in which there is an increase in cell number in the gill lamellae, along with damaged and leaking cells, was pervasive in samples. Additionally, the presence of the potentially harmful parasitic protozoan organisms epitheliocystis and *Amyloodinium ocellatum* was noted in September and October, with infections of *A. ocellatum* in October reaching dangerously high levels.
- During November 2010 and into 2011, *A. ocellatum* was not detected in sections. The presence of *A. ocellatum* in October may or may not have been the product of petroleum products present in the water column. When fish are immuno-compromised, (as could happen when stressed by the presence of petroleum hydrocarbons), infection with *A. ocellatum* has the potential to cause major mortality in populations of Atlantic croaker.

Task 7:

- Results from incubations with filtered and unfiltered treatments show that "background" bacterial production rates (BPRs) in untreated control incubations were lower than BPRs measured from 2008 to 2009.
    - Bacterial production was highest in the unfiltered control in September 2010 (11.45 $\mu g\ C\ L^{-1}\ d^{-1}$) and was below 5.85 $\mu g\ C\ L^{-1}\ d^{-1}$ for the remainder of the experiments in all treatments where bacterial growth was observed. Of the 32 total treatments run, 19 showed a small to dramatic decrease in bacterial abundance in 48 hr incubations.
    - Dispersant only treatments exhibited the largest reduction in biomass (as high as 60%).
- In control incubations, DOC concentrations ranged from 337 to 909 µM (4.04 to 10.91 mg/L) and overlapped with the previously reported range (181-640 µM or 2.17-7.68 mg/L, Carpenter 2009). The highest DOC concentrations measured to date at the GCRL pier were measured in the October 7, 2010 experiment. Initial DOC concentrations ranged from 1470 to 3970 µM (17.64 to 47.64 mg/L) except for the first dispersant experiment (15000 µM or 180 mg/L). Increases and decreases in DOC and TDN concentrations were observed during the incubations. The 0.2 µm filtered treatments showed no COD in the Corexit treatment. Control and dispersant incubations at 7°C had lower bacterial production, DOC uptake and respiration rates than incubations conducted at 20°C.
- The observed reduction in BPRs during the 2010 experiments relative to 2008 to 2009 experiments suggests that the oil spill did have a quantifiable impact on water column bacterial activity in Mississippi Sound. Oil and dispersant treatments exhibited similar oxygen

  uptake to the control treatments, but bacterial abundance of dispersant treatments were lower than control treatments, sometimes by as much as 60%. These results suggest that some bacteria are negatively affected by Corexit dispersant, reducing the total bacteria population, but the remaining bacteria thrive under the conditions and maintain respiration rates similar to control conditions.

Task 8:

- Oil came ashore in Mississippi saltmarshes over a period of time, ~early June to late September, 2010. Timing of heavy oiling in the marsh was observed to coincide with tropical storm systems, including Hurricane Alex (30 June -1 July), Tropical Storm Bonnie (24-25 July), and Tropical Depression #5 (12-13 August), which all brought strong southerly winds and a storm surge pushing ashore GOM waters. The elevated tides associated with the storm surge contributed to further inland penetration of the floating oil mats than predicted. Despite this, most oil was observed to coat vegetation (primarily S. alterniflora) within less than 10 meters from open water.
- The crude oil coating the immediately affected leaves within these small heavily oiled areas appears to have resulted in acute leaf effects by blocking transpiration and gas exchange through the stomata, and subsequent plant mortality, but new shoots and plants re-grew rapidly from intact roots within three months after the initial contamination.
- Oil was very patchy, both on arrival and after subsequent degradation, making it hard to detect without significant sampling effort on a fine spatial scale (1m2 or finer). Some of the heavily oiled areas were less than 50x50m2 in total, and substantial patchiness of the oil within this size area was also observed. Many of the oil patches which washed ashore were much smaller than this, on the order of less than 0.25m2. Because of this highly localized impact it was important to use a stratified random sampling approach, based on apriori knowledge of impact locations. Much of the shoreline remained clear of heavy oiling, making it difficult to extrapolate to ecosystem-level contamination.
- The contaminants detected from patches where oil was generally still visible at the time of sampling was composed of mainly longer carbon-chain compounds, C19-C36 non-halogenated organic chemicals. ORO was always detected analytically when oil was visible at time of sampling, but was also found in areas where oil was no longer visible (GBNERR, HI). When oil was not visible at the time of sample collection, the hydrocarbons were mainly found in plant tissues, suggesting biological uptake of contaminants, which could become bioavailable in the food chain as the plant tissues decompose after winter senescence. The different mechanisms involved in hydrocarbon concentrations in plants and sediments could also partly explain different patterns detected in the observations and statistical analysis.
- Natural degradation processes of the oil that was washed ashore in the marsh include weathering (temperature, sunlight), but also physical removal by waves and tides. In particular, sites exposed to the predominant south-easterly winds, common during the summer in this region, experienced substantial tidal “cleaning” with oil being removed during high tides and periods of strong wave action corresponding to tropical storms in the GOM. Warm temperatures, often exceeding 35^{o}C during the day are also common in the region from June through September, promoting rapid volatilization of lighter carbon fractions. Oil that was observed to persist over time at MP quickly became more asphalt-like in its appearance and consistency, which correlates to reduced toxicity.
- No oil was found in animal tissues analyzed, albeit the limited number of samples that satisfied the requirement for the minimum amount of sample needed (3 grams) to detect contamination affects this conclusion. A more extensive and better designed sampling strategy is required to determine if habitat contamination might be affecting the lower food chain populations. Other scientific studies conducted on offshore larval populations of marsh nekton detected oil contamination in blue crab larvae, indicating the potential for contamination of the lower food chain by oil.

Task 9:

- Although the primary objective of the project was to describe, assess and compare the diversity and abundance of juvenile fishes collected from ‘visibly’ oil-impacted *Sargassum* with ‘visibly’ non-impacted *Sargassum*, no ‘visibly’ impacted *Sargassum* was encountered during any of the three sampling cruises.
- The findings of this project represent valuable information pertaining to living marine resources and an essential pelagic habitat that will better inform NOAA, Gulf fishery councils and commissions, and Gulf states regarding the Gulf of Mexico ecosystem-based management decision making process.
- The project provided further evidence that pelagic *Sargassum* is critical habitat, particularly critical nursery habitat, for a diverse assemblage of species, many of which support valuable commercial and recreational fisheries. Identification of essential fish habitats in the Gulf of Mexico is critical to effective management of those habitats and species which utilize them. Pelagic *Sargassum* is one of those critical habitats.
- Critical data and information gaps exist in regard to current scientific understanding of the pelagic ecosystem in the northern Gulf of Mexico, particularly the northern Gulf region. This project provides new information on the diversity and abundance of young fishes (and macro invertebrates) that inhabit or associate with pelagic *Sargassum* habitat in the northern Gulf of Mexico. Although none of the pelagic *Sargassum* habitat encountered and/or sampled during the project’s field research activities was ‘visibly’ impacted by oil, the scientific collections for this study were taken from the north central Gulf of Mexico during the months of September 2010, December 2010, and January 2011 following the Deepwater Horizon spill. Project results are available for use in the protection, restoration and management of coastal and ocean resources through an ecosystem approach to management.

Task 10:

- People in the Gulf Coast, Mississippi had experienced two important disasters in the recent years, namely Hurricane Katrina and the BP Oil Spill. It was not easy to separate out the impact of the two events; however questions were asked specific to the events separately. Overall, 57% of the study population had to move from their own houses to another place because of Katrina. In Hancock County alone, 93% of the people moved out; this was significantly higher than the figures in the other two counties. On an average, they stayed in temporary shelters or houses for more than one year. After Katrina, housing mortgage payments went up in the affected areas. It was significantly higher in Jackson County compared to Hancock County ($p = .008$). Household income dropped more in Hancock County, and it was significantly greater compared to that in Jackson County. In general, about 14% of the study people were worried that their jobs could still be negatively affected by the BP Oil Spill
- This is the first study that addressed physical and mental health symptoms among the general population. Earlier studies reported such illnesses among cleanup and other workers directly involved in the disasters. However, because of the nature of the study design, it was not possible to identify if symptoms were attributable to the BP Oil Spill or other disasters. Based on this study, more mental health symptoms were observed among the residents, compared to their physical symptoms.
- A significantly higher proportion of people without having any health insurances or those who lost health insurances because of loss of jobs reported more mental health problems compared to those who had any existing health insurances. For example, people without health insurance reported having more sadness or mood changes (31% vs. 18%, $p = .03$),

compared to those having health insurance. Similarly, people without health insurances reported significantly more argument behaviors (24% vs. 10%, p = .004), compared to those with health insurance.

- Based on self-assessment of the risk of the BP Oil Spill on physical and mental health, the majority of the study population (85%) reported that their physical health was about the same after the BP Oil Spill. However, a significantly fewer people in Hancock county (59% in Hancock, 83% in Harrison, and 86% in Jackson, p = .003) believed that their mental health was about the same after the BP Oil Spill. Over 40% of the study people were worried that the BP Oil Spill might eventually affect their health.

Task 11:

- The significant findings from this study show that most persons living in Coastal Mississippi did not have an increase in depressive symptoms as a result of the BP Oil Disaster. Utilizing the CESD rating, approximately 14% of the sample scored higher than the cut-off point for depression. This score falls within a normal range for community level data.
- Another finding of interest, was those persons who had less education, (defined as less than a college degree) tended to have higher levels of depression than those with higher levels of education. We infer this is likely due to employment variables that are more associated with the seafood industry, and/or tourism.

3. Cruises & field expeditions:

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
R/V Pelican		A. Dierks	Early, rapid response to the incident	Early May, 2010
R/V Walton Smith		S. Joye	Investigation of the subsurface oil.gas plume	Late May/early June 2010
R/V Cape Hatteras		K. Yeager	Post-incident investigation of water column chemistry & collection of sediments	Mid-October 2010
R/V *Tom McIlwain*		Kevin Yeager	Collections of samples from Mississippi and Chandeleur Sounds	8/30, 9/1, and 9/3/2010
R/V *Tommy Munro*		J. Franks	Pendleton collected water samples and Sargassum for microbial analysis	June 2010
R/V *Ferrel*		T. Hazen	M. Pendleton collect water samples for presence of Vibrio species	3 legs in July 2010

R/V Tom McIwain		K. Dillon	Wilking collected offshore water for bacterial respiration experiments	10/20/2010
RV/Tommy Munro		James Franks	Pelagic sargassum studies in the northern Gulf of Mexico post-DWH spill; assessments of associated juvenile fishes	9 & 10/2010
LeMoyne	R/V	S. Milroy	PAHs in sed. & biota (MS Sound)	09/27/10
McIlwain	R/V	S. Milroy	PAHs in sed. & biota (MS Sound)	11/21/10
RV/TOMMY MUNRO		Perry	Surface neuston plankton collections	9/25/10-9/29/10
?		S. Curran and R. Overstgreet	Atlantic Croaker Collections for parasites	9/17/10
?		S. Curran and R. Overstgreet	Atlantic Croaker Collections for parasites	9/24/10
?		S. Curran and R. Overstgreet	Atlantic Croaker Collections for parasites	10/1/10
?		S. Curran and R. Overstgreet	Atlantic Croaker Collections for parasites	10/14/10
?		S. Curran and R. Overstgreet	Atlantic Croaker Collections for parasites	10/21/10
?		S. Curran and R. Overstgreet	Atlantic Croaker Collections for parasites	11/5/10
?		S. Curran and R. Overstgreet	Atlantic Croaker Collections for parasites	11/11/10
?		S. Curran and R. Overstgreet	Atlantic Croaker Collections for parasites	11/27/10
?		S. Curran and R. Overstgreet	Atlantic Croaker Collections for parasites	3/17/11
Singing River Island HFR Station		Stephan Howden	Field trip to try and reduce reflected power	6/2/2010
Singing River Island HFR Station		Stephan Howden	Field trip to replace cut power cables	6/16/2010
Orange Beach, AL HFR		Stephan Howden	Field trip to troubleshoot system	6/23/2010

Station				
Orange Beach, AL HFR Station		Stephan Howden	Field trip to replace loop antennas and perform antenna beam pattern	6/29/2010-6/30/2010
Singing River Island HFR Station		Stephan Howden	Attach ground-plane antenna	7/7/2010
Singing River Island HFR Station		Stephan Howden	Troubleshooting	7/15/2010
Singing River Island HFR Station		Stephan Howden	Attempted repairs, but had to stop due to thunderstorms	7/16/2010
Singing River Island HFR Station		Stephan Howden	Moved transmitting antenna	7/19/2010
Singing River Island HFR Station		Stephan Howden	Electronics were getting too hot, so we drove to the station and discovered the ac unit was broken	9/9/2010
Singing River Island HFR Station		Stephan Howden	Replaced broken ac unit	9/14/2010
Orange Beach, AL HFR Station		Stephan Howden	Electronics heating up. Troubleshooting trip led to discovery of ac unit icing up. Melted ice.	10/11/2010
Henderson Beach State Park HFR Station		Stephan Howden	Installed a networked power strip so that we can remotely hard reboot the system.	10/14/2010

4. Peer-reviewed publications, if planned:

Published, peer-reviewed bibliography (Copies of the papers are requested)
TASK 2:

Diercks, A.R., R.C. Highsmith, V.L. Asper, D. Joung, Z. Zhou, L. Guo, A.M. Shiller, S.B. Joye, A.P. Teske, N. Guinasso, T.L. Wade, and S.E. Lohrenz, 2010. Characterization of subsurface polycyclic aromatic hydrocarbons at the Deepwater Horizon site. *Geophysical Research Letters 37*: L20602, doi:10.1029/2010GL045046.

Wade, T.L, S.T. Sweet, J.L. Sericano, N.L. Guinasso, Jr, A.-R. Diercks, R.C. Highsmith, V.L. Asper, D. Joung, A.M. Shiller, S.E. Lohrenz & S.B. Joye, 2011. Analyses of water samples from the Deepwater Horizon oil spill: Documentation of the sub-surface plume. In: "Monitoring and

Modeling the *Deepwater Horizon* Oil Spill: A Record-Breaking Enterprise" (Y. Liu, A. MacFadyen, Z.-G. Ji, & R.H. Weisberg, Editors) AGU Geophysical Monograph Series, Vol. 195, pp 77-82.

a. Manuscripts submitted or in preparation (Please note target journal, and anticipated date of publication or submission)

TASK 1:

Carmichael, R. H., W. M. Graham, A. Aven, G. Worthy, and S. Howden (2012), Were Multiple Stressors a 'Perfect Storm' for Northern Gulf of Mexico Bottlenose Dolphins (Tursiops Truncatus) in 2011?, Submitted PLoS ONE (accepted with revisions).

TASK 2:

Crespo-Medina,M., A. Vossmeyer, K. S. Hunter, C. D. Meile, A.-R. Diercks, V. L. Asper, J. P. Chanton, A.M. Shiller, D.-J. Joung, J. Brandes, C. Mann, J. J. Battles, J. P. Montoya, T. A. Villareal, M. Wood, R.M.W. Amon, and S. B. Joye. Evolution of water column methane dynamics following the 2010 Macondo blowout in the Gulf of Mexico. Submitted to Nature Geoscience, March 2012.

Zhou, Z., L. Guo, A.M. Shiller, S.E. Lohrenz, V.L. Asper, and C.L. Osburn. Characterization of oil components from Deepwater Horizon oil spill in the northern Gulf of Mexico using fluorescence EEMs and PARAFAC modeling. To be submitted to Environmental Science and Technology, April 2012.

Joung, D. and A.M. Shiller. Trace element distributions in the water column affected by the Deepwater Horizon blowout. To be submitted to Environmental Science and Technology, April 2012.

Shiller, A.M., D. Joung, T. Wade, S. Sweet, and J. Sericano. Fractionation of polycyclic aromatic hydrocarbons in waters near the Deepwater Horizon blowout site. To be submitted to Environmental Science and Technology, May 2012.

TASK 3:

Detection of PAH-metabolites and biomarkers within the coastal Mississippi food webs affected by the Deepwater Horizon oil spill, Scott P. Milroy and Ken Scally. Target journal: J. Environ. Forensics (draft in progress; submission planned for September 2010).

Petrochemical contamination and seafood safety in coastal Mississippi: A critical analysis of the FDA standards in use during the Deepwater Horizon oil spill, Scott P. Milroy and Andreas Moshogianis. Target journal: J. Fisheries and Aquatic Science (draft in progress; submission planned for July 2010).

TASK 7:

Dillon, KS, L. Wilking, and K. Carpenter. In prep. Short term response of water column bacterial growth and respiration to nutrients and dissolved organic matter in the Northern Gulf of Mexico. for submission to Coastal, Estuarine and Shelf Science during April 2012

TASK 8:

Patrick D. Biber, Wei Wu, Mark S. Peterson, Linh Pham. (submitted Jan 2011). Oil impacts to saltmarsh habitats from the BP Deepwater Horizon spill. Marine Pollution Bulletin. Rejected by Editor after a single peer-review response.

Patrick D. Biber, Wei Wu, Mark S. Peterson. (in prep). Oil impacts to saltmarsh habitats from the BP Deepwater Horizon spill: environmental contamination and plant responses. Pages X-X in Impacts of Oil Spill Disasters on Marine Fisheries and Habitats in North America. J. Brian Alford, Mark S. Peterson and Christopher Green, editors. CRC Press, Boca Raton, FL

TASK 11*:

"Resiliency and Adaptation of South Mississippi Communities Following Recurrent Disasters" Tom Osowski, Lacey Mai Boswell, and Brandon Dobson.

"Descriptive and Inferential Statistics on Depression for the BP Oil Spill Survey in Mississippi Gulf Coast". Tom Osowski, Alan Bougere, Tim Rehner and Amal Mitra.

"Descriptive and Inferential Statistics of Children's Behavior for the BP Oil Spill Survey in Mississippi Gulf Coast". Tom Osowski, Alan Bougere, Tim Rehner and Amal Mitra.

"Public health impact of the BP Oil Spill in Mississippi Gulf Coast". Mitra AK, Osowski T, Bougere A, Rehner T, McGuire J.

* Co-Is did not provide report in new template

5. Presentations and posters, if planned:

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Task 1					
Applications of High Frequency Radar for Emergency Response in the Coastal Ocean: Utilization of the Central Gulf of Mexico Ocean Observing System during the Deepwater Horizon Oil Spill and Vessel Tracking	Stephan D. Howden	Stephan Howden, Don Barrick, and Hector Aguilar	SPIE Ocean Sensing and Monitoring Conference, April 26-27, 2011 Orlando, FL.	Y	4/26-4/27/2011

Applications of High Frequency Radar Surface Currents for Response to the Deepwater Horizon Oil Spill	Stephan D. Howden	Stephan D. Howden	*Oil Spill.* Deepwater Horizon Oil Spill Principal Investigator One Year Update Workshop, St Petersburg, FL October 25-26, 2011	Y	10/25-10/26/2011
The Integrated Ocean Observing System in the Gulf of Mexico	Stephan D. Howden	Stephan D. Howden	Oceans in Action TechSurge Workshop, Marine Technology Society, 22-23 August, 2011. Biloxi, MS.		8/22-8/23/2011
Task 2					
Trace element distributions in waters affected by the Deepwater Horizon oil spill.	D. Joung	D. Joung and A.M. Shiller	2010 Fall Meeting, AGU, San Francisco, Calif.	Y	13-17 Dec. 2010
Documentation of Sub-Surface Oil Plume by Analyses of Toxic PAH in Water Samples from the Deep Water Horizon Oil Spill.	T. Wade	Wade, T.L., Sweet S.T., Sericano, J.L., Guinasso, N.L. Jr., Lohrenz, S.E., Shiller, A.M., Joye, S.B, Dierks, A.R., Asper, V.L. and Highsmith, R.C.	SETAC 31th Annual Meeting	Y	7-11 Nov. 2010
Polycyclic aromatic hydrocarbon, trace element, and nutrient distributions as affected by the Deepwater Horizon Oil Spill.	A.M. Shiller	Shiller, A.M., D. Joung, T.L. Wade, J.L. Sericano, S.T. Sweet, K.M. Yeager, C.A. Brunner, and P. Louchouarn	SOST Workshop, St. Pete Beach, FL	Y	Oct. 2011
Polycyclic Aromatic Hydrocarbon Distribution and Modification in the Sub-surface Plume Near the Deepwater Horizon Wellhead	A.M. Shiller	Shiller, A.M., D. Joung, T.L. Wade	AGU 2011 Fall Meeting, San Francisco, CA	Y	Dec. 2011
Deepwater Horizon Polycyclic Aromatic Hydrocarbon Distribution and	A.M. Shiller	Shiller, A.M., D. Joung, T.L. Wade, J.L. Sericano, S.T. Sweet, K.M. Yeager,	2012 Ocean Sciences Meeting	Y	Feb. 2012

Modification from wellhead to coastal marshes		C.A. Brunner, and P. Louchouarn			
Characterization of oil and dispersant in the northern Gulf of Mexico using fluorescence EEM and size fractionation techniques	L. Guo	Zhou, Z., Guo, L., Shiller, A.M. and Lohrenz, S.E.	Oil Spill conference in New Orleans, sponsored by NSF and Louisiana Board of Regents		Nov. 1-2, 2010
Influence of oil and dispersant on optical properties of dissolved organic matter in the Mississippi Sound/Bight	Z. Zhou	Zhou, Z., Guo, L., Shiller, A.M. and Lohrenz, S.E.	2010 Alabama-Mississippi Bays & Bayous Symposium	Y	December 1-2, 2010
Optical characterization of Crude Oils and Dispersant Used in the Northern Gulf of Mexico by Fluorescence EEM Techniques	L. Guo	Guo, L. Zhou, Z., Shiller A.M. and Lohrenz S.E. 2010.	2010 AGU Fall Meeting	Y	December 13-17, 2010
Optical properties of DOM from the Gulf of Mexico after the Deepwater Horizon oil spill.	Z. Zhou	Zhou, Z., Guo, L., He, H. and Shiller, A.M.	Deepwater Horizon Oil Spill Principal Investigator One Year Update Workshop, FL	Y	October 25-26, 2011
Task 3					
Polycyclic Aromatic Hydrocarbon (PAH) Contamination within Mississippi Sound Biota (presentation)	S.P. Milroy	Milroy, S.P, A.M. Moshogianis C.A. Brunner S. Howden K. Yeager	Northern Gulf Institute (NGI) Annual Conference, Mobile, AL	Y (online)	05/18/11
The Summer of Glub: Preliminary Results from Hypoxia and Oil Spill Studies in the MS Sound (presentation)	S.P. Milroy	Milroy, S.P.	Univ. of Southern Mississippi Dept. Marine Science Seminar: Dept. Biology Seminar:	 N N	 10/22/10 02/16/11
PAH Contamination within the MS Sound (presentation)	S.P. Milroy	Milroy, S.P.	Public Outreach Delta Discussion Group:	 Y (online)	 06/23/11

			(New Orleans, LA) Sierra Club: (Biloxi, MS)	N	12/05/11
Task 4*					
Impacts of Deepwater Horizon oil spill to estuarine fish growth and ecosystem functionality	Brewton, R.A	Brewton, R.A., R. J. Griffitt, and R.S. Fulford	American Fisheries Society Southern Division Spring Meeting, Tampa, FL		January 14,2010
Task 5					
Deepwater Horizon: Coastal ocean to marsh margin sedimentary impacts [oral presentation].	Kevin M. Yeager	C. A. Brunner, K. B. Briggs, P. Louchouarn, L. Guo, V. Asper, K. J. Schindler, K. M. Martin, J. Prouhet, N. Couey, C. Fortner	*American Association of Petroleum Geologists Annual Convention and Exhibition*, Houston, Tx., http://www.searchanddiscovery.com/abstracts/html/2011/annual/abstracts/Yeager.html	Y	April 10-13, 2011.
Deepwater horizon: Coastal ocean to marsh margin sediment impacts. [poster]	Patrick Louchouarn (not given, but abstract published)	K. M. Yeager, C. A. Brunner, K. Briggs, L. Guo, V. Asper, N. Couey, C. Fortner, J. Prouhet, K. J. Schindler, K. M. Martin, Z. Zhou, J. Loeffler, A. Jung, V. Cruz	*241st American Chemical Society (ACS) National Meeting*, Anaheim Ca., http://abstracts.acs.org/chem/241nm/program/view.php?obj_id=80358&terms=	Y	3/27-31/2011
NSF RAPID and NGI-BP: Response of benthic communities and sedimentary dynamics to hydrocarbon exposure in intertidal, neritic and bathyal ecosystems of the northern Gulf of Mexico [Poster].	Charlotte Brunner	Yeager, K. M., C. Brunner, L. Guo, P. Louchouarn, K. Briggs	*National Science Foundation: Collaborative Scientific Research Opportunities Relative to the Gulf Oil Spill*, New Orleans, La.	N	11/1-2/2010
Task 6*					
Changes in the parasite fauna of the	Stephen	Stephen Curran and	Southeastern Society of Parasitologists Annual		

Atlantic croaker, *Micropogonias undulatus*, from coastal waters impacted by the Deepwater Horizon oil spill	Curran	Robin Overstreet	Meeting at Unicoi State Park, Helen, Georgia		4/08/2011
Task 7					
Marine Bioremediation: The Microbial Response to the Deepwater Horizon Incident	DJ Grimes	DJ Grimes	9th International Marine Biotechnology Conference Qingdao, PR China	N	10/11/2010
Effects of Macono Oil and Corexit Dispersant on Bacterial Respiration and Growth	KS Dillon	KS Dillon and L. Wilking	2011 NGI Conference	N	5/16/2011
Task 8					
Using PAM to detect Oil Stress in Spartina Alterniflora	Patrick Biber	Patrick Biber	Bays and Bayous Symposium	Y	Dec 2010
Using PAM to detect Oil Stress in Spartina Alterniflora	Patrick Biber	Patrick Biber	Benthic Ecology Meeting	Y	Mar 2011
Task 11*					
Deep Water Horizon Release Incident: Community Impact Assessment	Tom Osowski	Tom Osowski, Alan Bougere, and Tim Rehner	National Association of Social Workers – Mississippi Chapter, Annual Meeting. Jackson, MS.		03/23/2011
The Gulf Coast that Could. Resiliency and Adaptation in South Mississippi	Lacey Mai Boswell, and Brandon Dobson	Lacey Mai Boswell, and Brandon Dobson	National Association of Social Workers – Mississippi Chapter, Annual Meeting. Jackson, MS		03/23/2011

* Co-Is did not provide report in new template

6. Other products or deliverables:

Task 1:

Howden, S. D., D. Barrick and H. Aguilar. *Applications of High Frequency Radar for Emergency Response in the Coastal Ocean: Utilization of the Central Gulf of Mexico Ocean Observing System during the Deepwater Horizon Oil Spill and Vessel Tracking*, in Ocean Sensing and Monitoring III, edited by Weilin W. Hou, Robert Arnone, Proceedings of SPIE Vol. 8030 (SPIE, Bellingham, WA, 2011) doi: 10.117/12.884047.

Howden, S. D., Applications of High Frequency Radar Surface Currents for Response to the Deepwater Horizon Oil Spill, in Deepwater Horizon Oil Spill Principal Investigator Workshop Final Report (http://www.marine.usf.edu/conferences/fio/NSTC-SOST-PI-2011/documents/SOST_2011_DWH_Workshop_Final_Report.pdf)

Braatz, Andrea, An Analytical Study of Air-Sea CO2 Gas Exchange in the Northwest Mississippi Bight Region, University of Southern Mississippi, Masters Thesis, 2011.

Task 2:

Video of presentation at 2011 AGU Fall Meeting is at http://sites.agu.org/fallmeeting/scientific-program/sessions-on-demand-7-december/

Task 9:

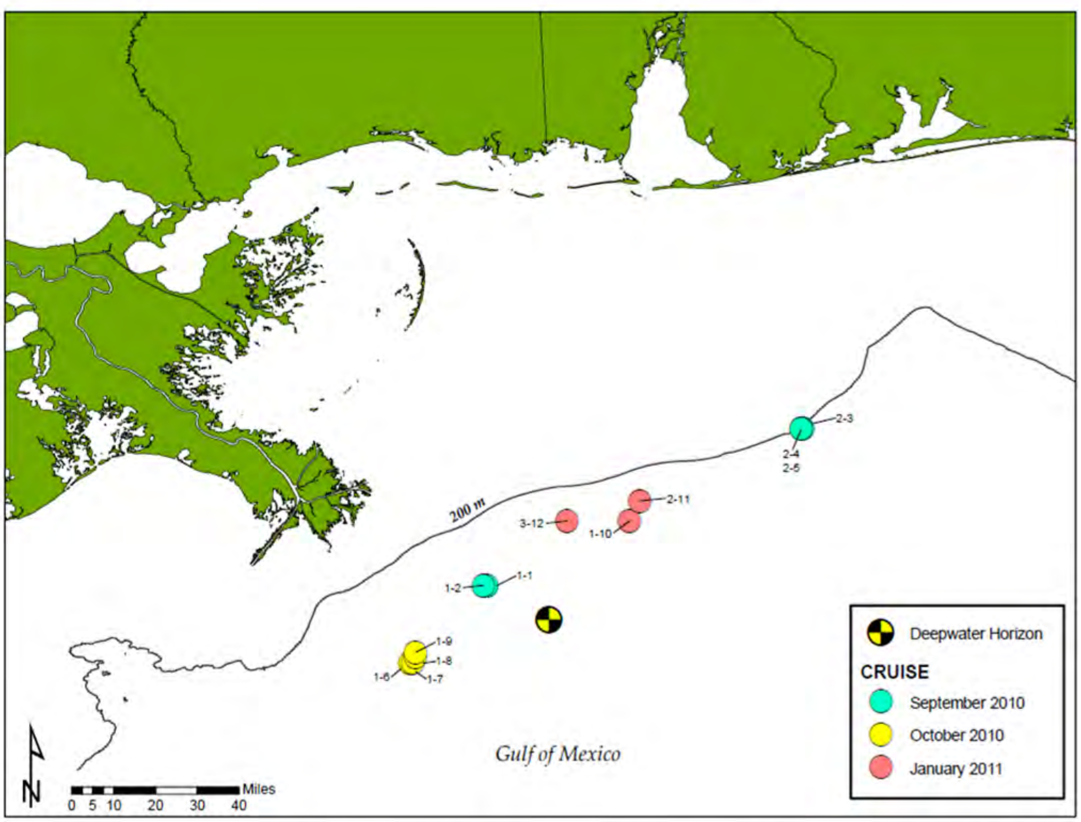

Figure 1. Study Area. The location of each collection site is labeled as "Station - Collection Number". (See Table 1 for specific N Latitude and W Longitude for each of the 12 collections.)

7. Data

Task 1 &Task 2

In general, data is/will be presented in publications, theses, and dissertations listed above. Samples are almost entirely consumed in the analytical procedures, so there are no relevant archived samples.

Task 3

Due to the rapid application for (and review of) Phase I proposals, there was no requirement for (or inclusion of) a data archiving schedule and/or plan; nor were there any funds set aside for this purpose. Without funded support for data archival personnel, the scientific workload on the PI and Co-PIs has caused significant delays in the archival and availability of project-related data.

Task 4 & Task 5

Data of various kinds have been compiled and will be reported to the Harte Research Institute as papers are published. Physical samples (as opposed to sensor data) have aliquots or fractions that are retained, though typically these require special handling that an archive cannot offer, so they are maintained in the PI's laboratory. Attached are two spreadsheets of ancillary information on the location and status of such archived samples.

Task 8 (See Task 8)

- *NGI Oil – Animal Map121610*
- *NGI Oil – Plant Map121310*
- *NGI Oil – Soil Map121310*

Task 9:

All Project data were entered and stored in the Excel file titled:

Final NGI Sargassum Project Data.xlsx

All data and data analyses can be found as reported in Figures and Tables provided in the Project Final Report, submitted to NGI in April 2011. A copy of that report is attached to this document.

All project data and biological samples are archived at the Gulf Coast Research Laboratory and available upon request.

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Steven	Lohrenz	PI (7/2/2010-6/30/2011)	USM, now UMASS-D	slohrenz@umassd.edu
Stephan	Howden	Co-I (7/2/2010-6/30/2011) PI (7/15/2011-3/31/2012)	USM	Stephan.howden@usm.edu
Kjell	Gundersen	Scientific Participant	USM	Kjell.gundersen@usm.edu
Jamie	Davis	Technician (Data Manager)	USM	Jamie.davis@usm.edu
Richard	Slaughter	Technician (Electronics)	USM	Richard.slaughter@usm.edu
Robyn	Montgomery	Administrative Support (Contract Specialist)	USM	Robyn.montgomery@us.edu
Alan	Shiller	Co-PI	USM	Alan.shiller@usm.edu
Laodong	Guo	Co-PI	USM (now at U. Wisc.)	guol@uwm.edu
Scott	Milroy	Co-PI (lead)	USM	Scott.milroy@usm.edu
Stephan	Howden	Co-PI	USM	Stephan.howden@usm.edu
Kjell	Gundersen	Co-PI	USM	Kjell.gundersen@usm.edu
Karen	Orcutt	Co-PI	USM	
Charlotte	Brunner	Scientific Participant	USM	
Kevin	Yeager	Scientific Participant	USM	
Kevin	Martin	Technician	USM	
Andreas	Moshogianis	Lab/Field Assistant	USM	
Kim	Johnson	Admin/Grant Support	USM	
Harriet	Perry	PI	USM	Harriet.perry@usm.edu

Bruce	Comyns	Co-PI	USM	Bruce.comyns@usm.edu
Richard	Fulford	Co-PI	USM (now EPA/Gulf Breeze)	
Jay	Dieterich	Technician	USM	
Kevin	Yeager	Co-PI	USM	kevin.yeager@usm.edu
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Patrick	Louchouarn	Collaborator	TAMUG	loup@tamug.edu
Robin	Overstreet	Co-I (lead)	USM	Robin.overstreet@usm.edu
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D. Jay	Grimes	Principle Investigator	USM	Jay.grimes@usm.edu
Kevin	Dillon	Principle Investigator	USM	Kevin.Dillon@usm.edu
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Wei	Wu	Co-PI	USM-GCRL	Wei.wu@usm.edu
Mark	Peterson	Co-PI	USM-GCRL	Mark.peterson@usm.edu
Scott	Caldwell	Technician	USM-GCRL	n/a
James	Franks	Co_PI (lead)	USM-GCR	Jim.franks@usm.edu
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Eric	Hoffmayer	Co-PI	Former - USM-GCRL Current - NOAA/NMFS	eric.hoffmayer@noaa.gov
Dyan	Gibson	Research Associate	USM-GCRL	dyan.gibson@usm.edu
Jason	Tilley	Research Associate	USNM-CGRL	jason.tilley@usm.edu
Amal	Mitra	Co-I	USM	Amal.mitra@usm.edu

Tom	Osowski	Co-PI (lead)	USM	Tom.osowski@usm.edu
Tim	Rehner	Co-PI	USM	tim.rehner@usm.edu
Alan	Bougere	Co-PI	USM	alan.bougere@usm.edu

*Co-Is did not supply report in updated template

MENTORING AND TRAINING

9. Student and post-doctoral participants:

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Andrea	Braatz	MS	An Analytical Study of Air-Sea CO2 Gas Exchange in the Northwest Mississippi Bight Region.	USM	Stephan Howden	Successfully defended June 2, 2011
Amy	Kern	BS	Summer Internship: CenGOOS CODAR surface currents analysis	USM	Stephan Howden	Summer 2011
Huijun	He	Post-doc		USM	L. Guo	
Yinghao	Chen	MS		USM	A. Shiller	
DongJoo	Joung	PhD	Metals in LA/MS shelf region	USM	A. Shiller	2012
Zhengzhen	Zhou	PhD	Characterization of DOM influenced by oil in the Gulf of Mexico	USM	L. Guo	2012
Kusumica	Mitra	MS	Dynamics of carbohydrates in the Mississippi Sound and Mississippi Bight in the northern Gulf of Mexico	USM	L Guo	2012

Andreas	*Moshogianis*	*PhD*	*Dynamics of Hypoxia in MS Sound/Bight*	*USM*	*Milroy, S.P.*	*2015*
Rachael	Brewton	MS				
Valerie	Cruz	MS	Live foraminifera at oiled and unoiled sites in the bathyal GOM	USM	C. Brunner	2013
Valerie	Hartmann	MS	Hypoxia	USM	K. Briggs/C. Brunner	2011
Shivakumar	Shivarudrappa	PhD	Hypoxia	USM	K. Briggs/S. Lohrenz	2013
Jeremy	Prouhet	MS	Physical properties of sediment	USM	K. Yeager	2011
Michael	Dalton	BS	NA	TAMUG	P. Louchouarn	2011
Lenai	Despins	BS	NA	TAMUG	P. Louchouarn	2011
Natalie	Marcussen	BS		USM		
Duncan	Perkins	BS		USM		
Jessica	Parker	MS		USM		
Lynn	Wilking	MS	Bacterial respiration in surface waters and biofilm communities of artificial reefs in MS Sound	USM	K. Dillon	2013
Marcia	Pendleton	MS	Vibrio motility and the role of cellular attachment in oil degredation	USM	D.J. Grimes	2013
Adrienne	Flowers		Role of turbidity and substrate type in the distribution of Vibrio	USM	D.J. Grimes	2013

			parahaemolyticus			
Linh	Pham	PhD	n/a	USM-GCRL	Biber	n/a
Bradley	Ennis	MS	n/a	USM-GCRL	Peterson	n/a
Lina	Fu	MS	n/a	USM-GCRL	Wu	n/a
Lacey	Boswell	BA		USM		
Brandon	Dobson	BS		USM		
Justin	Jackson	BA		USM		

*Co-I's did not supply report in updated template

n/a indicates student's dissertation/thesis research was NOT funded by GoMRI activities.

10. Student and post-doctoral publications, if planned:
a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation

Task 1:

Braatz, A., S. D. Howden, S. E. Lohrenz, C. Sabine and R. Wanninkhof (2012), An Analytical Study of Air-Sea CO_2 Gas Exchange in the Northwest Mississippi Bight Region (In Preparation. To be submitted to Journal of Geophysical Research).

Task 7:

Dillon, KS, L. Wilking, and K. Carpenter. In prep. Short term response of water column bacterial growth and respiration to nutrients and dissolved organic matter in the Northern Gulf of Mexico. for submission to Coastal, Estuarine and Shelf Science during April 2012

11. Student and post-doctoral presentations and posters, if planned:

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Task 3					
Comparisons of Organic Content with Brown Shrimp (Penaeus aztecus) Affected by the Deepwater Horizon Oil Spill (poster)	Moshogianis, A.	Moshogianis, A. Milroy, S.P.	Northern Gulf Institute (NGI) Annual Conference, Mobile, AL	N	05/18/11
Task 7					
Poster: Methods and Measurements: Effects of Macono Oil and Corexit Dispersant on Bacterial Respiration and Growth	L. Wilking	L. Wilking and KS Dillon	2011 NGI Conference	N	5/16/2011

12. Images:

Please see the attached individual task reports.

10-BP_GRI_USM-01 (Task 1): A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release - Task 1: Coastal observation platforms in support of characterization of oil extent and transport

1. NGI Project File Number: 10-BP_GRI_USM (Task 1)

2. Project Title: A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release - Task 1: Coastal Observation platforms in support of characterization of oil extent and transport

Stephan D. Howden

SCIENCE ACTIVITIES

1. General Summary: Even after the flow of oil from the Macondo wellhead site stopped, there continued to be a need to track the movement of oil in the surface waters of the northern Gulf of Mexico. This task provided support to maintain CODAR stations for the Central Gulf of Mexico Ocean Observing System (CenGOOS) through December of 2010. Funding for CenGOOS, through the NOAA CSC, ended in June 2010 and it was vitally important to keep the stations operational and providing surface current information over the Mississippi Bight for oil spill trajectory forecasting. The NOAA Office of Response and Restoration (OR&R) used the surface current data from the stations in developing their oil spill trajectory forecasts. The primary objective of this effort was to provide a near-real time and archived characterization of surface currents in the northern Gulf of Mexico shelf region west of the Mississippi Birdfoot delta, as a resource for NOAAA/OR&R and for GRI funded research projects.

The use of high frequency (3-50 MHz) radar (HFR) for monitoring surface currents has been done since the early 1970's. USM has been operating long-range CODAR HFR stations since October 2007. USM has 3 long-range CODAR stations that operate in the 4.3-5.4 MHz range. Each station is capable of along shore range of 100-220 km and offshore range of 140-220 km. Range resolution can vary from 3 and 12 km with angular resolution varying between 1-5 degrees. The stations are located at Singing River Island in Pascagoula, MS, Gulf State Park in Orange Beach, AL, and Henderson State Park in Destin, FL. Each station retrieves the component of the current ("radials") along radial directions from the receive antenna. Where these radials overlap between stations, the total surface current vector ("totals") can be estimated.

It was crucial to minimize any downtime of the three CenGOOS HF radar stations, especially while there was surface oil in the Gulf from the Deepwater Horizon well. This required monitoring of operations and quick response to any problems that arose in the station systems. This effort is labor intensive and requires attention to a variety of details including power, telemetry, radar systems, and computers that are all operating in a hostile and vulnerable environment.

USM archived (and continues to archive) both the radials and totals. Additionally, the radials were automatically transferred by ftp to the national HF Radar Network (HFRNet), where totals are computed using different algorithms. This project addressed the following research themes of the Northern Gulf Institute (NGI), NOAA Strategic Goals, Gulf of Mexico Alliance (GoMA) and Gulf of Mexico Research Initiative (GRI)

NGI:

- NGI Theme #2: Geospatial data/information and visualization in environmental science
- NGI Theme #4: Coastal hazards and resiliency

NOAA Strategic Goals:

- Strategic Goal #1: Protect, restore, and manage the use of coastal and ocean resources through an ecosystem approach to management
- Strategic Goal #3: Serve society's needs for weather and water information
- Strategic Goal #4: Support the Nation's commerce with information for safe, efficient, and environmentally sound transportation
- Strategic Goal #5: Provide critical support for NOAA's mission

Gulf of Mexico Alliance Priority Issues:

- Water Quality
- Habitat Conservation and Restoration
- Coastal Community Resilience

Gulf of Mexico Research Initiative Themes:

- Physical distribution, dispersion and dilution of contaminants under the action of ocean currents and tropical storms
- Environmental effects of the oil/dispersant system on the sea floor, water column, coastal waters, shallow water habitats, wetlands, and beach sediments, and the science of ecosystem recovery
- Technology developments for improved mitigation, detection, characterization and remediation of oil spills

2. Results and scientific highlights:

- NOAA OR&R used the surface current data from these stations for guidance in producing their surface oil forecasts.
- Archived surface currents in the Mississippi Bight. These surface currents can be downloaded from the national servers at Scripps and NOAA/NDBC and are freely available to scientists to use for their research related to the oil spill or otherwise.
- From the surface current time series, trajectories of virtual water parcels were created to shed light on where dead turtles may have originated, and for understanding dolphin mortality in the northern Gulf.

3. Cruises & field expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
Singing River Island HFR Station		Stephan Howden	Field trip to try and reduce reflected power	6/2/2010
Singing River Island HFR Station		Stephan Howden	Field trip to replace cut power cables	6/16/2010
Orange Beach, AL HFR Station		Stephan Howden	Field trip to troubleshoot system	6/23/2010
Orange Beach, AL HFR Station		Stephan Howden	Field trip to replace loop antennas and perform antenna beam pattern	6/29/2010-6/30/2010
Singing River Island HFR Station		Stephan Howden	Attach ground-plane antenna	7/7/2010
Singing River Island HFR Station		Stephan Howden	Troubleshooting	7/15/2010
Singing River Island HFR Station		Stephan Howden	Attempted repairs, but had to stop due to thunderstorms	7/16/2010
Singing River Island HFR Station		Stephan Howden	Moved transmitting antenna	7/19/2010
Singing River Island HFR Station		Stephan Howden	Electronics were getting too hot, so we drove to the station and discovered the ac unit was broken	9/9/2010
Singing River Island HFR Station		Stephan Howden	Replaced broken ac unit	9/14/2010
Orange Beach, AL HFR Station		Stephan Howden	Electronics heating up. Troubleshooting trip led to discovery of ac unit icing up. Melted ice.	10/11/2010
Henderson Beach State Park HFR Station		Stephan Howden	Installed a networked power strip so that we can remotely hard reboot the system.	10/14/2010

4. Peer-reviewed publications, if planned:
a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation

Carmichael, R. H., W. M. Graham, A. Aven, G. Worthy, and S. Howden (2012), Were Multiple Stressors a 'Perfect Storm' for Northern Gulf of Mexico Bottlenose Dolphins (*Tursiops Truncatus)* in 2011?, *Submitted* PLoS ONE (accepted with revisions).

5. Presentations and posters, if planned:

Title	**Presenter**	**Authors**	**Meeting or Audience**	**Abstract published (Y/N)**	**Date**
Applications of High Frequency Radar for Emergency Response in the Coastal Ocean: Utilization of the Central Gulf of Mexico Ocean Observing System during the Deepwater Horizon Oil Spill and Vessel Tracking	Stephan D. Howden	Stephan Howden, Don Barrick, and Hector Aguilar	SPIE Ocean Sensing and Monitoring Conference, April 26-27, 2011 Orlando, FL.	Y	4/26-4/27/2011
Applications of High Frequency Radar Surface Currents for Response to the Deepwater Horizon Oil Spill	Stephan D. Howden	Stephan D. Howden	*Oil Spill.* Deepwater Horizon Oil Spill Principal Investigator One Year Update Workshop, St Petersburg, FL October 25-26, 2011	Y	10/25-10/26/2011
The Integrated Ocean Observing System in the Gulf of Mexico	Stephan D. Howden	Stephan D. Howden	Oceans in Action TechSurge Workshop, Marine Technology Society, 22-23 August, 2011. Biloxi, MS.		8/22-8/23/2011

6. Other products or deliverables:

Howden, S. D., D. Barrick and H. Aguilar. *Applications of High Frequency Radar for Emergency Response in the Coastal Ocean: Utilization of the Central Gulf of Mexico Ocean Observing System during the Deepwater Horizon Oil Spill and Vessel Tracking*, in Ocean Sensing and Monitoring III, edited by Weilin W. Hou, Robert Arnone, Proceedings of SPIE Vol. 8030 (SPIE, Bellingham, WA, 2011) doi: 10.117/12.884047.

Howden, S. D., Applications of High Frequency Radar Surface Currents for Response to the Deepwater Horizon Oil Spill, in Deepwater Horizon Oil Spill Principal Investigator Workshop Final Report (http://www.marine.usf.edu/conferences/fio/NSTC-SOST-PI-2011/documents/SOST_2011_DWH_Workshop_Final_Report.pdf)

Braatz, Andrea, An Analytical Study of Air-Sea CO2 Gas Exchange in the Northwest Mississippi Bight Region, University of Southern Mississippi, Masters Thesis, 2011.

7. Data:

Data and metadata from the CenGOOS CODAR stations are available in several places. In addition to servers at USM (cengoos.org), CenGOOS participates in the National High Frequency Radar (HFR) Network that was designed as part of the National Surface Currents Initiative. The CODAR data are pushed to the servers of the National HFR Network where they are available from servers at Scripps Institution of Oceanography (http://cordc.ucsd.edu/projects/mapping/) and the NOAA National Data Buoy Center (http://cordc.ucsd.edu/projects/mapping/).

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Stephan	Howden	Principal Investigator	USM	Stephan.howden@usm.edu
Kjell	Gundersen	Scientific Participant	USM	Kjell.gundersen@usm.edu
Jamie	Davis	Technician (Data Manager)	USM	Jamie.davis@usm.edu
Richard	Slaughter	Technician (Electronics)	USM	Richard.slaughter@usm.edu
Robyn	Montgomery	Administrative Support (Contract Specialist)	USM	Robyn.montgomery@us.edu

MENTORING AND TRAINING

9. Student and post-doctoral participants:

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Andrea	Braatz	MS	An Analytical Study of Air-Sea CO2 Gas Exchange in the Northwest Mississippi Bight Region.	USM	Stephan Howden	Successfully defended June 2, 2011
Amy	Kern	BS	Summer Internship: CenGOOS CODAR surface currents analysis	USM	Stephan Howden	Summer 2011

10. Student and post-doctoral publications, if planned:
a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation

Braatz, A., S. D. Howden, S. E. Lohrenz, C. Sabine and R. Wanninkhof (2012), An Analytical Study of Air-Sea CO_2 Gas Exchange in the Northwest Mississippi Bight Region (In Preparation. To be submitted to Journal of Geophysical Research).

11. Student and post-doctoral presentations and posters, if planned:
NA

12. Images:

Figure 2. CODAR receive antenna at Singing River Island in Pascagoula, MS. (Photo: Stephan Howden.)

Figure 3 on the Beach. CODAR receive antenna at Henderson Beach State Park in Destin, FL. In the background is the Inn on the Beach. (Photo: Stephan Howden).

Figure 4. CODAR receive antenna at Orange Beach, AL, shortly after reinstallation at Gulf State Park. Work on the ongoing dune replenishment project is seen in the background to the left. The white utility trailer in the background houses the CODAR electronics .

10-BP_GRI_USM-01 (Task 2): A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the Deepwater Horizon oil release - Task 2: Chemical effects associated with leaking Macondo well oil in the Northern Gulf of Mexico

1. Project File Number: 10-BP_GRI_USM (Task 2)

2. Project Title: The University of Southern Mississippi: A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the Deepwater Horizon oil release - Task 2: Chemical effects associated with leaking Macondo well oil in the Northern Gulf of Mexico

Alan M. Shiller & Laodong Guo

SCIENCE ACTIVITIES

1. General Summary: Our working hypotheses included: i) selective evaporation and photodegradation of oil components in the water should be reflected in the optical properties based on UV-Vis absorbance and EEM fluorescence, ii) presence of spilled oil in the water column should alter the partitioning of organic carbon between dissolved, colloidal and particulate phases, shifting the size distribution into more colloidal and particulate phases after selective evaporation, photodegradation and oxidation, iii) distributions of Ni and Cu will be affected by input from crude oil, though V will not be because of its higher natural levels, iv) distributions of Mn and Fe will be affected if oil alters dissolved oxygen levels and dispersants may also affect metal distributions if the presence of complexing sulfonic acids is significant, v) the presence of oil will exacerbate hypoxia problems by limited air-sea exchange of oxygen and contributing to respiration (alternatively, the oil may limit phytoplankton growth which then diminishes the supply of natural organic matter fueling hypoxia). During the project, we participated in three research cruises to the Deepwater Horizon site as well as some small boat day cruises closer to the Mississippi coast. Samples were collected on these cruises to address the hypotheses listed above. Not all of the hypotheses were completely addressed due to the broad range of topics versus the limited time and funding. Continued funding in phase 2 has allowed us be more complete in pursuing our objective. However, we were also able to modify our goals and add a new direction by the collection and analysis of samples for polycyclic aromatic hydrocarbons (PAH's). Research results are described in the next section. Beyond the research results, there were some important lessons learned. These include: a) in quickly responding to a new and uncertain event, discussions with colleagues are vital because an individual may not have the time to completely think through the details of the science alone, b) the first responders to an environmental incident are likely to have a different agenda from scientific responders and their needs should be respected, and c) the public has a need and desire for information about ongoing environmental incidents and they need to be presented the information in a clear, consistent fashion without resort to hyperbole.

Overall, we have provided critical support to the GRI's mission by examining chemical distributions associated with the oil spill. We acquired basic water quality data in the spill-affected region. We provided the first PAH data for the subsurface oil plumes, obtained in early May; we also have a complementary PAH dataset from late May. We have the only data set on dissolved trace elements associated with the subsurface plume. We contributed to the knowledge of the fate of the subsurface methane plume.

2. Results and scientific highlights:

We examined the distributions of polycyclic aromatic hydrocarbons (PAHs), dissolved metals, nutrients, dissolved organic carbon (DOC), and colored dissolved organic matter (CDOM) in the vicinity of the Deepwater Horizon oil spill. Samples were collected during three cruises including one in early May right as the spill began, another in late May during the peak of the spill, and a final cruise in mid-October after the well was sealed. Chemical effects were greatest during the late May cruise. At that time we observed chemical anomalies in a subsurface plume near 1100 m depth to distances >15 km from the wellhead.

The chemical anomalies we observed in the subsurface plume included enrichments in PAH concentrations. PAH levels of probable biological significance were found in the plume for at least 15 km from the wellhead. We also saw fractionations in PAH composition compatible with solubility effects. This includes enrichments in the more soluble methyl-naphthalene component relative to other PAH components near the wellhead followed by a progressive decrease in the percentage of methyl-naphthalenes with distance away from the wellhead. In surface waters, the methyl-naphthalene percentage also decreased rapidly with distance away from the wellhead, probably due to volatilization.

We also observed depletions in nitrate and phosphate in the sub-surface plume, associated with oxygen depletion. The nutrient removal is compatible with large blooms of oil and gas-consuming organisms.

Small enrichments in some dissolved metals were observed, including Co (which has very low background concentrations) and Ba (which was likely derived from drilling fluids used in the top kill procedure). Distributions of dissolved Fe and Mn appear to have been affected by benthic inputs. Careful examination of our data also suggestions possible Fe limitation of methanotrophic organisms and possible input of Mn from the top kill.

Elevated DOC concentrations, higher absorption values, and lower spectral slope or higher molecular weight DOM were found in the surface waters during May and early June 2010. Two types of DOM were found in the water column, one with high optical reactivity but low in abundance and the other with low optical reactivity but high in DOC concentration. The fluorescence EEM spectra of both surface oil and seawater samples strongly resemble those of crude oil, with maximum Ex/Em centered on 226/340 nm. Four fluorescence components were identified using multivariate PARAFAC analysis: three of them are oil components and the fourth component is UV humic-like DOM. Based on the dynamic changes between the fluorescence components in the water samples, two components were the degradation products of crude oil and contained mostly lower molecular weight materials, whereas one component was preferentially degraded through photochemical processes.

3. Cruises & field expeditions:

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
R/V Pelican		A. Dierks	Early, rapid response to the incident	Early May, 2010
R/V Walton Smith		S. Joye	Investigation of the subsurface oil.gas plume	Late May/early June 2010
R/V Cape Hatteras		K. Yeager	Post-incident investigation of water column chemistry & collection of sediments	Mid-October 2010

1) **Peer-reviewed publications, if planned:**

a. Published, peer-reviewed bibliography

Diercks, A.R., R.C. Highsmith, V.L. Asper, D. Joung, Z. Zhou, L. Guo, A.M. Shiller, S.B. Joye, A.P. Teske, N. Guinasso, T.L. Wade, and S.E. Lohrenz, 2010. Characterization of subsurface polycyclic aromatic hydrocarbons at the Deepwater Horizon site. *Geophysical Research Letters 37*: L20602, doi:10.1029/2010GL045046.

Wade, T.L, S.T. Sweet, J.L. Sericano, N.L. Guinasso, Jr, A.-R. Diercks, R.C. Highsmith, V.L. Asper, D. Joung, A.M. Shiller, S.E. Lohrenz & S.B. Joye, 2011. Analyses of water samples from the Deepwater Horizon oil spill: Documentation of the sub-surface plume. In: "Monitoring and Modeling the *Deepwater Horizon* Oil Spill: A Record-Breaking Enterprise" (Y. Liu, A. MacFadyen, Z.-G. Ji, & R.H. Weisberg, Editors) AGU Geophysical Monograph Series, Vol. 195, pp 77-82.

b. Manuscripts submitted or in preparation

Crespo-Medina,M., A. Vossmeyer, K. S. Hunter, C. D. Meile, A.-R. Diercks, V. L. Asper, J. P. Chanton, A.M. Shiller, D.-J. Joung, J. Brandes, C. Mann, J. J. Battles, J. P. Montoya, T. A. Villareal, M. Wood, R.M.W. Amon, and S. B. Joye. Evolution of water column methane dynamics following the 2010 Macondo blowout in the Gulf of Mexico. Submitted to Nature Geoscience, March 2012.

Zhou, Z., L. Guo, A.M. Shiller, S.E. Lohrenz, V.L. Asper, and C.L. Osburn. Characterization of oil components from Deepwater Horizon oil spill in the northern Gulf of Mexico using fluorescence EEMs and PARAFAC modeling. To be submitted to Environmental Science and Technology, April 2012.

Joung, D. and A.M. Shiller. Trace element distributions in the water column affected by the Deepwater Horizon blowout. To be submitted to Environmental Science and Technology, April 2012.

Shiller, A.M., D. Joung, T. Wade, S. Sweet, and J. Sericano. Fractionation of polycyclic aromatic hydrocarbons in waters near the Deepwater Horizon blowout site. To be submitted to Environmental Science and Technology, May 2012.

5. Presentations and posters, if planned:

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Trace element distributions in waters affected by the Deepwater Horizon oil spill.	D. Joung	D. Joung and A.M. Shiller	2010 Fall Meeting, AGU, San Francisco, Calif.	Y	13-17 Dec. 2010
Documentation of Sub-Surface Oil Plume by Analyses of Toxic PAH in Water Samples from the Deep Water Horizon Oil Spill.	T. Wade	Wade, T.L., Sweet S.T., Sericano, J.L., Guinasso, N.L. Jr., Lohrenz, S.E., Shiller, A.M., Joye, S.B, Dierks, A.R., Asper, V.L. and Highsmith, R.C.	SETAC 31th Annual Meeting	Y	7-11 Nov. 2010
Polycyclic aromatic hydrocarbon, trace element, and nutrient distributions as affected by the Deepwater Horizon Oil Spill.	A.M. Shiller	Shiller, A.M., D. Joung, T.L. Wade, J.L. Sericano, S.T. Sweet, K.M. Yeager, C.A. Brunner, and P. Louchouarn	SOST Workshop, St. Pete Beach, FL	Y	Oct. 2011
Polycyclic Aromatic Hydrocarbon Distribution and Modification in the Sub-surface Plume Near the Deepwater Horizon Wellhead	A.M. Shiller	Shiller, A.M., D. Joung, T.L. Wade	AGU 2011 Fall Meeting, San Francisco, CA	Y	Dec. 2011
Deepwater Horizon Polycyclic Aromatic Hydrocarbon Distribution and Modification from wellhead to coastal marshes	A.M. Shiller	Shiller, A.M., D. Joung, T.L. Wade, J.L. Sericano, S.T. Sweet, K.M. Yeager, C.A. Brunner, and P. Louchouarn	2012 Ocean Sciences Meeting	Y	Feb. 2012
Characterization of oil and dispersant in the northern	L. Guo	Zhou, Z., Guo, L., Shiller, A.M. and Lohrenz, S.E.	Oil Spill conference in New Orleans,		Nov. 1-2, 2010

Gulf of Mexico using fluorescence EEM and size fractionation techniques			sponsored by NSF and Louisiana Board of Regents		
Influence of oil and dispersant on optical properties of dissolved organic matter in the Mississippi Sound/Bight	Z. Zhou	Zhou, Z., Guo, L., Shiller, A.M. and Lohrenz, S.E.	2010 Alabama-Mississippi Bays & Bayous Symposium	Y	December 1-2, 2010
Optical characterization of Crude Oils and Dispersant Used in the Northern Gulf of Mexico by Fluorescence EEM Techniques	L. Guo	Guo, L. Zhou, Z., Shiller A.M. and Lohrenz S.E. 2010.	2010 AGU Fall Meeting	Y	December 13-17, 2010
Optical properties of DOM from the Gulf of Mexico after the Deepwater Horizon oil spill.	Z. Zhou	Zhou, Z., Guo, L., He, H. and Shiller, A.M.	Deepwater Horizon Oil Spill Principal Investigator One Year Update Workshop, FL	Y	October 25-26, 2011

6. Other products or deliverables:

Video of presentation at 2011 AGU Fall Meeting is at http://sites.agu.org/fallmeeting/scientific-program/sessions-on-demand-7-december/

7. Data:
In general, data is/will be presented in publications, theses, and dissertations listed above. Samples are almost entirely consumed in the analytical procedures, so there are no relevant archived samples.

PARTICIPANTS AND COLLABORATORS

8. Project participants:

First Name	Last Name	Role in Project	Institution	Email
Alan	Shiller	Co-PI	USM	Alan.shiller@usm.edu
Laodong	Guo	Co-PI	USM (now at U. Wisc.)	guol@uwm.edu

MENTORING AND TRAINING

9. Student and post-doctoral participants:

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Huijun	He	Post-doc		USM	L. Guo	
Yinghao	Chen	MS		USM	A. Shiller	
DongJoo	Joung	PhD	Metals in LA/MS shelf region	USM	A. Shiller	2012
Zhengzhen	Zhou	PhD	Characterization of DOM influenced by oil in the Gulf of Mexico	USM	L. Guo	2012
Kusumica	Mitra	MS	Dynamics of carbohydrates in the Mississippi Sound and Mississippi Bight in the northern Gulf of Mexico	USM	L Guo	2012

10. Student and post-doctoral publications, if planned:

a. Published, peer-reviewed bibliography

Both published papers listed in 4a include student co-authors (Joung and Zhou), though neither is first author.

b. Manuscripts submitted or in preparation

All papers listed in 4b include student co-authors; D. Joung and Z. Zhou are lead authors on two of them.

11. Student and post-doctoral presentations and posters, if planned:
All presentations listed above in 5 include student co-authors (D. Joung and Z. Zhou).

12. Images:
A video of graduate student DongJoo Joung making spectral measurements during an oil spill cruise (R/V Pelican, May 2010) is at: http://www.youtube.com/watch?v=6SKX5EiFORk

10-BP_GRI_USM-01 (Task 3): Monitoring and Assessment of Potential Impacts of Oil Contamination on Coastal and Marine Ecosystems and Food Webs in the northern Gulf of Mexico

1. Project File Number: 10-BP_GRI_USM (Task 3)

2. Project Title: Monitoring and Assessment of Potential Impacts of Oil Contamination on Coastal and Marine Ecosystems and Food Webs in the northern Gulf of Mexico (Task 3)

Scott P. Milroy, Ph.D.

SCIENCE ACTIVITIES

1. General Summary: Project Overview: In an effort to assess water quality and petrochemical contamination as a result of the Deepwater Horizon oil spill, multiple repeat stations within the MS Sound/Bight were sampled for polycyclic aromatic hydrocarbon (PAH) contamination among several ecologically- and commercially-important species and across multiple routes of exposure. Since PAHs are among the most toxic and environmentally persistent of the SLC oil petrochemicals, they represent an effective "tracer" of petroleum hydrocarbon exposure, contamination, and eventual depuration within the biota and organic detritus. Lethal and sub-lethal effects of PAH exposure on marine organisms (particularly the more sensitive juvenile forms) are expected to drive significant shifts in primary and secondary production, larval recruitment, and community structure within the lower tiers of the marine food web. The potential incorporation of PAH-related carcinogens into commercially-important finfish (*e.g.* Menhaden, Anchovy) and shellfish (*e.g.* oysters, shrimp) is also a major cause of concern. Hence, this project was enjoined to meet the need for a coherent set of metrics and seasonal variables that could be used to assess the immediate and long-term ecosystem impacts due to hydrocarbons derived from the *DwH* oil spill.
Project Activities/Accomplishments: A total of 412 PAH analyses were performed, over the course of six oceanographic cruises, to measure parent and alkylated PAHs either: 1) dissolved in the water column; 2) within the suspended particulate fraction; 3) within the superficial sediments; or 4) incorporated into the tissues of benthic and nektonic macrofauna. Results indicated that while *in situ* concentrations of PAHs (almost exclusively C0-Naphthalene) within the dissolved and suspended particulate fraction of the water column were diffuse (<0.01 – 1.39 ppb), concentrations within the macrofauna were indicative of significant bioaccumulation of C0-Naphthalene (up to 42,620 ppb) within those samples collected within 6 weeks after the well-head had been capped (from 30 August – 03 September 2010).

As PAH levels within the sediments were uniformly below detection limits, it was evident that the primary route of PAH exposure for the coastal macrofauna was either direct exposure to dissolved PAHs in the water column or through ingestion of contaminated particulates suspended in the water column. Within three months (i.e. by the final project cruise, conducted 21 November 2010), C_0-Naphthalene concentrations within the water column and within the macrofauna were almost universally below detection limits (<0.014 ppb), indicating a significant dilution of legacy PAHs within the water column. Analyses also indicated a commensurate decline in PAH exposure and bioaccumulation, suggesting effective depuration of C_0-Naphthalene (and other PAHs) from the micro- and macrobiota by 21 November 2010.

Lessons Learned: While analyses of petrogenic PAHs (including the alkylated forms) were useful in determining the extent of SLC exposure and subsequent contamination, additional evidence (Barron et al. 1999) suggests that PAHs are not the major determinant of toxicity in some weathered oils. Thus, it may be necessary to extend these hydrocarbon analyses to include dissolved alkanes. Additionally, the metabolic conversion of PAHs into cyclic alcohols (*e.g.* naphthols, phenanthrols) will reduce *in vivo* concentrations of PAHs over time, but without a concurrent analysis of these PAH-metabolites (and their potential toxicity), it may be impossible to accurately describe PAH depuration rates. Extending these analyses to include "biomarker" hydrocarbons which are more resistant to metabolic conversion (*e.g.* the steranes and triterpanes) will provide further insight into the routes and extent of exposure to SLC.

2. Results and scientific highlights:

Background: The key accomplishments of this project centered upon a time-series assessment of PAH contamination within the: (1) surface and near-bottom waters; (2) superficial sediments (*i.e.* the top 5 cm); (3) 20–53 μm and 53+ μm size fractions of suspended particulate matter; (4) representative sessile suspension-feeders (*e.g.* Eastern Oysters – *Crassostrea virginica*); (5) representative benthic deposit-feeders (*e.g.* Brown Shrimp – *Penaeus aztecus*); (6) representative planktivorous fishes (*e.g.* Bay Anchovy – *Anchoa mitchilli*, Gulf Menhaden – *Brevoortia patronus*); and (7) representative carnivorous fishes (*e.g.* Atlantic Croaker – *Micropogonias undulatus*, Silver Sea Trout – *Cynoscion nothus*) within the coastal waters of the northern Gulf of Mexico. These data were used to chemically trace the PAH source, track the most-likely routes of PAH exposure, determine *in vivo* tissue concentrations, deconvolve bioaccumulation and/or depuration rates, and provide resource managers with additional aquatic toxicity and seafood safety data for a diverse group of commercially- and ecologically-important marine species harvested from PAH-afflicted waters.

Significant Results: While the project period within this project was sufficient to meet the PAH data acquisition objectives, the assimilation of that data is on-going and shall require further resources to complete (especially with regard to future analyses of biomarkers and PAH metabolites within the biota, as suggested in the "General Summary – Lessons Learned" section above). However, pursuant to our significant results and milestones met, current results indicate:

1) 100% of the tissue samples gathered from various species within the MS Sound from 30 Aug – 03 Sep 2010 indicated PAH concentrations (specifically, C_0-Naphthalene) well above background levels:

   7,190 – 42,620 ppb C_0-Naph within whole-body *Penaeus aztecus* (Brown Shrimp)
   15,670 – 30,340 ppb C_0-Naph within whole-body *Crassostrea virginica* (Eastern Oyster)
   31,360 ppb C_0-Naph within whole-body *Anchoa mitchilli* (Bay Anchovy)
   570 – 14,700 ppb C_0-Naph within the viscera of *Brevoortia patronus* (Gulf Menhaden)

2) In all but one tissue sample from 30 Aug – 03 Sep 2010, C0-Naphthalene was the only PAH measured above detection limits; all alkylated forms of PAHs (incl. alkylated Naphthalenes) were absent from all 30 Aug – 03 Sep 2010 tissue samples, indicating

disparities between the source crude, potential routes of exposure, and/or preferential sequestration/bioaccumulation of C_0-Naph which require further elucidation.

3) Using FDA protocols to establish acceptable "Levels of Concern" (LOC) for PAHs, only one tissue sample from 30 Aug – 03 Sep 2010 (MC4 Shrimp) contained PAHs other than C_0-Naph, and these exceeded the cancer-risk LOC using Benzo(a)Pyrene Equivalents (BaPE).

4) Despite C_0-Naph levels within the 30 Aug – 03 Sep 2010 tissues being well above background concentrations, PAHs were below detection limits (<10 ppb) in all sediment samples from 30 Aug – 03 Sep 2010. By contrast, dissolved PAHs (specifically, C_0-Naph) ranged from <0.01-0.14 ppb; PAHs within the particulate fraction ranged from <0.01-1.39 ppb (20-53 μm size fraction) to <0.01-0.24 ppb (53+ μm size fraction) for the 30 Aug – 03 Sep 2010 samples. These results indicate a greater likelihood of PAH exposure (and subsequent bioaccumulation) from the water column and from the ingestion of suspended particulates rather than from the sediments.

5) At no time, at any station, were sediment PAHs above detection limits.

6) During water sampling within the MS Sound on 27 Sep 2010, dissolved PAHs (specifically, C_0-Naph) ranged from <0.01-0.11 ppb and PAHs among the particulates were below detection limits.

7) During water sampling at offshore GIP stations from 11-20 Oct 2010, dissolved PAHs (specifically, C_0-Naph) ranged from <0.01-0.80 ppb.

8) By 21 Nov 2010, dissolved PAHs were below detection limits at all stations save that furthest offshore (NGI8), where C_0-Naph was 0.04 ppb.

9) By 21 Nov 2010, PAHs within the suspended particulates and all tissues were below detection limits, indicating the complete depuration of C_0-Naph within the biota. However, further analyses of additional petrogenic hydrocarbon biomarkers (*e.g.* hopanes, steranes, triterpanes) and the presence of PAH metabolites (*e.g.* Naphthols) within these tissues is warranted to confirm depuration endpoints (which will therefore enable a calculation of natural depuration rates). Also, the presence/absence and concentration(s) of various PAH metabolites will also help to establish the relative toxicity of PAH exposure (primarily from C_0-Naph) and the residence time of potentially toxic PAH-metabolites.

10) The dominance of C_0-Naph, and the absence of alkylated PAHs, will make it more difficult to establish the source of PAH contamination as BP crude without the addition of petrogenic hydrocarbon biomarker analysis (*e.g.* hopanes, steranes, triterpanes). As these analyses were not funded within this project, these analyses were not conducted; however, they represent a great need in the assimilation of the data discussed herein.

11) As alkylated PAHs comprised a significant portion of the source oil, it is as yet unknown why none of the alkylated PAHs were measured above detection limits in any of the

samples analyzed. This may be due to the reduced solubility of alkylated PAHs (in comparison to parent PAHs); however, a thorough investigation of these dynamics is warranted.

12) Analyses of Total Organic "C-band" content within the biota indicated the whole thorax ("head") of *Penaeus aztecus* (Brown Shrimp) could contain up to 97.2% of the total organic content of the whole organism when compared to the shelled abdomen ("tail"). Hence, the FDA seafood safety protocol of analyzing only shelled tails for PAH contamination may be warranted for organisms choosing to ingest only the shelled tails of shrimp. Therefore, any organism ingesting the entire shrimp may be receiving a much larger PAH dosage than the FDA protocol would suggest.

2. Cruises & field expeditions:

Ship or Platform Name	Class (if applicable)	Chief Scientist	Objectives	Dates
McIlwain	R/V	C. Brunner	PAHs in sed. & biota (MS Sound)	08/30/10
McIlwain	R/V	C. Brunner	PAHs in sed. & biota (MS Sound)	09/01/10
McIlwain	R/V	C. Brunner	PAHs in sed. & biota (Chandeleur)	09/03/10
LeMoyne	R/V	S. Milroy	PAHs in sed. & biota (MS Sound)	09/27/10
Cape Hatteras	R/V	K. Yeager	PAHs in sed. & water (Gulf)	10/11-20/10
McIlwain	R/V	S. Milroy	PAHs in sed. & biota (MS Sound)	11/21/10

3. Peer-reviewed publications, if planned:

a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation

"Detection of PAH-metabolites and biomarkers within the coastal Mississippi food webs affected by the Deepwater Horizon oil spill", Scott P. Milroy and Ken Scally. Target journal: J. Environ. Forensics (draft in progress; submission planned for September 2010).

"Petrochemical contamination and seafood safety in coastal Mississippi: A critical analysis of the FDA standards in use during the Deepwater Horizon oil spill", Scott P. Milroy and Andreas Moshogianis. Target journal: J. Fisheries and Aquatic Science (draft in progress; submission planned for July 2010).

4. Presentations and posters, if planned:

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Polycyclic Aromatic Hydrocarbon (PAH) Contamination within Mississippi Sound Biota (presentation)	S.P. Milroy	Milroy, S.P, A.M. Moshogianis C.A. Brunner S. Howden K. Yeager	Northern Gulf Institute (NGI) Annual Conference, Mobile, AL	Y (online)	05/18/11
The Summer of Glub: Preliminary Results from Hypoxia and Oil Spill Studies in the MS Sound (presentation)	S.P. Milroy	Milroy, S.P.	Univ. of Southern Mississippi Dept. Marine Science Seminar: Dept. Biology Seminar:	N N	10/22/10 02/16/11
PAH Contamination within the MS Sound (presentation)	S.P. Milroy	Milroy, S.P.	Public Outreach Delta Discussion Group: (New Orleans, LA) Sierra Club: (Biloxi, MS)	Y (online) N	06/23/11 12/05/11

6. Other products or deliverables:
N/A

7. Data:
Due to the rapid application for (and review of) Phase I proposals, there was no requirement for (or inclusion of) a data archiving schedule and/or plan; nor were there any funds set aside for this purpose. Without funded support for data archival personnel, the scientific workload on the PI and Co-PIs has caused significant delays in the archival and availability of project-related data.

Schedule (and nature) of data collection was as follows:

30 Aug 2010: MS Sound – Cruise 1 (Stations MC 1-3)
Hydrography, Sediment, Dissolved PAHs, Particulate PAHs, Plankton, Shrimp, Finfish

01 Sep 2010: MS Sound – Cruise 2 (Stations MC 4-5; ED; MS 1-2)
Hydrography, Sediment, Dissolved PAHs, Particulate PAHs, Plankton, Oysters, Shrimp, Finfish

03 Sep 2010: Chandeleur Sound – Cruise 3 (Stations MC 7,10)
Hydrography, Sediment, Dissolved PAHs, Particulate PAHs, Plankton

27 Sep 2010: MS Sound – Cruise 4 (Stations MS 1-15)
Hydrography, Dissolved PAHs, Particulate PAHs, Plankton, Oysters

11-20 Oct 2010: Gulf of Mexico – Cruise 5 (Stations GIP 1-6,13,15,21,25)
Hydrography, Sediment, Dissolved PAHs

21 Nov 2010: MS Sound – Cruise 6 (Stations MC 3-4; MS 8,15; NGI 5-8; ED; 204,307)
Hydrography, Sediment, Dissolved PAHs, Particulate PAHs, Plankton, Shrimp, Finfish

"Hydrography" includes vertical CTD profiles of *in situ* temperature, salinity, density, dissolved oxygen, Chl-*a* and CDOM fluorescence:

SBE 49 FastCAT CTD Sensor

Temperature
Sensitivity 1×10^{-4} °C
Range -5 to +35
Accuracy 0.002 ° C
Conductivity
Sensitivity 1×10^{-5} S m^{-1} (0.1 ppm salinity)
Range 0 – 9 S m^{-1}
Accuracy 0.0003 S m^{-1}

Hydrostatic Pressure

Sensitivity 0.002%

Range 0 – 100 dbar

Accuracy 0.1%

Density (σ_t as kg m^{-3}, *derived*)

<u>SBE 43 DO Sensor</u>

Dissolved Oxygen

Sensitivity 1 x 10^{-5} mg L^{-1}

Range 0 – 10 mg L^{-1}

Accuracy 0.0005 mg L^{-1}

<u>WET Labs ECO-FL3 Fluorometer</u>

Chlorophyll-*a*

Ex/Em 470/695 nm

Sensitivity 0.02 mg L^{-1}

Range 0.01 – 125 mg L^{-1}

Linearity 99% R^2

Verified w/periodic winkler titrations

CDOM

Ex/Em 370/460 nm

Sensitivity 0.09 ppb QS

Range 0 – 500 ppb

Linearity 99% R^2

Phycoerythrin

Ex/Em 540/570 nm

Sensitivity 0.03 ppb

Range 0 – 230 ppb

Linearity 99%R^2

"Sediment" includes analyses of PAHs (all parent + alkylated forms) within the top 5 cm of the undisturbed sediment matrix collected either with a stainless steel ponar grab or multi-coring device.

“Dissolved PAH” includes analyses of dissolved PAHs (all parent + alkylated forms) in waters collected from surface and 0.5m from the bottom using a 5L Niskin bottle (certified for trace metal analysis).

“Particulate PAH” includes analyses of PAHs (all parent + alkylated forms) within the 20-53 μm and 53+ μm particulate fractions collected from surface waters (collected with a 30 cm diameter, 90 cm long, 20 μm mesh plankton net; surface tow for 5 minutes @ 2 knots).

“Plankton” includes plankton samples, preserved in buffered formalin, within the 20-53 μm and 53+ μm size fractions collected from surface waters (as “Particulates”) and preserved for future identification and enumeration (pending successful funding).

“Oysters” includes standard biometrics and analyses of PAHs (all parent + alkylated forms) from tissues collected from live Eastern Oysters (*Crassostrea virginica*).

“Shrimp” includes standard biometrics and analyses of PAHs (all parent + alkylated forms) from tissues collected from live Brown Shrimp (*Penaeus aztecus*). Tissues were analyzed either as whole organism, or as whole thorax (head) vs. shelled abdomen (tail).

“Finfish” includes standard biometrics and analyses of PAHs (all parent + alkylated forms) from tissues collected from live Atlantic Croaker (*Micropogonias undulatus*), Bay Anchovy (*Anchoa mitchilli*), Gulf Menhaden (*Brevoortia patronus*), and/or Silver Sea Trout (*Cynoscion nothus*). Tissues were segregated for PAH analysis within the gills, the viscera, and the filet.

<u>USEPA 16PAH Samples</u>
21 Sediment Samples
79 Water Samples
16 Particulate Samples
2 Oyster Samples
6 Shrimp Samples
25 Finfish Samples

<u>ION28 PAH Samples</u>
21 Sediment Samples
6 Water Samples
10 Particulate Samples
4 Oyster Samples
19 Shrimp Samples
42 Finfish Samples

<u>Total Organic “C-band” Samples</u>
23 Sediment Samples
65 Water Samples
10 Particulate Samples
4 Oyster Samples

19 Shrimp Samples
40 Finfish Samples

412 Grand Total

Chain-of-custody (CoC) was maintained for all samples, from collection to analysis; records of CoC are on file.

Only half of the composite samples of oyster, shrimp, and finfish tissues were submitted for USEPA16, ION28, and C-BAND analysis. The balance of the tissues are being maintained @ -14 °C in a controlled-entry laboratory.

Station locations are indicated below:

MC Station #	LAT	LON
MC1	30.2938	-88.4747
MC2	30.2461	-88.4730
MC3	30.3052	-88.7568
MC4	30.3095	-89.1330
MC5	30.1988	-89.4124
MC6	30.1850	-89.0664
MC7	29.8589	-89.1821
MC8	29.8293	-89.1051
MC9	29.8053	-89.0036
MC10	29.7022	-89.1212
MC11	30.1291	-89.1272
MC12 (NGI6)	30.1330	-88.9072
MC13 (NGI8)	30.0425	-88.6473
MC14	30.1400	-89.5350

MS Station #	LAT	LON
MS1	30.2833	-89.2600
MS2	30.2500	-89.2600
MS3	30.2083	-89.2600
MS4	30.1614	-89.2600
MS5	30.2833	-89.1529
MS6	30.2500	-89.1529
MS7	30.2083	-89.1529
MS8	30.1614	-89.1529
MS9	30.2833	-89.0458
MS10	30.2500	-89.0458
MS11	30.2083	-89.0458
MS12 (NGI5)	30.1614	-89.0458
MS13	30.2833	-88.9387
MS14	30.2500	-88.9387
MS15	30.1614	-88.9387
MS16	30.2833	-88.8316
MS17	30.2500	-88.8316
MS18	30.2083	-88.8316
MS19	30.1614	-88.8316

Cake Station	LAT	LON
Ed Cake	30.2810	-89.1749

MS Station #	LAT	LON
MS1	16.9980	-15.6000
MS2	15.0000	-15.6000
MS3	12.4980	-15.6000
MS4	9.6840	-15.6000
MS5	16.9980	-9.1740
MS6	15.0000	-9.1740
MS7	12.4980	-9.1740
MS8	9.6840	-9.1740
MS9	16.9980	-2.7480
MS10	15.0000	-2.7480
MS11	12.4980	-2.7480
MS12 (NGI5)	9.6840	-2.7480
MS13	16.9980	-56.3220
MS14	15.0000	-56.3220
MS15	9.6840	-56.3220
MS16	16.9980	-49.8960
MS17	15.0000	-49.8960
MS18	12.4980	-49.8960
MS19	9.6840	-49.8960

PARTICIPANTS AND COLLABORATORS

8. Project participants:

First Name	Last Name	Role in Project	Institution	Email
Stephan	*Howden*	*PI*	USM	
Kjell	*Gundersen*	*Co-PI*	USM	
Karen	*Orcutt*	*Co-PI*	USM	
Charlotte	*Brunner*	*Scientific Participant*	USM	
Kevin	*Yeager*	*Scientific Participant*	USM	
Kevin	*Martin*	*Technician*	USM	
Andreas	*Moshogianis*	*Lab/Field Assistant*	USM	
Kim	*Johnson*	*Admin/Grant Support*	USM	

MENTORING AND TRAINING

10. Student and post-doctoral participants:

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Andreas	Moshogianis	PhD	Dynamics of Hypoxia in MS Sound/Bight	USM	Milroy, S.P.	2015

10. Student and post-doctoral publications, if planned
a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation

None planned for Moshogianis on a topic directly related to this project. Incoming PhD student will likely pursue publication(s) related to this project; specifically with the inclusion of biomarker and PAH metabolite research, or follow-on research RE: nutritional consequence of oil spill related organics in the coastal food web.

11. Student and post-doctoral presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Comparisons of Organic Content with Brown Shrimp (<u>Penaeus</u> <u>aztecus</u>) Affected by the Deepwater Horizon Oil Spill (poster)	Moshogianis, A.	Moshogianis, A. Milroy, S.P.	Northern Gulf Institute (NGI) Annual Conference, Mobile, AL	N	05/18/11

12. Images:

Figure 12-1. Station map for cruises conducted within the Chandeleur Sound and the MS Sound/Bight, specific to Task 3 of 10-BP_GRI_USM-01 (30 August – 21 November 2010).

Figure 12-2. Station map for the cruise conducted within the MS Bight and the northern Gulf of Mexico, specific to Task 3 of 10-BP_GRI_USM-01 (11-20 October 2010).

10-BP_GRI_USM-01 (Task 4): A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release - Task 4 Assessing Possible Impacts of the Deepwater Horizon Oil Spill on Summer Plankton Assemblages of the Inner Continental Shelf in the North Central Gulf of Mexico

1. Project File Number: 10-BP_GRI_USM (Task 4)

2. Project Title: A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release - Task 4 Assessing Possible Impacts of the Deepwater Horizon Oil Spill on Summer Plankton Assemblages of the Inner Continental Shelf in the North Central Gulf of Mexico

Harriet Perry

SCIENCE ACTIVITIES

1. General Summary: One of the objectives of this study was to provide a comparison of the species composition and abundance of fish larvae collected at two locations during September 2010 within the area impacted by the Deepwater Horizon oil spill, with a historical database of ichthyoplankton collections taken at the same locations during the previous five or six years. All collections were taken with bongo and neuston nets. Densities of anchovy larvae in bongo collections taken two months after the Deepwater Horizon oil spill were lower (often by an order of magnitude) than during the five or six year period before the spill. This would be of ecological importance because anchovies are a primary food source for many species of fish. Red snapper larvae were actually more abundant in post-spill bongo collections than in pre-spill collections, but this might be the result of small sample sizes and patchy distributions of larvae. More credence is given to the disparity in anchovy abundances before and after the oil spill because of the large and consistent differences. Additional zooplankton samples were taken to collect invertebrate larvae. Seven surface bongo tows were made along a north/south transect and examined for postlarval stages of commercially important decapod crustaceans. White shrimp (*Litopenaeus setiferus*) postlarvae were taken at five of the stations in very small numbers; no portunid megalopae were collected. A final objective was to investigate movement of dispersed oil and dispersant into the food web and this was accomplished by examining oil contamination of zooplankton and pelagic prey fishes on the continental shelf. We also initiated an opportunistic project to investigate ecological effects of the oil spill in the near shore marsh food web by examining sub-lethal effects of exposure of juvenile marsh fishes to oil and dispersant.

The Deepwater Horizon oil spill and subsequent application of oil dispersants not only affected large areas of surface waters in the northcentral Gulf, but also affected the water column over large areas. One aspect of this report addressed the question of whether there was a difference in assemblages of fish larvae at particular locations between historical pre-spill plankton collections and post-spill collections. A second question was the indirect effect of oil and dispersants on the food web through alternation in prey resources and reductions in fish health. This was addressed using a combination of hydrocarbon analysis of index species (zooplankton, prey fishes, and juvenile fishes), as well as molecular analyses of fish liver and muscle tissue to look for gene expression in biochemical pathways known to be involved in the breakdown of PAH's in fish.

2. Results and scientific highlights:

A. Oblique plankton collections were taken at two SEAMAP station locations in the northcentral Gulf of Mexico in September 2010.
B. Fish larvae were removed from collections and identified, and historical SEAMAP larval fish data were obtained from NMFS.
C. Plankton samples for invertebrate larvae were collected along a transect ending at the DWH wellhead. Decapod postlarvae were removed from transect zooplankton collections and identified.
D. Pelagic prey fish and zooplankton were collected during a single cruise in October of 2010.
E. Hydrocarbon analysis and molecular analysis were completed in January 2011.
F. Data analyses were completed.
G. Final report was completed.

One of the objectives of this portion of study was to provide a comparison of the species composition and abundance of fish larvae collected at two locations during September 2010 within the area impacted by the Deepwater Horizon oil spill, with a historical database of ichthyoplankton collections taken at the same locations during previous years in September. Historical data using the same collection protocols was provided by the Southeast Area Monitoring and Assessment Program (SEAMAP). We had originally planned to make comparisons with a historical database of collections taken during the past 10 years. However, to reduce the effect of a possible temporal shift in the composition of ichthyoplankton assemblages, we did not include historical data that was collected earlier than 2004. Because of the variability in catch data, small sample sizes, and particular ecological or commercial significance attributed to certain taxa, descriptive comparisons were made rather than using traditional statistical techniques. The taxonomic level to which taxa were identified was the same for all comparisons.

Collections of fish larvae were taken throughout the water column with a paired bongo net ($330_{\mu m}$ mesh), and at the surface with a neuston net ($950_{\mu m}$ mesh). Numbers of fish larvae in bongo collections were converted to densities (number per 100 m^3 of water filtered), and numbers of fish larvae in neuston collections were standardized as number of larvae per 10 minute tow. Bongo and neuston collections were taken at SEAMAP stations B178 and B179. Because the neuston collection at station B179 contained a lot of *Sargassum*, i.e. was atypical, it was discarded and a second neuston collection was taken at SEAMAP station B176. Station B178 was 27 miles south of Pascagoula, MS., in a water depth of 26 m, station B179 was 57 miles south of Pascagoula in a water depth of 50 m, and station B176 was 57 miles south of Mobile bay in a water depth of 43 m.

The post-spill bongo collection taken at station B178 could be compared with pre-spill collections taken at this location in 2004, 2006, 2007 and 2008. The number of taxa identified in the post-spill collection (n=17) was similar to numbers of taxa found in pre-spill collections (n=27, 14, 17, 12). However, the density of engraulid larvae (anchovies) was an order of magnitude lower in the post-spill bongo collection than in the pre-spill collections. Engraulid larvae were the most abundant taxa in all four pre-spill collections with densities ranging from 64 to 683 larvae per 100 m^3 of water filtered, but in the post-spill collection the density of engraulid larvae was only 4 per 100 m^3. Anchovies are not commercially important in the northern Gulf of Mexico, but they are a very important food source for many species of fish. In contrast, larval red snapper (*Lutjanus campechanus*) were more abundant in the post-spill collection than in the four pre-spill collections, and were actually the most abundant taxa in the post-spill collection (14 larvae/100 m^3). It is often difficult to draw conclusions with a small number of collections, particularly when the distribution of fish larvae is very patchy. The relatively high density of red snapper larvae could easily be a reflection of a patchy distribution, but the decrease in abundance of anchovy larvae is so striking that it may well reflect a true decrease in the abundance of this important prey species.

The post-spill neuston collection taken at station B 178 was compared with neuston collection data obtained from this location in 2004, 2006, 2007 and 2008. There was too much variability in these data to discern any distinct trends, although it should be noted that engraulid larvae were again the most abundant taxa in all pre-spill collectons. Seven taxa were found in the post-spill collection, while numbers of taxa found in the 2004, 2006, 2007 and 2008 collections were 5, 17, 7 and 4, respectively.

The post-spill bongo collection at station B179 showed similar trends, although not as distinct as at station B178. The post-spill density of engraulid larvae was lower at station B179 than in collections taken at this station in 2004, 2006, 2007 and 2008. In addition, similar to findings at station B178, red snapper (*Lutjanus campechanus*) larvae were more abundant in the post-spill collection than in the four pre-spill collections. The number of taxa found in the post-spill collection (10) was lower than found in 2004, 2006, 2007 and 2008 (21, 15, 30, and 20, respectively). However, this may simply be a reflection of the small sample size and patchy distribution of larval fishes.

Because the neuston collection at station B179 could not be used for comparative purposes (contained heavy density of *Sargassum*), post- and pre-spill comparisons were made for neuston collections taken at neighboring station B176. Available data for pre-spill collections were available from 2004, 2007 and 2008. Fewer taxa were found in the post-spill collection (5) than in 2004, 2007 or 2008 (15, 9, and 7, respectively), but as with the previous neuston collection, this may be a reflection of the small sample size and patchy distribution of larval fishes.

Although the sample collections for this portion of the study were small due to limited funding, it appears that densities of anchovy larvae two months after the Deepwater Horizon oil spill was capped were lower than during the five or six year period before the spill. This would be of ecological importance because anchovies are a primary food source for many species of fish. Red snapper larvae were actually more abundant in post-spill bongo collections than in pre-spill collections, but this might be the result of small sample sizes and patchy distributions of larvae. More credence is given to the disparity in anchovy abundances before and after the oil spill because of the large and consistent differences.

As part of this study, additional bongo tows were taken at the surface and the samples examined for the presence of commercially important decapod postlarval stages. Tows were made at seven stations along a north/south transect (Figure 1, Transect Stations 2, 3, 4, 5, 7, 9; Crab Station 1) beginning south of Horn Island and ending just north of the DWH wellhead. White shrimp (*Litopenaeus setiferus*) postlarvae were taken at five of the stations in very small numbers; no portunid megalopae were collected.

No evidence of hydrocarbon or dispersant presence was detected in zooplankton or pelagic prey fish as a part of this study. Molecular analysis was not completed due to sample loss in a faulty freezer but this portion of the study will be extended into Phase II in order to further examine molecular responses of plankton and fish to dispersed oil and dispersant.

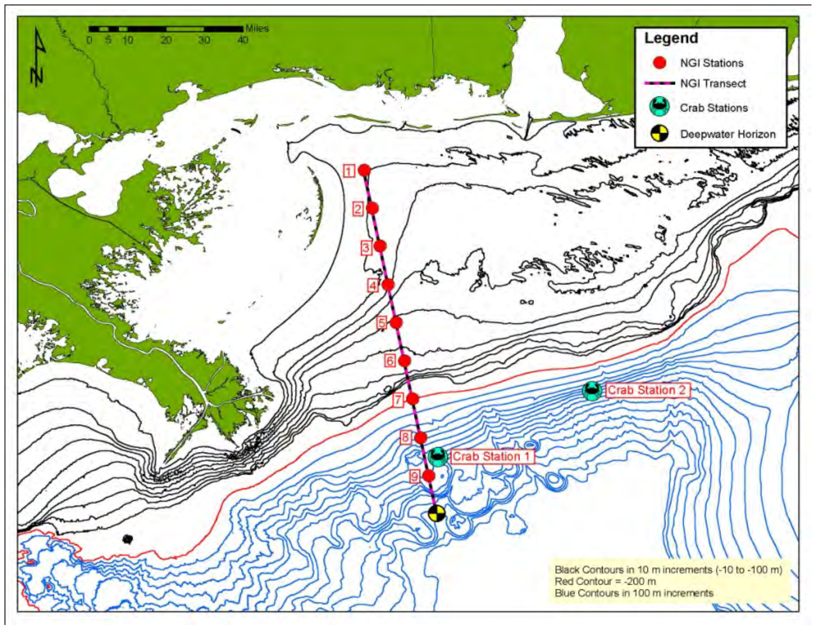

Figure 5. Location of crab and zooplankton stations.

3. Cruises and Field Expeditions

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
RV/TOMMY MUNRO		Perry	Surface neuston plankton collections	9/25/10-9/29/10

4. Peer-reviewed publications, if planned:
a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Impacts of Deepwater Horizon oil spill to estuarine fish growth and ecosystem functionality	Brewton, R.A	Brewton, R.A., R. J. Griffitt, and R.S. Fulford	American Fisheries Society Southern Division Spring Meeting, Tampa, FL		January 14,2010

6. Other products or deliverables:
N/A.

7. Data:
N/A

PARTICIPANTS AND COLLABORATORS

8. Project participants:

First Name	Last Name	Role in Project	Institution	Email
Harriet	Perry	PI	USM	Harriet.perry@usm.edu
Bruce	Comyns	Co-PI	USM	Bruce.comyns@usm.edu
Richard	Fulford	Co-PI	USM (now EPA/ Gulf Breeze)	
Jay	Dieterich	Technician	USM	

MENTORING AND TRAINING

9. Student and post-doctoral participants:

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Rachael	Brewton	MS				

10. Student and post-doctoral publications, if planned:
a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation
N/A

11.Student and post-doctoral presentations and posters, if planned:
N/A

12. Images

10-BP_GRI_USM-01 (Task 5): A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release - task 5: responses of benthic communities and sedimentary dynamics to hydrocarbon exposure in neritic and bathyal ecosystems.

1. Project File Number: 10-BP_GRI_USM (Task 5)

2. Project Title: A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release - task 5: responses of benthic communities and sedimentary dynamics to hydrocarbon exposure in neritic and bathyal ecosystems.

Dr. Kevin M. Yeager

SCIENCE ACTIVITIES

1. General Summary: This NGI Phase I project was focused on determining if and where oil has reached the seafloor below the intertidal zone and if at these sites it has affected benthic ecosystems. Oil was observed over large areas of the ocean surface and has been reported in the peer-reviewed literature as having been present in thin, discrete layers on subsurface isopycnals. To date, the OSAT-1 report has published both qualitative observations and total PAH data that indicate that some oil did reach the sea floor at neritic to bathyal depths. However, comprehensive and quantitative data on this and related subjects remain lacking. Consequently, this research began to address the crucial questions of if, where, and to what degree petroleum hydrocarbon and chemical dispersant contamination has impacted bottom sediment ecosystems across the region from deep to shallow water.

The proposed research is comprehensive and strongly multi-disciplinary. Field sampling has included sedimentary environments in high-turbidity, coastal settings including the Mississippi and Chandeleur Sounds, the continental shelf (La., Ms.) and the deeper environments of the continental slope and upper rise, near the Macondo well. Analytical elements include the following:

- Organic geochemistry, to characterize the distribution and concentration of total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAHs), to assist in determining their source, primary degradation pathways, and degradation rates;
- Sedimentology, to determine how hydrocarbon contamination may alter sediment textures, geotechnical properties, and carbon storage capacity;
- Radiochemistry, to quantify sediment mixing, rates of sediment accumulation and chronology, which will ultimately allow for fluxes of oil to the seafloor to be determined; and
- Benthic ecology, specifically of meio- and macrofauna, which will allow for the impacts of hydrocarbon contamination on ecosystem health to be assessed by examining changes in and recovery of overall biomass, species diversity, and community structure.

Lessons learned are several. The initial proposal did not request ship time (with the expectation that NGI would cover his activity as NSF does), and although additional moneys were allocated, the research goals were necessarily reduced to offset this expense. A ship for the deepwater work of the 8-month-long project was not available until the fourth month on the project, allowing for collection of samples but limited, shore-based, analytical work before the close of the project.

Nonetheless, major findings were produced and are outlined in the next section. Successful activities include these:

- Three short cruises in the Mississippi and Chandeleur Sounds resulted in occupation of 13 stations where CTD casts (including O_2), water samples, and 10 replicate cores per station (3 multicorer casts) were collected for macrofauna, meiofauna, sedimentology, radiochemistry, and hydrocarbon analyses; and
- The 10-day, deepwater cruise onboard the R/V *Hatteras* successfully occupied 24 stations at depths from 16 m to 2530 m. Collected were a total of 207 water bottles, 26 CTD casts, and 57 multicorer casts that recovered 357 cores for macrofauna, meiofauna, sedimentology, radiochemistry, and hydrocarbon analyses.

2. Results and scientific highlights:

Major results were produced in the 9 month period of the grant (7 July 2010 – 31 March 2011).

A. Have hydrocarbons derived from the Deepwater Horizon spill reached the seafloor at any depth below the intertidal zone, from shelfal to bathyal depths, including sites down slope from the well site?

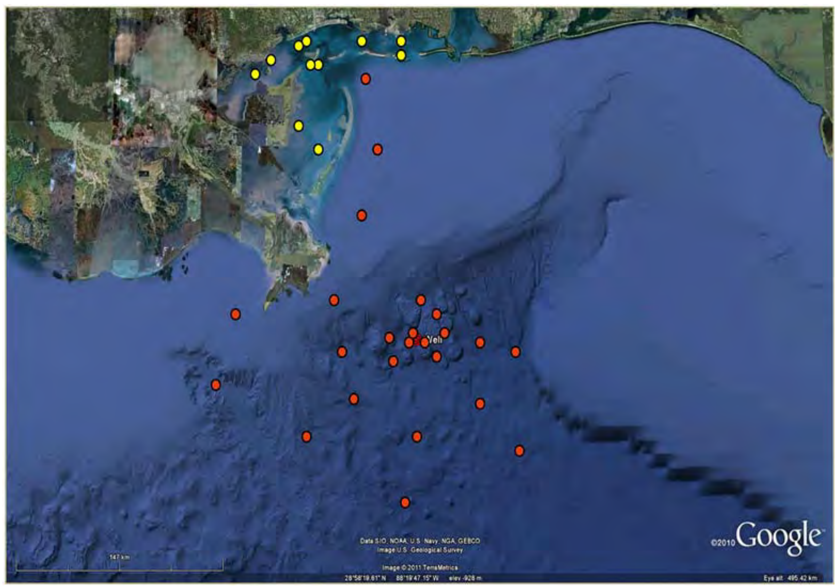

Figure 1. Locations of all Mississippi and Chandeleur Sounds (yellow), and continental shelf, slope and upper rise (orange) sediment coring stations for this project. Imagery courtesy of Google Earth (2011).

We currently have total, sedimentary PAH concentrations for 7 of 19 bathyal sites. These data compare favorably to the spatial trend of total, sedimentary PAH concentrations provided in the Operational Science Advisory Team's (OSAT) first report (2010) (Fig. 2).

While we have identified some stations where the concentrations of total PAHs at the sediment surface (1 cm) are above background (Fig. 3), we have not yet determined if the composition, or "fingerprint," of the hydrocarbons in these samples is, or is not, consistent with Macondo oil as a source.

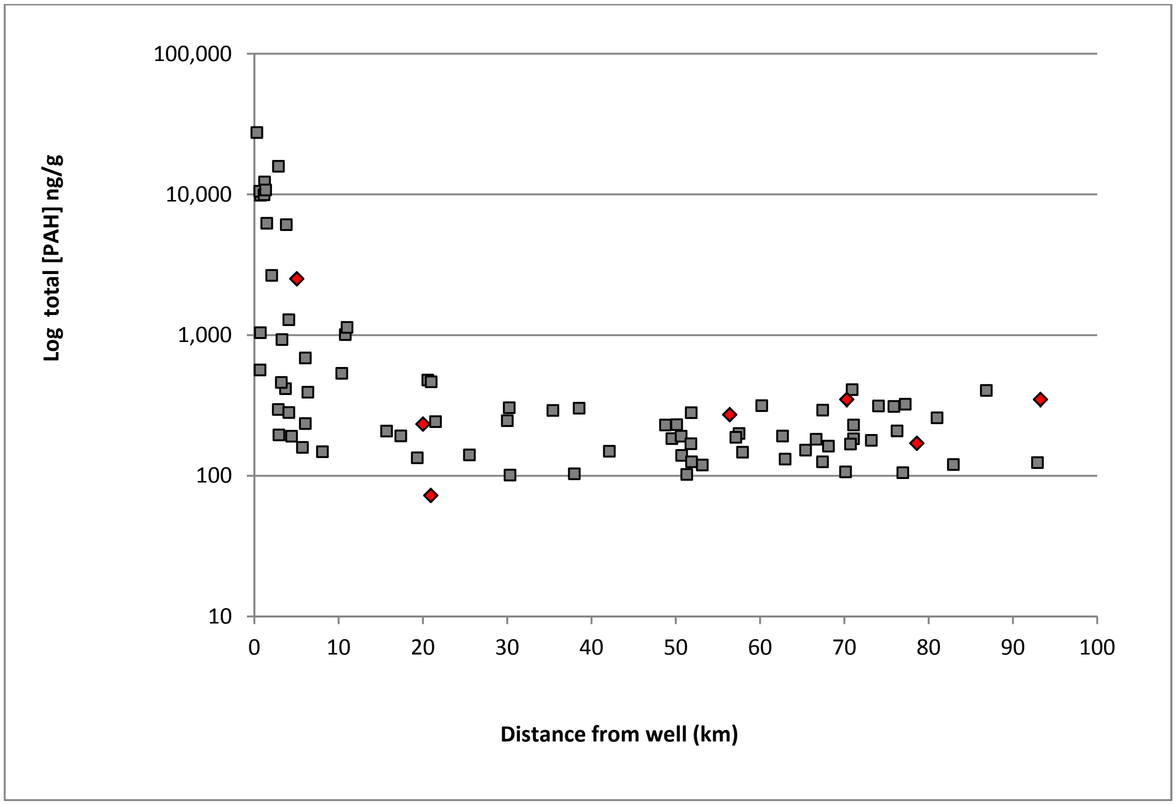

Figure 2. A comparison of the preliminary total PAH data derived from this project (red) to those presented in the OSAT-1 report (2010) (grey). To facilitate a direct comparison, only those OSAT-1 report data from "offshore" and "deepwater" stations which have total PAH concentrations $\geq$ 100 ng/g and were located $\leq$ 100 km from the Macondo well are included.

B. Has hypoxia—known on the Mississippi shelf centered on 10-m isobaths—been exacerbated, extended to other regions, or reduced beneath the surface water slick of oil?

We continue to work on this question. Qualitative observations showed that the abundance of fish in trawls and plankton tows and live macrofauna from the hypoxic floor of the Chandeleur channel were dramatically lower than elsewhere in the Mississippi and Chandeleur Sounds. Quantitative results and interpretation will require the integration of data from water column instrumentation, discrete water samples, organic geochemistry, sedimentology, radiochemistry and benthic ecology. No surface water slicks of oil were observed at any station during the August-September sampling.

C. What have been the fluxes of hydrocarbons derived from the Deepwater Horizon spill to bottom sediments in the environments sampled?

We continue to work on this question. This will require the integration of data derived from organic geochemistry, sedimentology, and radiochemistry.

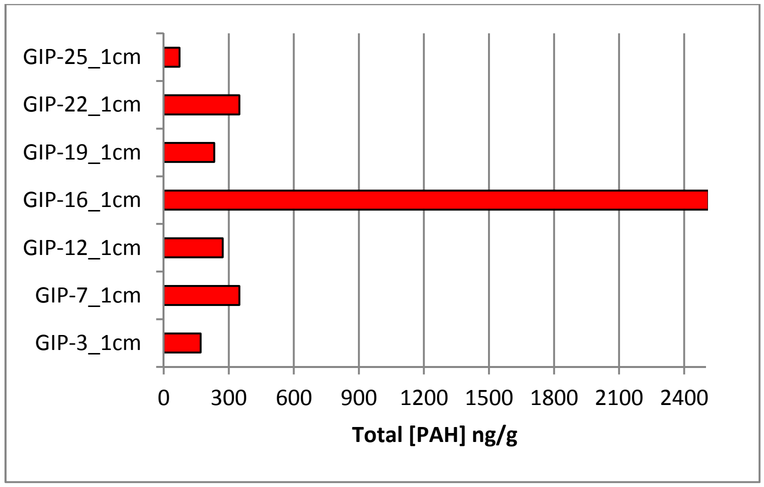

Figure 3. Total PAH concentrations at the sediment surface (0-1 cm) for select deep sea stations. These stations are found at various distances from the Macondo well site (e.g., station GIP-16 = 5 km; station GIP-7 = 93 km).

D. What are the degradation rates of hydrocarbons derived from the Deepwater Horizon spill in bottom sediments in the environments sampled?

We continue to work on this question. This will require the integration of data derived from organic geochemistry, sedimentology, and radiochemistry, as well as extended time-series sampling.

E. What are the impacts to and responses of benthic meio- and macrofaunal communities that have been exposed to hydrocarbons derived from the Deepwater Horizon spill in the environments sampled?

We continue to work on this question. Qualitative observations show that live meio- and macrofauna survived in noticeable numbers in all samples collected, includes sample GIP-16, which had the highest concentration of PAH measured to date in our collection. The one exception was samples collected from the deep Chandeleur channel, which was hypoxic in early September 2010.

F. What concentrations of suspended oil and oil-particulate matter aggregates within the water column have been present during sampling of bottom sediments?

We continue to work on this question. While water column hydrocarbons were suggested at some stations based on fluorescence data collected using a Chelsea Aquatracka, discrete water samples are still being analyzed to definitively address this.

3. Cruises & field expeditions

Table 1. Cruises and field expeditions.

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
R/V *Tom McIlwain*		Kevin Yeager	Collections of samples from Mississippi and Chandeleur Sounds	8/30, 9/1, and 9/3/2010
R/V *Cape Hatteras*		Kevin Yeager	Collection of samples from the Mississippi/Louisiana shelf and the continental slope beneath and downslope from surface oil slicks and subsurface oil/gas plumes.	10/11-20/2010

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation

Peer-reviewed articles will be prepared as soon as sufficient results are analyzed to determine trends and processes.

5. Presentations and posters, if planned:

Table 2. Presentations and posters.

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Deepwater Horizon: Coastal ocean to marsh margin sedimentary impacts [oral presentation].	Kevin M. Yeager	C. A. Brunner, K. B. Briggs, P. Louchouarn, L. Guo, V. Asper, K. J. Schindler, K. M. Martin, J. Prouhet, N. Couey, C. Fortner	American Association of Petroleum Geologists Annual Convention and Exhibition, Houston, Tx., http://www.searchanddiscovery.com/abstracts/html/2011/annual/abstracts/Yeager.html	Y	April 10-13, 2011
Deepwater horizon: Coastal ocean to marsh margin sediment impacts. [poster]	Patrick Louchouarn (not given, but abstract published)	K. M. Yeager, C. A. Brunner, K. Briggs, L. Guo, V. Asper, N. Couey, C. Fortner, J. Prouhet, K. J. Schindler, K. M. Martin, Z. Zhou, J. Loeffler, A. Jung, V. Cruz	241st American Chemical Society (ACS) National Meeting, Anaheim Ca., http://abstracts.acs.org/chem/241nm/program/view.php?obj_id=80358&terms=	Y	March 27-31, 2011
NSF RAPID and NGI-BP: Response of benthic communities and sedimentary dynamics to hydrocarbon exposure in intertidal, neritic and bathyal ecosystems of the northern Gulf of Mexico [Poster].	Charlotte Brunner	Yeager, K. M., C. Brunner, L. Guo, P. Louchouarn, K. Briggs	National Science Foundation: Collaborative Scientific Research Opportunities Relative to the Gulf Oil Spill, New Orleans, La.	N	November 1-2, 2010

6. Other products or deliverables:
N/A

7. Data:

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Data of various kinds have been compiled and will be reported to the Harte Research Institute as papers are published. Physical samples (as opposed to sensor data) have aliquots or fractions that are retained, though typically these require special handling that an archive cannot offer, so they are maintained in the PI's laboratory. Attached are two spreadsheets of ancillary information on the location and status of such archived samples.

PARTICIPANTS AND COLLABORATORS

8. Project participants:

Table 3. Project participants. USM = University of Southern Mississippi , TAMUG = Texas A&M University at Galveston, NRL = U. S. Naval Research Laboratory at the Stennis Space Center.

First Name	Last Name	Role in Project	Institu-tion	Email
Kevin	Yeager	Project Lead	USM	kevin.yeager@usm.edu
Charlotte	Brunner	Co-PI	USM	charlotte.brunner@usm.edu
Vernon	Asper	Co-PI	USM	vernon.asper@usm.edu
Kevin	Briggs	Collaborator	NRL	kbriggs@nrlssc.many.mil
Patrick	Louchouarn	Collaborator	TAMUG	loup@tamug.edu

9. Student and post-doctoral participants:

Table 4. Student participants.

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Valerie	Cruz	MS	Live foraminifera at oiled and unoiled sites in the bathyal GOM	USM	C. Brunner	2013
Valerie	Hartmann	MS	Hypoxia	USM	K. Briggs/C. Brunner	2011
Shivakumar	Shivarudrappa	PhD	Hypoxia	USM	K. Briggs/S. Lohrenz	2013
Jeremy	Prouhet	MS	Physical properties of sediment	USM	K. Yeager	2011
Michael	Dalton	BS	NA	TAMUG	P. Louchouarn	2011
Lenai	Despins	BS	NA	TAMUG	P. Louchouarn	2011

10. Student and post-doctoral publications, if planned:

a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation

These activities are planned and appear in the Phase II timeframe.

11. Student and post-doctoral presentations and posters, if planned:
N/A

12. Images:

10-BP_GRI_USM-01 (Task 6): A Comprehensive Assessment of Oil Distribution, Transport, and Fate, and Impacts on Ecosystems and the Deepwater Horizon Oil Release - Task 6: Monitoring the impacts of dispersed oil exposure on ecologically and economically important species in the northern Gulf of Mexico using molecular biomarkers: Subtask: Parasites and lesions of Atlantic croaker as bioindicators

1. Project File Number: 10-BP_GRI_USM (Task 6)

2. Project Title: A Comprehensive Assessment of Oil Distribution, Transport, and Fate, and Impacts on Ecosystems and the Deepwater Horizon Oil Release - Task 6: Monitoring the impacts of dispersed oil exposure on ecologically and economically important species in the northern Gulf of Mexico using molecular biomarkers: Subtask: Parasites and lesions of Atlantic croaker as bioindicators

Robin Overstreet

SCIENCE ACTIVITIES

1. General Summary: Parasites serve as sentinels useful for understanding how pollution and ecosystem stressors affect the overall biodiversity in a habitat (see Overstreet and Howse, 1977; Overstreet, 1988, 1992, 1997; Marcogliese and Cone, 1997; Landsberg et al. 1998). Controlled experimental studies have demonstrated that some marine fish parasites are affected by crude oil (Khan, 1987a; Khan and Kiceniuk, 1983; Khan, 1991a; Abdul-Salam et al., 1996). Other experimental studies have shown how parasites are affected by petroleum hydrocarbons or aromatic hydrocarbons (PAH) in controlled settings, also addressing parasite host interactions (Moles, 1980; Khan, 1987b; Khan and Kiceniuk, 1988; Khan, 1990). Still other laboratory studies have addressed the effects of oil-contaminated sediments on marine fish parasites (Overstreet, 1988; Khan, 1991b; Marcogliese et al., 1998). In addition, a number of laboratory exposure studies have documented histopathological effects and gross physical effects of crude oil and its water-soluble fractions on various fish species (Solangi and Overstreet, 1982; Khan and Kiceniuk, 1984; Khan, 1991a; Khan and Thulin, 1991). In the aftermath of the Deepwater Horizon (DWH) oil spill (20 April 2010), this study was undertaken to investigate effects of the oil spill on the Atlantic croaker, *Micropogonias undulatus*, a commercially important wild marine fish present in Mississippi Sound and adjacent water. Two themes were studied: 1) the use of the parasite fauna as a bioindicator for possible petroleum hydrocarbon exposure in a wild marine fish, and 2) histopathological effects potentially caused by petroleum hydrocarbon exposure.

The key questions we asked for the preliminary task primarily involved whether the parasites and lesions of a representative fish species could serve as a model to indicate the effects of contamination in specific habitats and serve as a means to follow the severity and recovery of the noted effects over time post-exposure. We could answer the questions with some positive examples. Technical issues involved being able to start when potential employees were available and when oil was still abundant in specific habitats, being allowed to collect specimens in contaminated habitats, and being able to collect an adequate number of specimens from contaminated habitats. We solved most of the problems and obtained adequate data from the available specimens.

2. Results and scientific highlights:

I. Parasite study:

The parasite assemblage of the Atlantic croaker was surveyed at three localities in the Northern Gulf of Mexico during 2010-2011. A total of 311 croakers were captured by trawl across three localities during eight Autumn dates and one Spring date. Collected croakers were sampled for either parasites or examined histologically (Table 1). Parasites were identified and enumerated from the sample sites, and the parasite prevalence (% of hosts infected by a particular parasite) and parasite mean intensity (average number of a particular parasite present in an infected host) for each parasite species were calculated. These data were compared with historical parasite prevalence and mean intensity data from Atlantic croaker parasite surveys conducted in Mississippi Sound during Octobers of 1970 (n=72 croakers), 1971 (n=57), 1975 (n=60), 1976 (n=39), 1992 (n=30), March of 2006 (n=17), March 2008 (n=11), and June 2008 (n=15).

Table 1. Atlantic croaker collections. Dates of collections, locations, numbers of croakers surveyed for parasites, and numbers of croakers analyzed for histopathological effects.

Date	17/Sept/10	24/Sept/10	1/Oct/10	14/Oct/10	21/Oct/10	5/Nov/10	11/Nov/10	27/Nov/10	17/Mar/11
Location	Biloxi Ship Channel	South of Horn Island	Biloxi Ship Channel	Grand Isle, LA	South of Horn Island	Biloxi Ship Channel	South of Horn Island	Biloxi Ship Channel	Biloxi Ship Channel
Coordinates	30°22'09.55"N , 88°48'15.94" W	30°12'32.72"N , 88°41'30.41" W	30°22'09.55"N , 88°48'15.94" W	29°13'30.85"N , 90°02'08.59" W	30°12'32.72"N , 88°41'30.41" W	30°22'09.55"N , 88°48'15.94" W	30°12'32.72"N , 88°41'30.41" W	30°22'09.55"N , 88°48'15.94" W	30°22'09.55"N , 88°48'15.94" W
# croakers examined for parasites	30	29	30	30	30	30	30	29	30
# croakers examined histologically	5	5	5	5	5	5	5	3	5

The assemblage of croaker parasites from the 2010-2011 collection consisted conservatively of 29 species. The assemblage present between 1970 and 2008 consisted of approximately 31 species. Of these during the 2010-2011 sampling period, 12 species of parasites showed at least some possible evidence of exposure to petroleum hydrocarbons. These parasites included four species of external ones with direct life cycles, five additional adult ones from the digestive tract, and three species of larval parasites that inhabit the body cavity and mesentery of the host croaker.

II. Histopathological study:

Sections through gill tissue stained with hematoxylin and eosin revealed a variety of signs. Hyperplasia, a condition in which there is an increase in cell number in the gill lamellae, along with damaged and leaking cells, was pervasive in samples. Additionally, the presence of the potentially harmful parasitic protozoan organisms epitheliocystis and *Amyloodinium ocellatum* was noted in September and October, with infections of *A. ocellatum* in October reaching dangerously high levels.

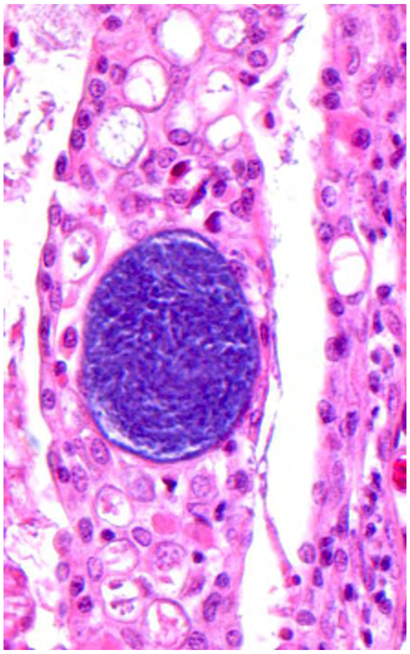
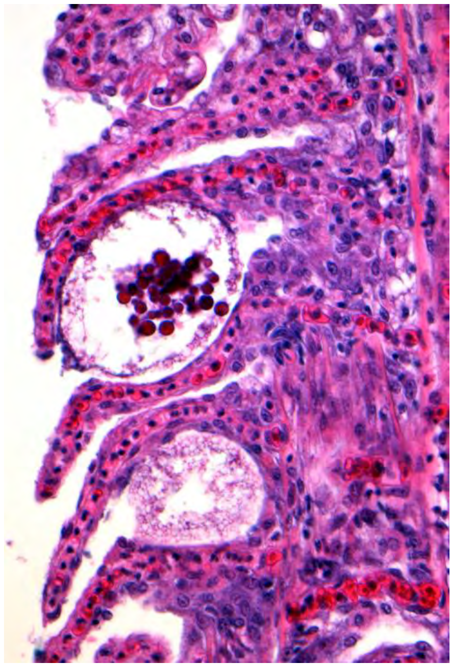
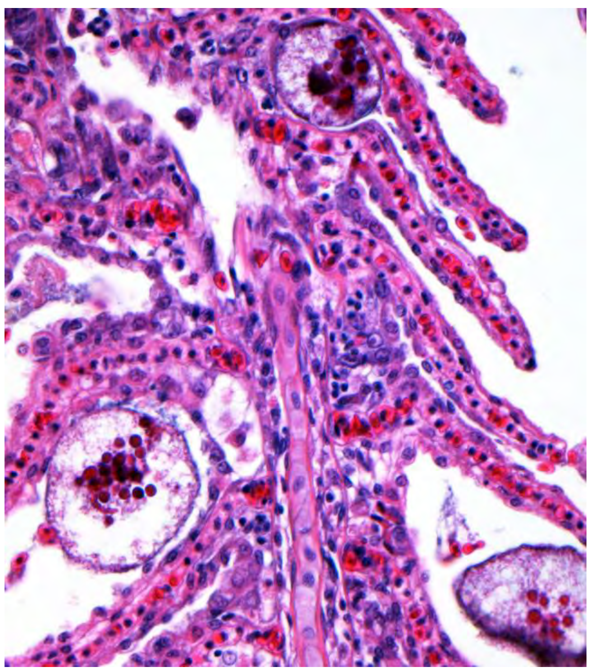


Figure 1. Hyperplastic gill filament of the Atlantic croaker from Grand Isle, Louisiana, on 14 October 2010, showing epitheliocystis. This and similar potentially pathogenic chlamydial-like agents also infected croaker in other collections from Mississippi and Louisiana.

Figure 2. Hyperplasia of gill of Atlantic croaker caught 5 November 2010 in the Ship Channel in Mississippi Sound. It is representative of the condition, some more and some less extensive, in croaker collected October and November 2010 in Mississippi and Louisiana. The filament is swollen and the increased number of cells on the right has resulted in fusion of the respiratory lamellae similar to that in fish experimentally exposed to whole crude oil or water soluble fractions.





Figures 3 and 4. *Amyloodinium ocellatum* on gills of two specimens of the Atlantic croaker from Biloxi Channel on 1 October 2010. A heavy infestation of this pathogenic dinoflagellate occurred on all fish from this collection but not on those other croaker caught October or November in Mississippi and Louisiana.

During November 2010 and into 2011, *A. ocellatum* was not detected in sections. The presence of *A. ocellatum* in October may or may not have been the product of petroleum products present in the water column. When fish are immuno-compromised, (as could happen when stressed by the presence of petroleum hydrocarbons), infection with *A. ocellatum* has the potential to cause major mortality in populations of Atlantic croaker.

We consider the Atlantic croaker a good model because it is infected by a variety of parasites that indicate wide biodiversity based on their additional hosts, it has parasites that are directly as well as indirectly affected by environmental factors, it, when stressed, is susceptible to harmful pathogens, and it has tissues that respond to contamination. Long-term monitoring of parasites and of histopathological signs in the representative model Atlantic croaker and other model fishes from Mississippi Sound would provide an inexpensive way to indirectly and qualitatively assess the effects of the spill and their longevity on the health of the environment. This study, however, was not selected for inclusion in the NGI Phase 2 funding process.

3. Cruises & field expeditions:

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
?		S. Curran and R. Overstreet	Atlantic Croaker Collections for parasites	9/17/10
?		S. Curran and R. Overstreet	Atlantic Croaker Collections for parasites	9/24/10
?		S. Curran and R. Overstreet	Atlantic Croaker Collections for parasites	10/1/10
?		S. Curran and R. Overstreet	Atlantic Croaker Collections for parasites	10/14/10
?		S. Curran and R. Overstreet	Atlantic Croaker Collections for parasites	10/21/10
?		S. Curran and R. Overstreet	Atlantic Croaker Collections for parasites	11/5/10
?		S. Curran and R. Overstreet	Atlantic Croaker Collections for parasites	11/11/10
?		S. Curran and R. Overstreet	Atlantic Croaker Collections for parasites	11/27/10
?		S. Curran and R. Overstreet	Atlantic Croaker Collections for parasites	3/17/11

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography

b. Manuscripts submitted or in preparation

N/A

5. Presentations and posters, if planned

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Changes in the parasite fauna of the Atlantic croaker, *Micropogonias undulatus*, from coastal waters impacted by the Deepwater Horizon oil spill	Stephen Curran	Stephen Curran and Robin Overstreet	Southeastern Society of Parasitologists Annual Meeting at Unicoi State Park, Helen, Georgia		8 April 2011

6. Other products or deliverables:

A. Presented a seminar at GCRL on parasitology and methods relating to spill monitoring to about 60 college students and instructors from several institutions on 16 March 2011.

B. Conducted a workshop on our task approach to this project with lecture at GCRL for 11 students of Hendrix College (Conway, Arkansas, with Professor Jennifer Dearolf, Environmental Studies course) on 24-25 March 2011.

C. Assisted group from numerous states (Washington, Maine, Pennsylvania, and others) from BioDiversity Research Institute funded to study the common loon in Mississippi following the oil spill. At least some of the members were here for several months. We showed them loons and contaminated locations, provided them information on loons and other birds, and performed necropsies on moribund and dead loons.

D. We escorted parties to contaminated habitats. These included botanical photojournalists and researchers on two occasions in November and December 2010; a journalist involved with recreational fishes in October 2010, and retired educators from Cape Cod, Massachusetts, on writing project on 3-4 April 2011 plus accompanied college students and instructors on visits to contaminated habitats at or near the barrier islands on R/V Hermes (12 people) and R/V McIlwain (20 people).

7. Data:

PARTICIPANTS AND COLLABORATORS

8. Project participants:

First Name	Last Name	Role in Project	Institution	Email
Robin	Overstreet	Co-I (lead)	USM	Robin.overstreet@usm.edu
Stephen	Curran	Co-I	USM	Stephen.curran@usm.edu

MENTORING AND TRAINING

9. Student and post-doctoral participants:

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Natalie	Marcussen	BS		USM		
Duncan	Perkins	BS		USM		
Jessica	Parker	MS		USM		

10. Student and post-doctoral publications, if planned:
a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation
N/A

11. Student and post-doctoral presentations and posters, if planned N/A

12. Images:
N/A

10-BP_GRI_USM-01 (Task 7): Microbial Response to Macondo Oil and Dispersant

1. NGI Project File Number: 10-BP_GRI_USM (Task 7)

2. Project Title: Microbial Response to Macondo Oil and Dispersant

D.J. Grimes and K.S. Dillon

SCIENCE ACTIVITIES

1. General Summary: The Grimes Lab has used our initial BP Gulf of Mexico Research Initiative funding administered by the Northern Gulf Institute to ask three fundamental microbiological questions that relate the Macondo oil incident and dispersant (Corexit 9500) use: (1) how prevalent are dioxygenase genes in the DH microbial community at sea and along Mississippi shorelines (both the coast itself and the barrier islands); (2) what is the involvement of *Vibrio* spp. in the microbial response to oil and dispersant; and (3) what is the effect of the oil/dispersant mixture and the dispersant alone on heterotrophic microbial activity in surface waters?

The Dillon Lab results from incubation experiments using unfiltered and bacterial size fractioned (<1µm) water conducted from September to December 2010 show that baseline bacterial production rates in untreated control incubations were lower than bacterial production rates measured through 2008 and 2009. Amendments of oil plus Corexit and Corexit dispersant alone were also conducted to examine the direct effect of these compounds on microbial growth and respiration relative to the untreated controls. Due to the limited supply of oil available from BP during the study period, oil was only used in two of the six experiments and when it was used, it was combined with Corexit to keep oil in solution and prevent oil slick formation/stratification within the incubation bottles. The remaining 4 experiments investigated the effects of Corexit dispersant alone. Bacterial production was highest in the unfiltered water control in September 2010 (11.45 µg C L-1 d-1) and was below 5.85 µg C L-1 d-1 for the remaining experiments in all treatments when bacterial growth was observed. Of the 32 total treatments ran during this study, 19 showed a small to dramatic decrease in bacterial abundance during 48 hour incubations. The largest declines in bacterial production were observed in the dispersant only treatments (as high as 60%). During a 2008-2009 study examining that the effects of inorganic nutrients and local sources of dissolved organic matter on bacterial activity, only 4 of 34 total treatments showed a decrease in bacterial abundance and the decreases were small (Carpenter, 2009) relative to those observed in this study. Respiration rates in the two treatments examining oil plus dispersant increased relative to the control while the highest respiration rates were measured in the dispersant only treatments. In all treatments that had bacterial growth and oxygen uptake (12 of 32 treatments), calculated bacterial growth efficiencies were low (<1 to 14%) relative to the previous study (3 to 60%). In control incubations, nonpurgable dissolved organic carbon (DOC) concentrations ranged from 337 to 909 µM and overlapped with the previously reported range (181-640 µM, Carpenter 2009). The highest DOC concentrations measured to date at the GCRL pier (909 µM) were measured during the September experiment. Initial DOC concentrations in amended incubations ranged from 1.47 to 3.97 mM except for the first dispersant treatment ([DOC]=15mM).

Increases and decreases of DOC and total dissolved nitrogen (TDN) concentrations were observed during the incubations. Control and dispersant incubations conducted at 7°C had lower bacterial production, DOC uptake and respiration rates than the counterpart amendments conducted at 20°C.

2. Results and scientific highlights:

Nearshore and offshore surface water ($\leq$ 2 m) were aseptically collected and preserved for microscopy; specifically, total bacteria (DAPI count), total Vibrios (FISH using a 16S rDNA primer labeled with Cy3), and polycyclic aromatic hydrocarbon (PAH) degraders (RING-FISH using an oxygenase primer labeled with Cy5) will be determined once the RING-FISH technique is developed. This protocol will provide an estimate of: 1. total bacteria, 2. total Vibrios (and percent Vibrios), 3. total PAH degraders (and percent PAH degraders), and 4. the percent of the Vibrio community that is capable of PAH degradation. We also collected and froze water samples for later PCR amplification of PAH degradation genes and for phylogenetic analysis. This work is in progress and is described in the next paragraph. Finally, we want to look at how bacteria are attracted and attached to microscopic oil and dispersant droplets in water. Attachment may involve biofilm formation and quorum sensing, but this is not known. We have begun laboratory microcosm studies using Davis Bayou water enriched with crude oil (MC252), dispersant (Corexit 9500) and crude oil plus dispersant and these studies will be completed in the summer of 2011.

The RING-FISH technique (Zwirglmaier et al. 2004) has been implemented in our laboratory for detecting *Vibrio* virulence factors (Noriea et al. 2010) and a RING-FISH methods paper for detecting *V. parahaemolyticus* has been accepted for publication (Griffitt et al. 2011). A RING-FISH dioxygenase probe that uses a 78-bp primer for the Rieske iron-sulfur center common to all PAH dioxygenase enzymes (Nı´ Chadhain et al. 2006) is in final stages of development. These three microscopic techniques will allow us to calculate the percent of Vibrios in the total DAPI count, the percent dioxygenase-positive bacteria in the total DAPI count and the percent dioxygenase-positive Vibrios. Finally, we will extract bulk DNA from all of these samples and PCR amplify the dioxygenase genes using the 78-bp primer (Nı´ Chadhain et al. 2006). Prelimninary results using this primer are shown in Fig. 1. These amplicons, along with others collected since the DH blowout, will be sequenced and subjected to phylogenetic analysis.

Dillon Lab: Results from incubations with filtered and unfiltered treatments show that "background" bacterial production rates (BPRs) in untreated control incubations were lower than BPRs measured from 2008 to 2009. Bacterial production was highest in the unfiltered control in September 2010 (11.45 µg C L^{-1} d^{-1}) and was below 5.85 µg C L^{-1} d^{-1} for the remainder of the experiments in all treatments where bacterial growth was observed. Of the 32 total treatments run, 19 showed a small to dramatic decrease in bacterial abundance in 48 hr incubations. Dispersant only treatments exhibited the largest reduction in biomass (as high as 60%). In a 2008 to 2009 study examining the effects of inorganic nutrients and local sources of dissolved organic matter on bacterial activity, only 3 of 34 treatments showed a decrease in bacterial production and the decreases were small (Carpenter 2009) relative to those observed in this study. In all treatments that had bacterial growth and oxygen uptake (12 of 32 treatments), calculated bacterial growth efficiencies were low (<1 to 14%) relative to the previous study (3 to 60%). In control incubations, DOC concentrations ranged from 337 to 909 µM

(4.04 to 10.91 mg/L) and overlapped with the previously reported range (181-640 µM or 2.17-7.68 mg/L, Carpenter 2009). The highest DOC concentrations measured to date at the GCRL pier were measured in the October 7, 2010 experiment. Initial DOC concentrations ranged from 1470 to 3970 µM (17.64 to 47.64 mg/L) except for the first dispersant experiment (15000 µM or 180 mg/L). Increases and decreases in DOC and TDN concentrations were observed during the incubations. The 0.2 µm filtered treatments showed no COD in the Corexit treatment. Control and dispersant incubations at 7°C had lower bacterial production, DOC uptake and respiration rates than incubations conducted at 20°C.

The observed reduction in BPRs during the 2010 experiments relative to 2008 to 2009 experiments suggests that the oil spill did have a quantifiable impact on water column bacterial activity in Mississippi Sound. Oil and dispersant treatments exhibited similar oxygen uptake to the control treatments, but bacterial abundance of dispersant treatments were lower than control treatments, sometimes by as much as 60%. These results suggest that some bacteria are negatively affected by Corexit dispersant, reducing the total bacteria population, but the remaining bacteria thrive under the conditions and maintain respiration rates similar to control conditions. More studies need to be conducted to confirm these hypotheses and examine the extent of the damage from the Deep Horizon oil spill in Mississippi Sound.

2. Cruises & Field Expeditions:

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
R/V *Tommy Munro*		J. Franks	Pendleton collected water samples and Sargassum for microbial analysis	June 2010
R/V *Ferrel*		T. Hazen	M. Pendleton collect water samples for presence of Vibrio species	3 legs in July 2010
R/V Tom McIwain		K. Dillon	Wilking collected offshore water for bacterial respiration experiments	10/20/2010

4. Peer-reviewed publications, if planned:

Dillon, KS, L. Wilking, and K. Carpenter. In prep. Short term response of water column bacterial growth and respiration to nutrients and dissolved organic matter in the Northern Gulf of Mexico. for submission to Coastal, Estuarine and Shelf Science during April 2012

5. Presentations and posters, if planned:

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Marine Bioremediation: The Microbial Response to the Deepwater Horizon Incident	DJ Grimes	DJ Grimes	9th International Marine Biotechnology Conference Qingdao, PR China	N	10/11/2010
Effects of Macono Oil and Corexit Dispersant on Bacterial Respiration and Growth	KS Dillon	KS Dillon and L. Wilking	2011 NGI Conference	N	5/16/2011

6. Other products or deliverables:
None

7. Data:
No archived samples

PARTICIPANTS AND COLLABORATORS

8. Project participants:

First Name	Last Name	Role in Project	Institution	Email
D. Jay	Grimes	Principle Investigator	USM	Jay.grimes@usm.edu
Kevin	Dillon	Principle Investigator	USM	Kevin.Dillon@usm.edu
Elizabeth	Myers	Technician	USM	Elizabeth.myers@usm.edu

MENTORING AND TRAINING

9. Student and post-doctoral participants:

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Lynn	Wilking	MS	Bacterial respiration in surface waters and biofilm communities of artificial reefs in MS Sound	USM	K. Dillon	2013
Marcia	Pendleton	MS	Vibrio motility and the role of cellular attachment in oil degredation	USM	D.J. Grimes	2013
Adrienne	Flowers		Role of turbidity and substrate type in the distribution of Vibrio parahaemolyticus	USM	D.J. Grimes	2013

10. Student and post-doctoral publications, if planned:

Dillon, KS, L. Wilking, and K. Carpenter. In prep. Short term response of water column bacterial growth and respiration to nutrients and dissolved organic matter in the Northern Gulf of Mexico. for submission to Coastal, Estuarine and Shelf Science during April 2012

11. Student and post-doctoral presentations and posters, if planned:

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Poster: Methods and Measurements: Effects of Macono Oil and Corexit Dispersant on Bacterial Respiration and Growth	L. Wilking	L. Wilking and KS Dillon	2011 NGI Conference	N	5/16/2011

12. Images: None

10-BP_GRI_USM-01 (Task 8): A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the Deepwater Horizon oil release - Task 8: Salt marsh habitat sampling to delineate potential oil impacts from BP Deepwater Horizon spill

1. Project File Number: 10-BP_GRI_USM (Task 8)

2. Project Title: A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the Deepwater Horizon oil release - Task 8: Salt marsh habitat sampling to delineate potential oil impacts from BP Deepwater Horizon spill

Biber, P.D., Wu, W. and Peterson, M.S.
Department of Coastal Sciences

SCIENCE ACTIVITIES

1. General Summary: Narrative (1 pages maximum): Chronic hydrocarbon contamination of saltmarshes from oil spilled in the 2010 BP "Deepwater Horizon" oil spill was assessed. Sampling was undertaken about 3 months after the well was capped, allowing sufficient time for oil to reach the coastline of Mississippi. Replicate samples from each site were collected and impacted and control sites were paired to better determine the impact of the oil on the sediments, plant tissues, and small resident nekton species. Samples were analyzed for polycyclic aromatic hydrocarbons (PAH) and non-halogenated oil range organics (ORO). PAH contamination was not found, with the exception of two plant tissue samples, where concentrations were less than 1ppm of chrysene. Concentrations of ORO in the sediments ranged from 0 – 67'500ppm and in plant tissues from 0 – 31'300ppm, no contamination was detected in animal muscle tissue samples. These results indicate that hydrocarbon contamination did occur in Mississippi saltmarshes, but observations suggest impacts were highly patchy and localized to a few small areas.

2. Results and scientific highlights:

Narrative (2 pages maximum): Oil came ashore in Mississippi saltmarshes over a period of time, approximately early June to late September, 2010. Timing of heavy oiling in the marsh was observed to coincide with tropical storm systems, including Hurricane Alex (30 June -1 July), Tropical Storm Bonnie (24-25 July), and Tropical Depression #5 (12-13 August), which all brought strong southerly winds and a storm surge pushing ashore GOM waters. The elevated tides associated with the storm surge contributed to further inland penetration of the floating oil mats than predicted. Despite this, most oil was observed to coat vegetation (primarily S. alterniflora) within less than 10 meters from open water.

The crude oil coating the immediately affected leaves within these small heavily oiled areas appears to have resulted in acute leaf effects by blocking transpiration and gas exchange through the stomata, and subsequent plant mortality, but new shoots and plants re-grew rapidly from intact roots within three months after the initial contamination.

Oil was very patchy, both on arrival and after subsequent degradation, making it hard to detect without significant sampling effort on a fine spatial scale (1m2 or finer). Some of the heavily oiled areas were less than 50x50m2 in total, and substantial patchiness of the oil within this size area was also observed. Many of the oil patches which washed ashore were much smaller than this, on the order of less than 0.25m2. Because of this highly localized impact it was important to use a stratified random sampling approach, based on apriori knowledge of impact locations. Much of the shoreline remained clear of heavy oiling, making it difficult to extrapolate to ecosystem-level contamination.

The contaminants detected from patches where oil was generally still visible at the time of sampling was composed of mainly longer carbon-chain compounds, C19-C36 non-halogenated organic chemicals. ORO was always detected analytically when oil was visible at time of sampling, but was also found in areas where oil was no longer visible (GBNERR, HI). When oil was not visible at the time of sample collection, the hydrocarbons were mainly found in plant tissues, suggesting biological uptake of contaminants, which could become bioavailable in the food chain as the plant tissues decompose after winter senescence. The different mechanisms involved in hydrocarbon concentrations in plants and sediments could also partly explain different patterns detected in the observations and statistical analysis.

Natural degradation processes of the oil that was washed ashore in the marsh include weathering (temperature, sunlight), but also physical removal by waves and tides. In particular, sites exposed to the predominant south-easterly winds, common during the summer in this region, experienced substantial tidal "cleaning" with oil being removed during high tides and periods of strong wave action corresponding to tropical storms in the GOM. Warm temperatures, often exceeding 35^{o}C during the day are also common in the region from June through September, promoting rapid volatilization of lighter carbon fractions. Oil that was observed to persist over time at MP quickly became more asphalt-like in its appearance and consistency, which correlates to reduced toxicity.

No oil was found in animal tissues analyzed, albeit the limited number of samples that satisfied the requirement for the minimum amount of sample needed (3 grams) to detect contamination affects this conclusion. A more extensive and better designed sampling strategy is required to determine if habitat contamination might be affecting the lower food chain populations. Other scientific studies conducted on offshore larval populations of marsh nekton detected oil contamination in blue crab larvae, indicating the potential for contamination of the lower food chain by oil.

3. Cruises & field expeditions:
None

4. Peer-reviewed publications, if planned:
a. Published, peer-reviewed bibliography (Copies of the papers are requested)
None

b. Manuscripts submitted or in preparation

Patrick D. Biber, Wei Wu, Mark S. Peterson, Linh Pham. (submitted Jan 2011). Oil impacts to saltmarsh habitats from the BP Deepwater Horizon spill. Marine Pollution Bulletin. Rejected by Editor after a single peer-review response.

Patrick D. Biber, Wei Wu, Mark S. Peterson. (in prep). Oil impacts to saltmarsh habitats from the BP Deepwater Horizon spill: environmental contamination and plant responses. Pages X-X in Impacts of Oil Spill Disasters on Marine Fisheries and Habitats in North America. J. Brian Alford, Mark S. Peterson and Christopher Green, editors. CRC Press, Boca Raton, FL

5. Presentations and posters, if planned:

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Using PAM to detect Oil Stress in Spartina Alterniflora	Patrick Biber	Patrick Biber	Bays and Bayous Symposium	Y	Dec 2010
Using PAM to detect Oil Stress in Spartina Alterniflora	Patrick Biber	Patrick Biber	Benthic Ecology Meeting	Y	Mar 2011

6. Other products or deliverables:

See attached maps (3):

- *NGI Oil – Animal Map121610*
- *NGI Oil – Plant Map121310*
- *NGI Oil – Soil Map121310*

7. Data:

PARTICIPANTS AND COLLABORATORS

8. Project participants

First Name	Last Name	Role in Project	Institution	Email
Patrick	Biber	Co-PI	USM-GCRL	Patrick.biber@usm.edu
Wei	Wu	Co-PI	USM-GCRL	Wei.wu@usm.edu
Mark	Peterson	Co-PI	USM-GCRL	Mark.peterson@usm.edu
Scott	Caldwell	Technician	USM-GCRL	n/a

MENTORING AND TRAINING

9. Student and post-doctoral participants:

First Name	Last Name	Post-doc / PhD / MS / BS	Thesis or research topic	Institution	Supervisor	Expected Completion year
Linh	Pham	PhD	n/a	USM-GCRL	Biber	n/a
Bradley	Ennis	MS	n/a	USM-GCRL	Peterson	n/a
Lina	Fu	MS	n/a	USM-GCRL	Wu	n/a

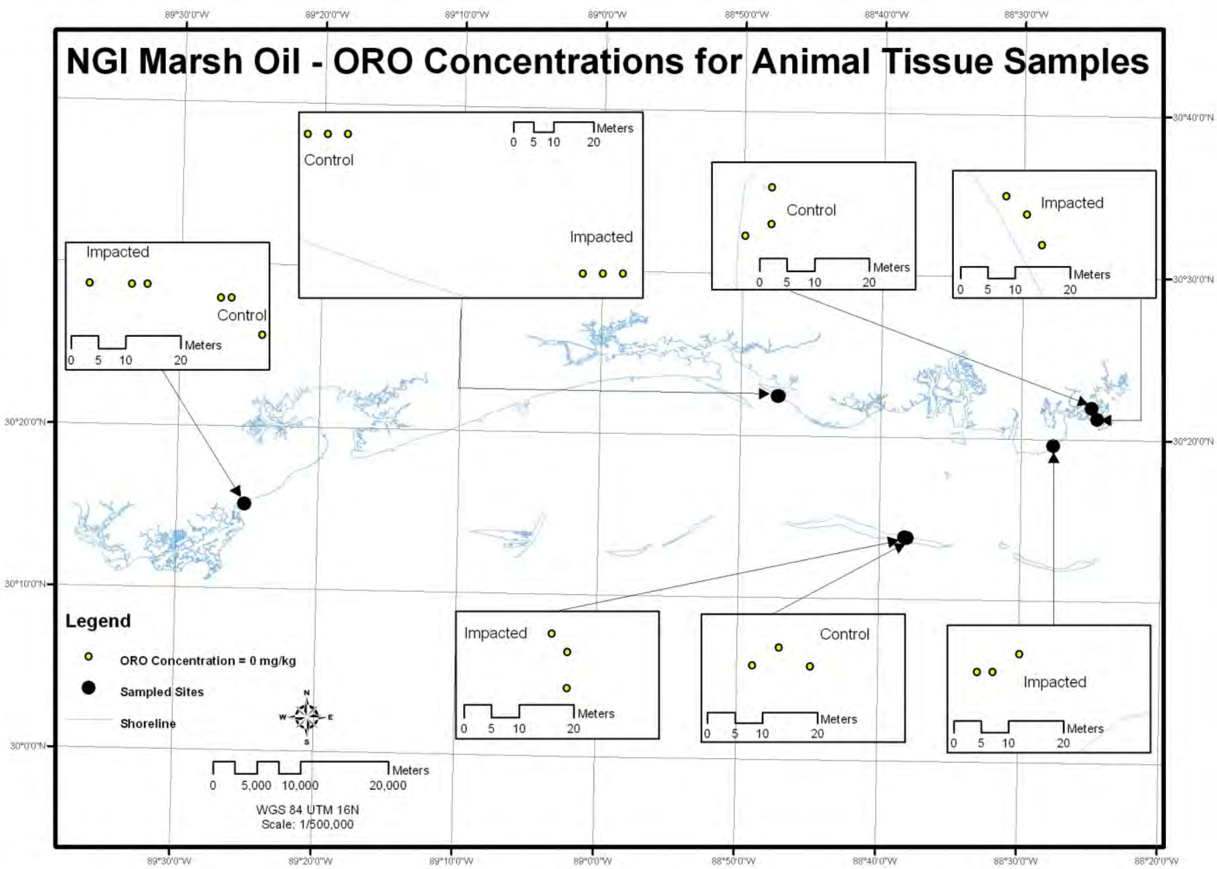
n/a indicates student's dissertation/thesis research was NOT funded by GoMRI activities.

10. Student and post-doctoral publications, if planned

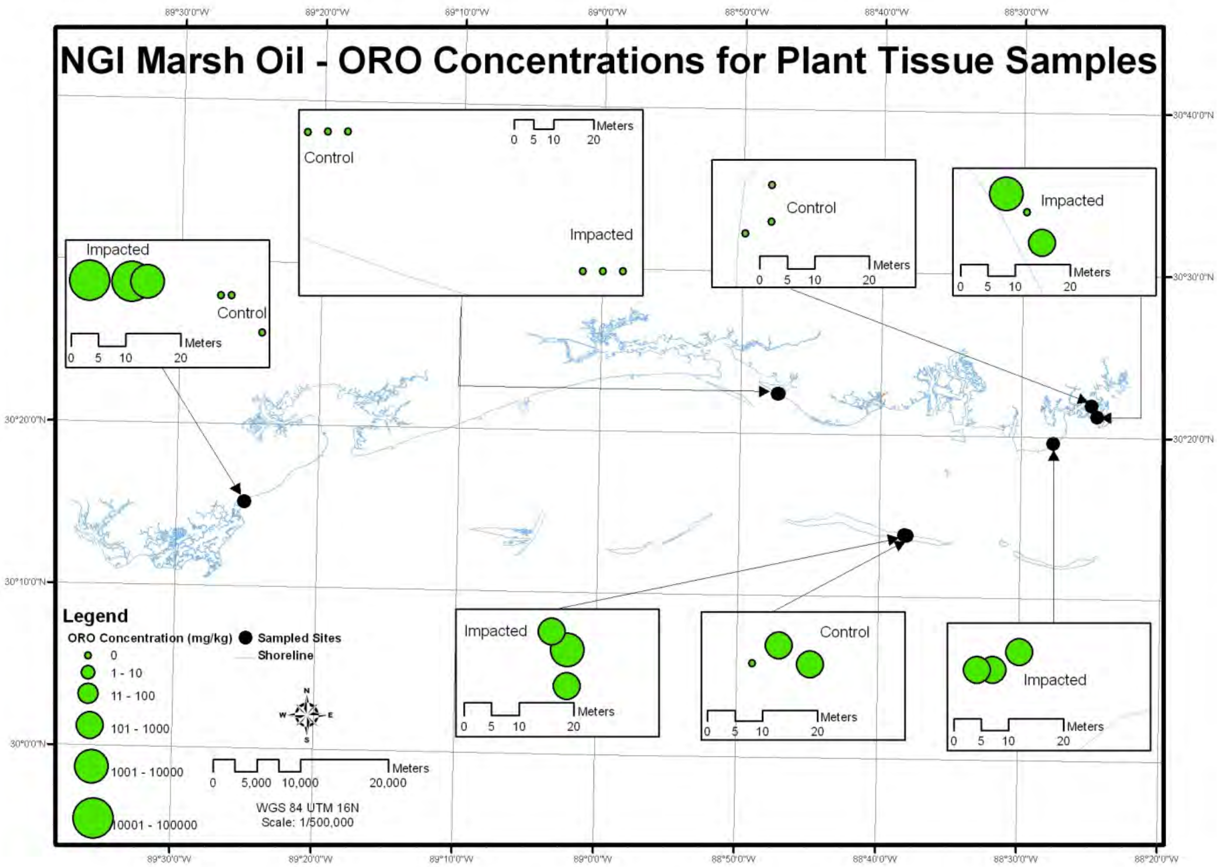
a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation

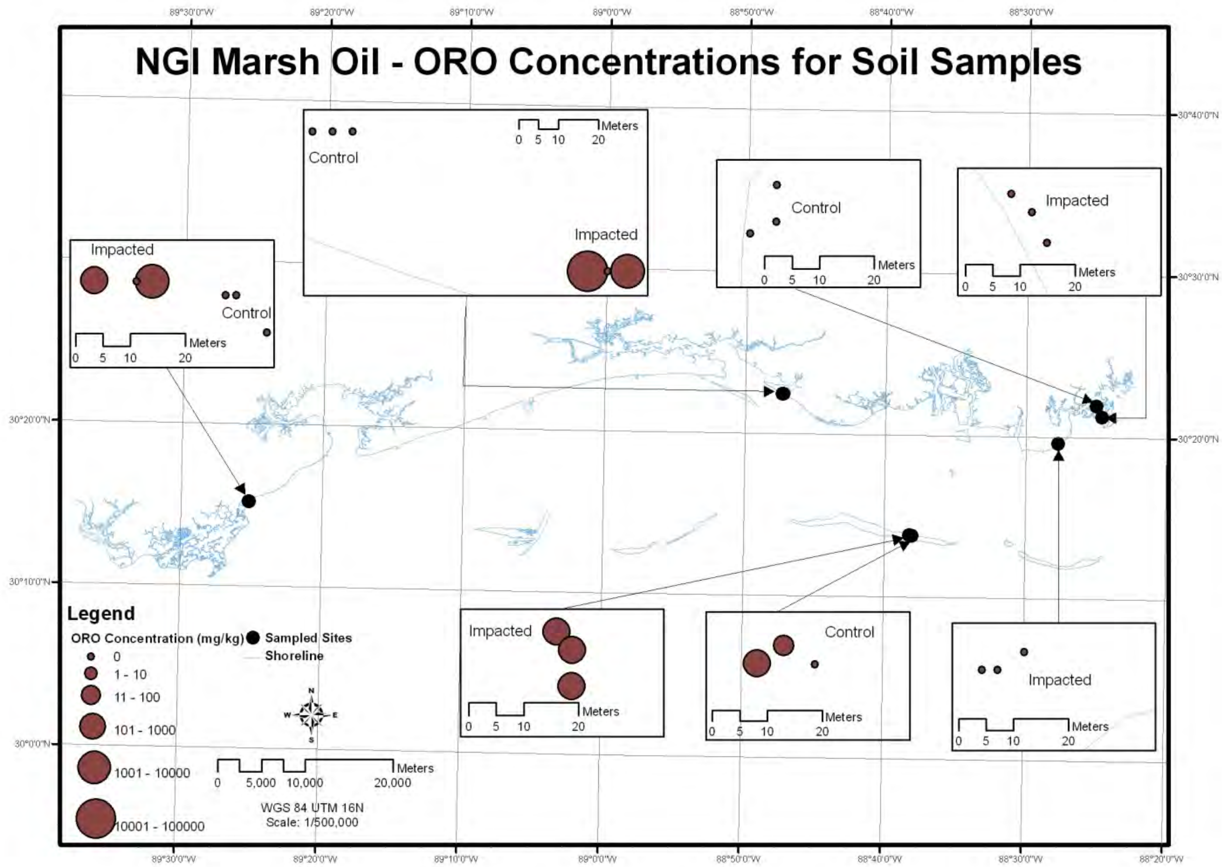
11. Student and post-doctoral presentations and posters, if planned:
NA

12. Images



NGI Marsh Oil - ORO Concentrations for Animal Tissue Samples
Control
Impacted
Meters
0 5 10 20
Legend
ORO Concentration = 0 mg/kg
Sampled Sites
Shoreline
0 5,000 10,000 20,000
WGS 84 UTM 16N
Scale: 1/500,000


NGI Marsh Oil - ORO Concentrations for Plant Tissue Samples
Impacted
Control
Meters
Legend
ORO Concentration (mg/kg)
Sampled Sites
Shoreline
0
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
0 5,000 10,000 20,000 Meters
WGS 84 UTM 16N
Scale: 1/500,000



NGI Marsh Oil - ORO Concentrations for Soil Samples
Control
Impacted
Meters
0 5 10 20
Legend
ORO Concentration (mg/kg)
0
1 - 10
11 - 100
101 - 1000
1001 - 10000
10001 - 100000
Sampled Sites
Shoreline
0 5,000 10,000 20,000
WGS 84 UTM 16N
Scale: 1/500,000

10-BP_GRI_USM-01 (Task 9): A Comprehensive Assessment of Oil Distribution, Transport, Fate and Impacts on Ecosystems and the Deepwater Horizon Oil Release – Task 9: Investigation of Juvenile Fishes Associated with Pelagic Sargassum Habitat in the North Central Gulf of Mexico

1. Project File Number: 10-BP_GRI_USM_01 (Task 9)

2. Project Title: A Comprehensive Assessment of Oil Distribution, Transport, Fate and Impacts on Ecosystems and the Deepwater Horizon Oil Release – Task 9: Investigation of Juvenile Fishes Associated with Pelagic Sargassum Habitat in the North Central Gulf of Mexico

3. Principal Investigator: James S. Franks

SCIENCE ACTIVITIES

1. General Summary: Due to the importance of pelagic *Sargassum* as critical nursery habitat for a diverse group of fishes in the northern Gulf of Mexico, the project was designed to assessment impacts to the *Sargassum* juvenile fish community relative to the Deepwater Horizon (MC252) oil spill. The study was undertaken to: 1) assist in post-spill impact assessments of the Gulf's fisheries resources, including future recruitment of young fishes into fisheries, and 2) in support of ecosystem-based management of fisheries resources in the Gulf of Mexico.

The primary scientific question was: were pelagic *Sargassum* habitat and associated juvenile fishes impacted by the Deepwater Horizon oil spill? This question was to be addressed through scientific field collections that provided biological samples and associated data in support the following study Objectives:

A. Describe and compare the juvenile fish community (species composition, sizes, and abundance) associated with visibly oiled and non-oiled *Sargassum* habitat.

B. Determine the relationships between species richness and abundance of juveniles fishes identified in the *Sargassum* collections and the quantities of *Sargassum* taken in collections.

For purposes of this study, we defined 'visibly' impacted *Sargassum* as that found in surface sheens of oil and/or visibly infused with dispersed oil, weathered oil or mousse. We proposed to test the hypothesis that the composition and abundance of the juvenile fish community associated with pelagic *Sargassum* would not differ between *Sargassum* sites (habitat) visibly impacted by the spilled oil vs. *Sargassum* sites not visibly impacted by the spilled oil.

Although the primary objective of the project was to describe, assess and compare the diversity and abundance of juvenile fishes collected from 'visibly' oil-impacted *Sargassum* with 'visibly' non-impacted *Sargassum*, no 'visibly' impacted *Sargassum* was encountered during any of the three sampling cruises. The relatively short duration of the field aspect of the study period allowed for fall and winter collections only. Fishes and invertebrates found in the collections were perhaps generally representative of seasonal fish and macro-invertebrate inhabitants of *Sargassum* in the northern GOM during fall and winter months or may have been representative of fish and macro-invertebrate *Sargassum* associates only for the specific times and locations of collections in September and October 2010 and January 2011 following the DWH event. This study documented that *Sargassum* habitat sampled in the north-central GOM during the months of September and October 2010 and January 2011 provided habitat for a multitude of young fishes.

2. Results and scientific highlights:

Twelve field collections containing juvenile fishes and macro invertebrates associated with *Sargassum* habitat (windrows/weedlines) in the north-central Gulf of Mexico (GOM) were taken during three research cruises (September and October 2010, January 2011) conducted within an area generally defined as north of Latitude 28^{o}N' and between Longitude 87^{o} 30'W and 90^{o}W and, inclusive of the Deepwater Horizon (DWH) site. Collections were taken using neuston net gear (3.2 mm mesh) towed perpendicular ('directly through') to *Sargassum* aggregations. Surface water temperature and salinity ranged 32.4 - 35.0 ppt. and 19.5 - 29.2^{o}C, respectively, for the total number of collections.

A total of 1,916 juvenile fishes was collected representing 27 species and 13 families, with *Mugil curema*, *Trachurus lathami*, *Histrio histrio*, *Balistes capriscus* and *Stephanolepis hispidus* numerically dominating the overall collection. Family Carangidae was represented by the greatest number of species (n = 8), followed by Balistidae and Monacanthidae, each with three species. The other fishes collected were members of families Centrolophidae, Phycidae, Kyphosidae, Lobotidae, Macroramphosidae, Pomacentridae, Scombridae and Syngnathidae. Recreationally and commercially important species were represented in the collections, including triggerfish, pompano and tripletail. The diversity, abundance and size (SL, mm) of fishes varied somewhat among the three cruises, but three species (*H. histrio, S. hispidus,* and *S. louisianae*) were present in collections from each cruise. Mean size (SL, mm) of individual species collected in each of the three cruises did not differ substantially among the cruises, even though samples were collected seasonally (September, October 2010, and January 2011).

Although the focus on this project was on juvenile fishes, 82,892 macro-invertebrates were collected, identified (to the lowest taxonomic level deemed possible) and enumerated. The invertebrates strongly dominated the overall collection numerically (98%), far outnumbering fishes in most individual collections. Nine families were represented in the total collection, and *Latreutes fucorum*, *L. tenuicornis*, *Portunus sayi* and *L. parvulus* accounted for 99.8% of invertebrates identifiable to species level and 90% of invertebrates collected overall.

Although the primary objective of the project was to describe, assess and compare the diversity and abundance of juvenile fishes collected from 'visibly' oil-impacted *Sargassum* with 'visibly' non-impacted *Sargassum*, no 'visibly' impacted *Sargassum* was encountered during any of the three sampling cruisesUnderstanding the structure and function of the *Sargassum* community and the role it plays as Essential Fish Habitat in supporting and sustaining the feeding and spawning requirements, survivorship, and distribution of larval and juvenile fishes in the GOM is paramount to expanding the knowledge of the recruitment of young fishes into GOM fisheries.

Project Baselines:

The findings of this project represent valuable information pertaining to living marine resources and an essential pelagic habitat that will better inform NOAA, Gulf fishery councils and commissions, and Gulf states regarding the Gulf of Mexico ecosystem-based management decision making process.

The project provided further evidence that pelagic *Sargassum* is critical habitat, particularly critical nursery habitat, for a diverse assemblage of species, many of which support valuable commercial and recreational fisheries. Identification of essential fish habitats in the Gulf of Mexico is critical to effective management of those habitats and species which utilize them. Pelagic *Sargassum* is one of those critical habitats.

Critical data and information gaps exist in regard to current scientific understanding of the pelagic ecosystem in the northern Gulf of Mexico, particularly the northern Gulf region. This project provides new information on the diversity and abundance of young fishes (and macro invertebrates) that inhabit or associate with pelagic *Sargassum* habitat in the northern Gulf of Mexico. Although none of the pelagic *Sargassum* habitat encountered and/or sampled during the project's field research activities was 'visibly' impacted by oil, the scientific collections for this study were taken from the north central Gulf of Mexico during the months of September 2010, December 2010, and January 2011 following the Deepwater Horizon spill. Project results are available for use in the protection, restoration and management of coastal and ocean resources through an ecosystem approach to management.

3. Cruises & field expeditions:

Ship or Platform Name	**Class** (if applicable)	**Chief Scientist**	**Objectives**	**Dates**
RV/TOMMY MUNRO		JAMES FRANKS	Pelagic sargassum studies in the northern Gulf of Mexico post-DWH spill; assessments of associated juvenile fishes	9 & 10/2010
				1/2011

4. Peer-reviewed publications, if planned:
N/A

5. Presentations and posters, if planned: None

6. Other products or deliverables:

MAP OF STUDY SITES PROVIDED BELOW:

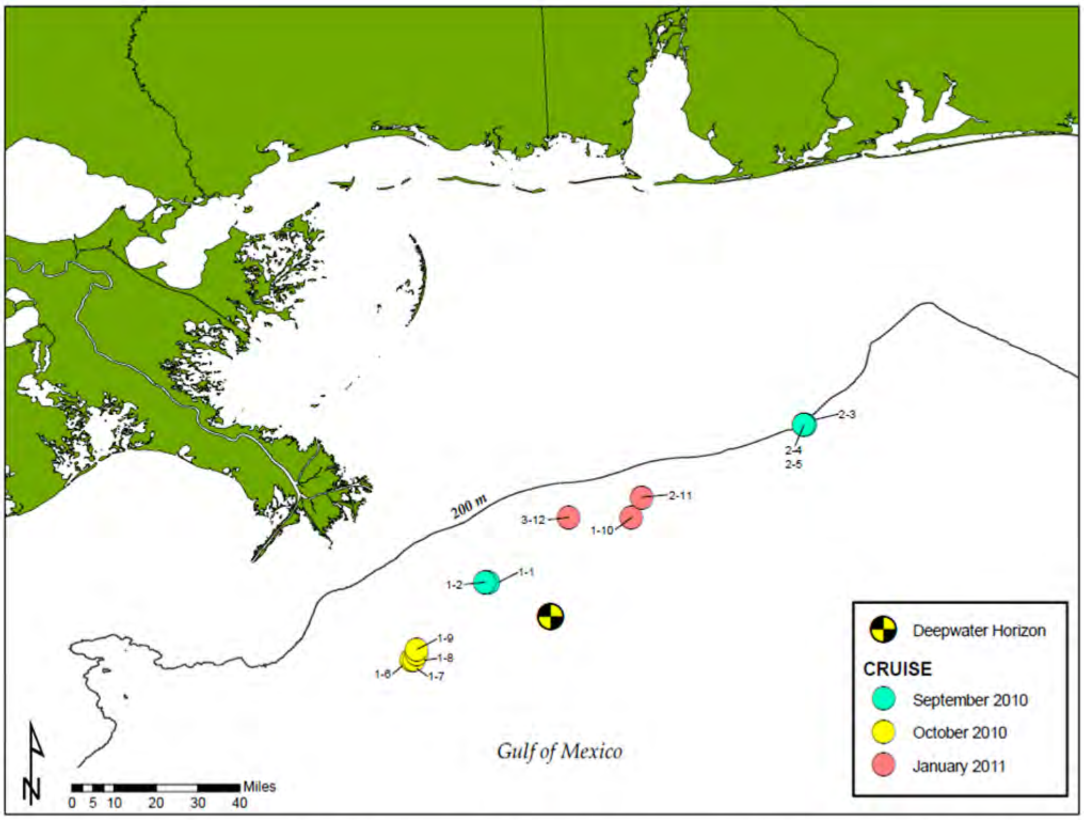


Figure 1. Study Area. The location of each collection site is labeled as "Station - Collection Number". (See Table 1 for specific N Latitude and W Longitude for each of the 12 collections.)

7. Data

Reporting on data is done separately through communications with Harte Research Institute; however, please provide a spreadsheet indicating the metadata and ancillary information on the location and status of the archived samples. Also, indicate if there are any issues with respect to data archiving schedule and plan.

All Project data were entered and stored in the Excel file titled: Final NGI Sargassum Project Data.xlsx

All data and data analyses can be found as reported in Figures and Tables at end of this report.

All project data and biological samples are archived at the Gulf Coast Research Laboratory and available upon request.

PARTICIPANTS AND COLLABORATORS

8. Project participants:

First Name	Last Name	Role in Project	Institution	Email
Bruce	Comyns	Co-PI	USM-GCRL Retired	bruce.comyns@gmail.com
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MENTORING AND TRAINING

9. Student and post-doctoral participants:
N/A

10. Student and post-doctoral publications, if planned:
NONE

11. Student and post-doctoral presentations and posters, if planned:
None

12. Images:

Tables and Figures are presented on the following pages

Table 1. Field collection data for pelagic Sargassum research cruises conducted in the north-central Gulf of Mexico in 2010 and 2011.

Date	Cruise	Station	Collection number	Time (h)	Latitude N	Longitude W	Salinity (ppt)	Temp. (°C)	Sea State (m)	Wind Spd. (knt)	Sarg Tot. Wt. (kg)
9/26/2010	1	1	1	1653	28°51.15	88°36.11	32.4	28.9	0.75	5	13.19
9/26/2010	1	1	2	1805	28°51.27	88°36.91	32.6	29.2	0.75	4	16.11
9/27/2010	1	2	3	1455	29°23.90	87°30.47	35.0	28.2	1.50	15	8.39
9/27/2010	1	2	4	1510	29°23.67	87°30.77	35.0	28.2	1.00	15	32.43
9/27/2010	1	2	5	1810	29°23.67	87°30.77	35.0	28.2	1.50	10	30.69
10/20/2010	2	1	6	1055	28°35.07	88°52.07	34.5	26.2	1.50	15	10.00
10/20/2010	2	1	7	1155	28°35.27	88°51.51	34.5	26.2	1.50	15	9.40
10/20/2010	2	1	8	1210	28°36.27	88°50.96	34.5	26.2	1.50	15	10.40
10/20/2010	2	1	9	1230	28°37.36	88°50.91	34.5	26.2	1.50	15	1.75
1/15/2011	3	1	10	1010	29°04.66	88°06.50	33.0	19.8	1.00	14	10.65
1/15/2011	3	2	11	1210	29°08.79	88°04.33	35.0	19.5	1.00	12	6.50
1/16/2011	3	3	12	1105	29°04.67	88°19.47	35.0	20.1		15	9.60

Table 2. Fish families and the diverse taxa of macro-invertebrates collected during the study in order of numeric contribution.

Family	Number		Taxa	Number
Mugilidae	903		Hippolytidae	70909
Carangidae	259		Order Neotaenioglossa	3997
Balistidae	248		Infraorder Caridea	3768
Antennariidae	189		Palaemonidae	2863
Monacanthidae	116		Portunidae	828
Pomacentridae	76		Class Polychaeta	288
Phycidae	72		Scyllaeidae	79
Kyphosidae	13		Lepadidae	57
Syngnathidae	12		Order Amphipoda	51
Lobotidae	11		Class Scyphozoa	14
Scombridae	9		Luciferidae	12
Macroramphosidae	6		Caprellidae	10
Centrolophidae	2		Class Gastropoda	8
Total	1916		Janthinidae	4
			Class Holothuroidea	2
			Phoxichilidiidae	1
			Subclass Copepoda	1
			Total	82892

Table 3. Fishes and invertebrates identified to species level (when possible) with respective numeric contribution to the total collection and common name.

Species	Number		Common name
Latreutes fucurum	70165		Slender sargassum shrimp
-	3997		Walker snails
-	3768		True shrimp
Leander tenuicornis	2863		Brown glass shrimp
Mugil curema	903		Silver mullet, white mullet
Portunus sayi	748		Sargassum swimming crab
Latreutes parvulus	744		Sargassum shrimp
-	288		Polychaetes
Trachurus lathami	227		Rough scad
Histrio histrio	189		Sargassumfish
Balistes capriscus	168		Gray triggerfish
Stephanolepis hispida	112		Planehead filefish
Scyllaea pelagica	79		Sargassum nudibranch
Abudefduf saxatilis	76		Sergeant major
Canthidermis sufflamen	69		Ocean triggerfish
Lepas sp.	57		Stalked barnacle

-	51		Amphipods
Urophycis cirrata	39		Gulf hake
Urophycis floridanus	33		Southern hake
Callinectes similis	31		Lesser blue crab
-	14		Jellyfish
Portunus spinicarpus	13		Longspine swimming crab
Portunus spinimanus	13		Blotched swimming crab
Lucifer sp.	12		Lucifer shrimp
Canthidermis maculata	11		Rough triggerfish
Lobotes surinamensis	11		Tripletail
Arenaeus cribrarius	11		Speckled swimming crab
Callinectes sapidus	11		Blue crab
-	10		Skeleton shrimp
Elagatis bipinnulata	9		Rainbow runner
Kyphosus sectator	9		Bermuda chub
Scomber colias	9		Altantic chub mackerel
Syngnathus louisianae	8		Chain pipefish
-	8		Snails
Caranx crysos	6		Blue runner
Seriola rivoliana	6		Almaco jack
Caranx ruber	6		Bar jack
Macroramphosus scolopax	6		Longspine snipefish
Kyphosus incisor	4		Yellow chub
Syngnathus pelagicus	4		Sargassum pipefish
Species	**Number**		**Common name**
Janthina sp.	4		purple snails
Cantherines pullus	3		Orangespotted filefish
Caranx hippos	2		Crevalle jack
Seriola zonata	2		Banded rudderfish
Schedophilus pemarco	2		Pemarco blackfish
-	2		Sea cucumber
Trachinotus carolinus	1		Florida pompano
Aluterus schoepfii	1		Orange filefish
Anoplodactylus petiolatus	1		Sea spider
-	1		Swimming crabs
-	1		Copepod

Table 4. Fishes collected during the study with size range (SL, mm), mean size and number of individuals in the total collection.

Family	Species	Size range (SL mm)	Mean size (SL mm)	Number
Phycidae	*Urophycis cirrata*	6.9 - 36.8	19.2	39
	Urophycis floridana	15.3 - 54.6	32.1	33
Antennariidae	*Histrio histrio*	6.7 - 56.7	14.0	189
Mugilidae	*Mugil curema*	6.8 - 25.2	22.4	903
Macroramphosidae	*Macroramphosus scolopax*	7.4 - 10.4	8.7	6
Syngnathidae	*Syngnathus louisianae*	84.9 - 126.1	104.5	8
	Syngnathus pelagicus	79.4 127.0	107.2	4
Carangidae	*Caranx ruber*	30.4 - 45.0	35.9	6
	Caranx crysos	29.9 - 52.5	42.2	6
	Caranx hippos	17.6 - 28.8	23.2	2
	Elagatis bipinnulata	15.7 - 37.3	21.0	9
	Seriola rivoliana	18.7 - 44.5	34.1	6
	Seriola zonata	21.4 - 33.6	27.5	2
	Trachinotus carolinus	67.2	67.2	1
	Trachurus lathami	13.3 - 60.5	22.4	227
Lobotidae	*Lobotes surinamensis*	6.3 - 260.0	65.2	11
Kyphosidae	*Kyphosus incisor*	8.6 - 13.3	10.7	4
	Kyphosus sectator	16.2 - 48.0	36.2	9
Pomacentridae	*Abudefduf saxatilis*	9.3 - 40.1	16.5	76
Scombridae	*Scomber colias*	18.0 - 27.8	20.9	9
Centrolophidae	*Schedophilus pemarco*	20.2 - 25.2	22.7	2
Balistidae	*Balistes capriscus*	20.9 - 81.1	42.9	168
	Canthidermis maculata	7.3 - 124.8	43.0	11
	Canthidermis sufflamen	11.7 - 120.0	39.8	69
Monacanthidae	*Aluterus schoepfii*	63.4	63.4	1
	Cantherhines pullus	43.9 - 58.0	51.6	3
	Stephanolepis hispida	10.5 - 50.9	31.3	112
			Total	1916

Table 5. Composition, abundance and size (SL, mm) of collected fishes listed by cruise and station.

					Size Range	Mean Size
Cruise	Station	Family	Species	Number	(SL mm)	(SL mm)
1	1	Antennariidae	*Histrio histrio*	37	7.7 - 55.5	12.9
1	1	Balistidae	*Balistes capriscus*	5	20.9 - 81.1	43.2
1	1	Balistidae	*Canthidermis maculata*	8	7.3 - 142.8	40.0
1	1	Balistidae	*Canthidermis sufflamen*	11	30.3 - 69.3	47.7
1	1	Carangidae	*Caranx crysos*	1	42.4	42.4
1	1	Carangidae	*Elagatis bipinnulata*	1	24.2	24.2
1	1	Kyphosidae	*Kyphosus incisor*	1	13.3	13.3
1	1	Kyphosidae	*Kyphosus sectator*	1	16.2	16.2
1	1	Lobotidae	*Lobotes surinamensis*	1	63.3	63.3
1	1	Monacanthidae	*Stephanolepis hispida*	2	10.5 - 15.2	12.9
1	1	Pomacentridae	*Abudefduf saxatilis*	26	9.6 - 40.1	13.8
1	1	Syngnathidae	*Syngnathus louisianae*	5	93.9 - 107.5	101.9
1	2	Antennariidae	*Histrio histrio*	59	6.7 - 37.5	12.0
1	2	Balistidae	*Balistes capriscus*	162	26.0 - 79.4	42.8
1	2	Balistidae	*Canthidermis maculata*	3	38.0 - 69.9	51.0
1	2	Balistidae	*Canthidermis sufflamen*	58	11.7 - 120.0	38.3
1	2	Carangidae	*Caranx ruber*	6	30.4 - 45.0	35.9
1	2	Carangidae	*Caranx crysos*	4	29.9 - 46.5	39.6
1	2	Carangidae	*Caranx hippos*	1	28.8	28.8
1	2	Carangidae	*Elagatis bipinnulata*	7	15.7 - 37.3	20.7
1	2	Carangidae	*Seriola rivoliana*	4	37.3 - 44.5	40.7
1	2	Carangidae	*Seriola zonata*	2	21.4 - 33.6	27.5
1	2	Carangidae	*Trachinotus carolinus*	1	67.2	67.2
1	2	Kyphosidae	*Kyphosus sectator*	7	21.7 - 48.0	39.0
1	2	Lobotidae	*Lobotes surinamensis*	10	6.3 - 260.0	65.4
1	2	Monacanthidae	*Cantherhines pullus*	3	43.9 - 58.0	51.6
1	2	Monacanthidae	*Stephanolepis hispida*	65	16.8 - 47.9	28.0
1	2	Pomacentridae	*Abudefduf saxatilis*	27	9.3 - 29.5	18.9
1	2	Syngnathidae	*Syngnathus pelagicus*	2	124.0 - 127.0	125.5
2	1	Antennariidae	*Histrio histrio*	87	7.9 - 56.7	15.4
2	1	Balistidae	*Balistes capriscus*	1	43.5	43.5
2	1	Carangidae	*Caranx crysos*	1	52.5	52.5
2	1	Carangidae	*Elagatis bipinnulata*	1	19.7	19.7
2	1	Carangidae	*Seriola rivoliana*	2	18.7 - 23.3	21.0
2	1	Kyphosidae	*Kyphosus incisor*	3	8.6 - 10.5	9.8
2	1	Kyphosidae	*Kyphosus sectator*	1	36.4	36.4
2	1	Monacanthidae	*Aluterus schoepfii*	1	63.4	63.4
2	1	Monacanthidae	*Stephanolepis hispida*	44	16.7 - 50.9	37.0
2	1	Pomacentridae	*Abudefduf saxatilis*	23	10.6 - 23.4	16.6
2	1	Syngnathidae	*Syngnathus louisianae*	2	112.8 - 126.1	119.5
2	1	Syngnathidae	*Syngnathus pelagicus*	2	79.4 - 98.3	88.9
3	1	Antennariidae	*Histrio histrio*	3	19.4 - 24.8	21.6
					Size Range	Mean Size
Cruise	Station	Family	Species	Number	(SL mm)	(SL mm)

3	1	Carangidae	*Caranx hippos*	1	17.6	17.6
3	1	Phycidae	*Urophycis floridana*	2	30.3 - 37.8	34.1
3	2	Antennariidae	*Histrio histrio*	2	9.9 - 28.1	19.0
3	2	Carangidae	*Trachurus lathami*	169	13.3 - 60.5	20.0
3	2	Centrolophidae	*Schedophilus pemarco*	1	20.2	20.2
3	2	Phycidae	*Urophycis cirrata*	39	6.9 - 36.8	19.2
3	2	Phycidae	*Urophycis floridana*	25	15.3 - 54.6	32.4
3	2	Macroramphosidae	*Macroramphosus scolopax*	6	7.4 - 10.4	8.7
3	2	Monacanthidae	*Stephanolepis hispida*	1	34.8	34.8
3	2	Mugilidae	*Mugil curema*	899	6.8 - 25.2	22.4
3	2	Scombridae	*Scomber colias*	9	18.0 - 27.8	20.9
3	2	Syngnathidae	*Syngnathus louisianae*	1	84.9	84.9
3	3	Antennariidae	*Histrio histrio*	1	21.3	21.3
3	3	Carangidae	*Trachurus lathami*	58	16.8 - 34.0	26.5
3	3	Centrolophidae	*Schedophilus pemarco*	1	25.2	25.2
3	3	Phycidae	*Urophycis floridana*	6	24.2 - 38.4	30.1
3	3	Mugilidae	*Mugil curema*	4	21.9 - 23.5	22.6

Table 6. Composition, abundance and mean size (SL, mm) of collected fishes listed by cruise.

Species	Cruise 1 Abundance	Cruise 2 Abundance	Cruise 3 Abundance	Cruise 1 Mean Size (SL mm)	Cruise 2 Mean Size (SL mm)	Cruise 3 Mean Size (SL mm)
Balistes capriscus	167	1	0	42.9	43.5	
Histrio histrio	96	87	6	12.4	15.4	20.7
Canthidermis sufflamen	69	0	0	39.8		
Stephanolepis hispida	67	44	1	27.5	37.0	34.8
Abudefduf saxatilis	53	23	0	16.4	16.6	
Canthidermis maculata	11	0	0	43.0		
Lobotes surinamensis	11	0	0	65.2		
Elagatis bipinnulata	8	1	0	21.9	19.7	
Kyphosus sectator	8	1	0	36.1	36.4	
Caranx ruber	6	0	0	35.9		
Caranx crysos	5	1	0	40.1	52.5	
Syngnathus louisianae	5	2	1	101.9	119.5	84.9
Seriola rivoliana	4	2	0	40.7	21.0	
Cantherhines pullus	3	0	0	51.6		
Seriola zonata	2	0	0	27.5		
Syngnathus pelagicus	2	2	0	125.5	88.9	
Trachinotus carolinus	1	0	0	67.2		
Kyphosus incisor	1	3	0	13.3	9.8	
Caranx hippos	1	0	1	28.8		17.6
Aluterus schoepfii	0	1	0		63.4	
Schedophilus pemarco	0	0	2			22.7
Macroramphosus scolopax	0	0	6			8.7
Scomber colias	0	0	9			20.9
Urophycis floridana	0	0	33			32.1
Urophycis cirrata	0	0	39			19.2
Trachurus lathami	0	0	227			22.4
Mugil curema	0	0	903			22.4

Table 7. Relationship between fish diversity and abundance, and biomass (weight) of *Sargassum* sampled per cruise, expressed as Pearson's correlation coefficient (r). The Pearson's correlation scale ranges from +1 (a perfect positive linear relationship between variables) to -1 (a total negative relationship between variables).

	Weight vs. abundance	Weight vs. diversity
All cruise samples combined	-0.12	0.67
Cruise 1 samples	0.69	0.93
Cruise 2 samples	-0.28	0.23
Cruise 3 samples	-0.98	-1.00

Table 8. Macro-invertebrates collected during the study with numeric contributions to the total collection.

Class	Order	Family	Species	Number
Scyphozoa				14
Holothuroidea				2
Polychaeta				288
Gastropoda				8
	Nudibranchia	Scyllaeidae	*Scyllaea pelagica*	79
	Neotaenioglossa			3997
		Janthinidae	*Janthina sp.*	4
Pycnogonida	Pantopoda	Phoxichilidiidae	*Anoplodactylus petiolatus*	1
Maxillopoda	Pedunculata	Lepadidae	*Lepas sp.*	57
(Copepoda)				1
Malacostraca	Amphipoda			51
		Caprellidae		10
	Decapoda	Luciferidae	*Lucifer sp.*	12
	(Caridea)			3768
		Hippolytidae	*Latreutes fucorum*	70165
			Latreutes parvulus	744
		Palaemonidae	*Leander tenuicornis*	2863
	(Brachyura)	Portunidae		1
			Arenaeus cribrarius	11
			Callinectes sapidus	11
			Callinectes similis	31
			Portunus sayi	748
			Portunus spinicarpus	13
			Portunus spinimanus	13
			Total	82892

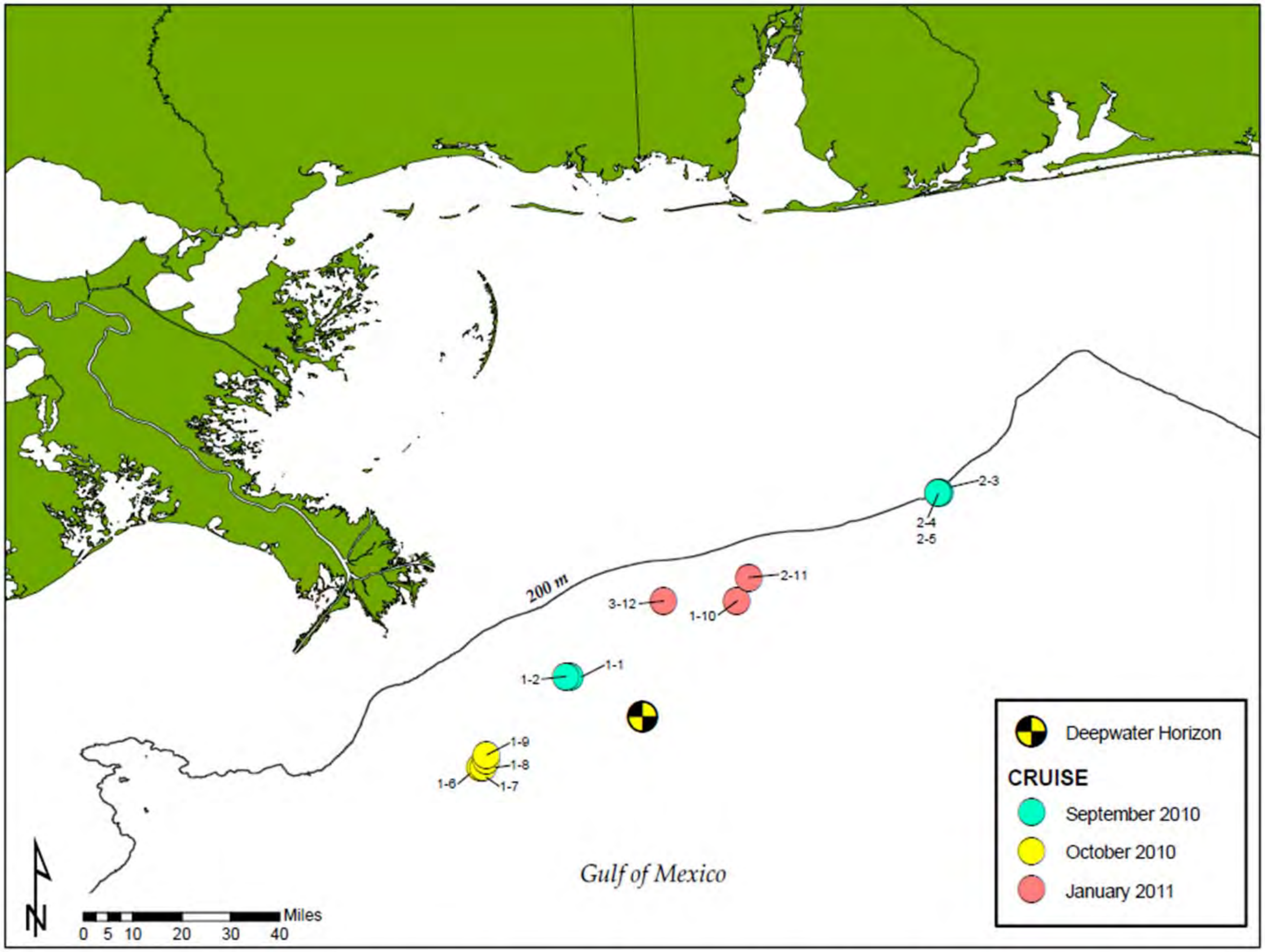


Figure 1. Study Area. The location of each collection site is labeled as "Station - Collection Number". (See Table 1 for specific N Latitude and W Longitude for each of the 12 collections.)

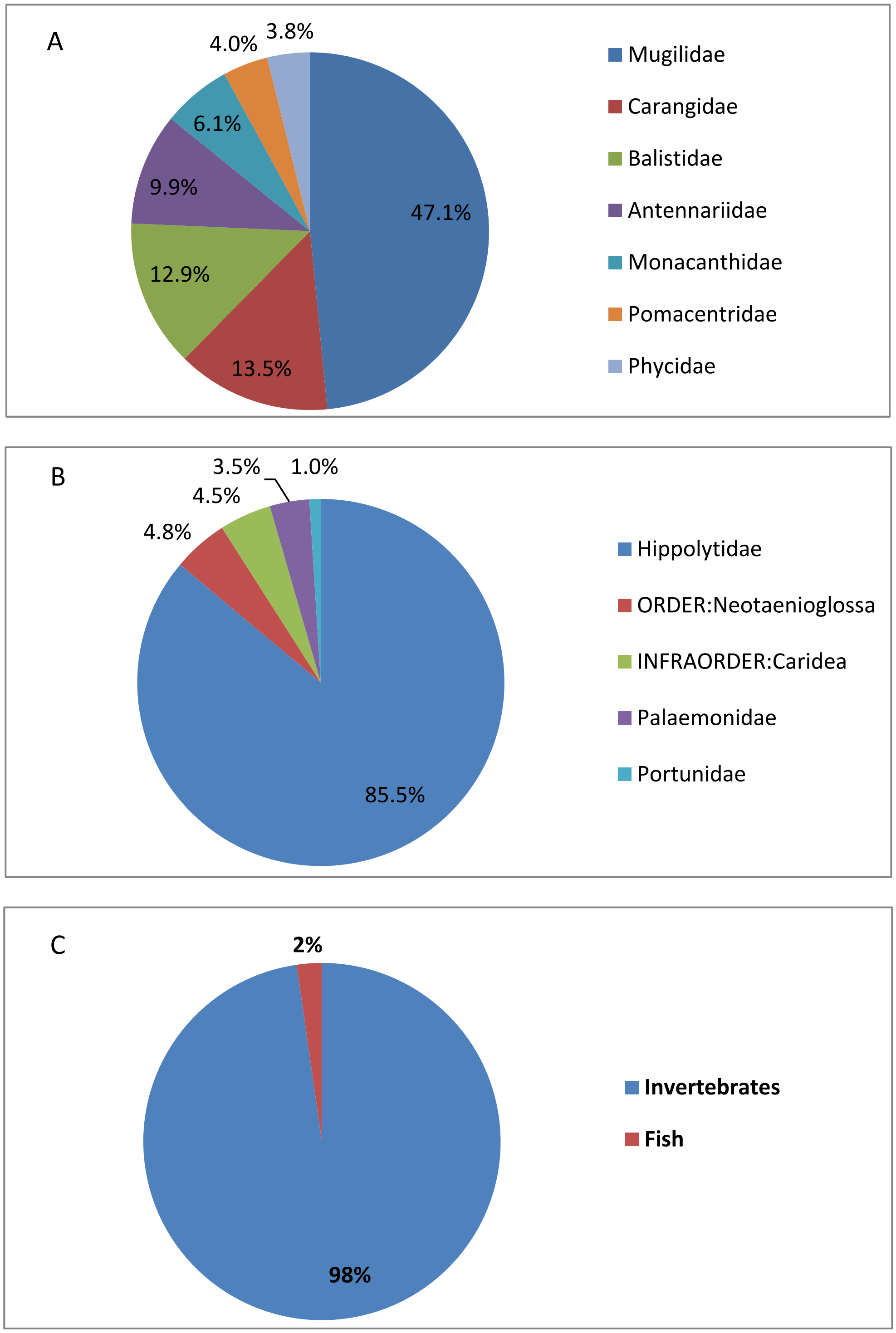


Figure 2. Relative abundance of fish families (A) and macro-invertebrates (B) in the total collection (species comprising <1% are not represented). Relative abundance of all fishes and macro-invertebrates in the total collection (C).

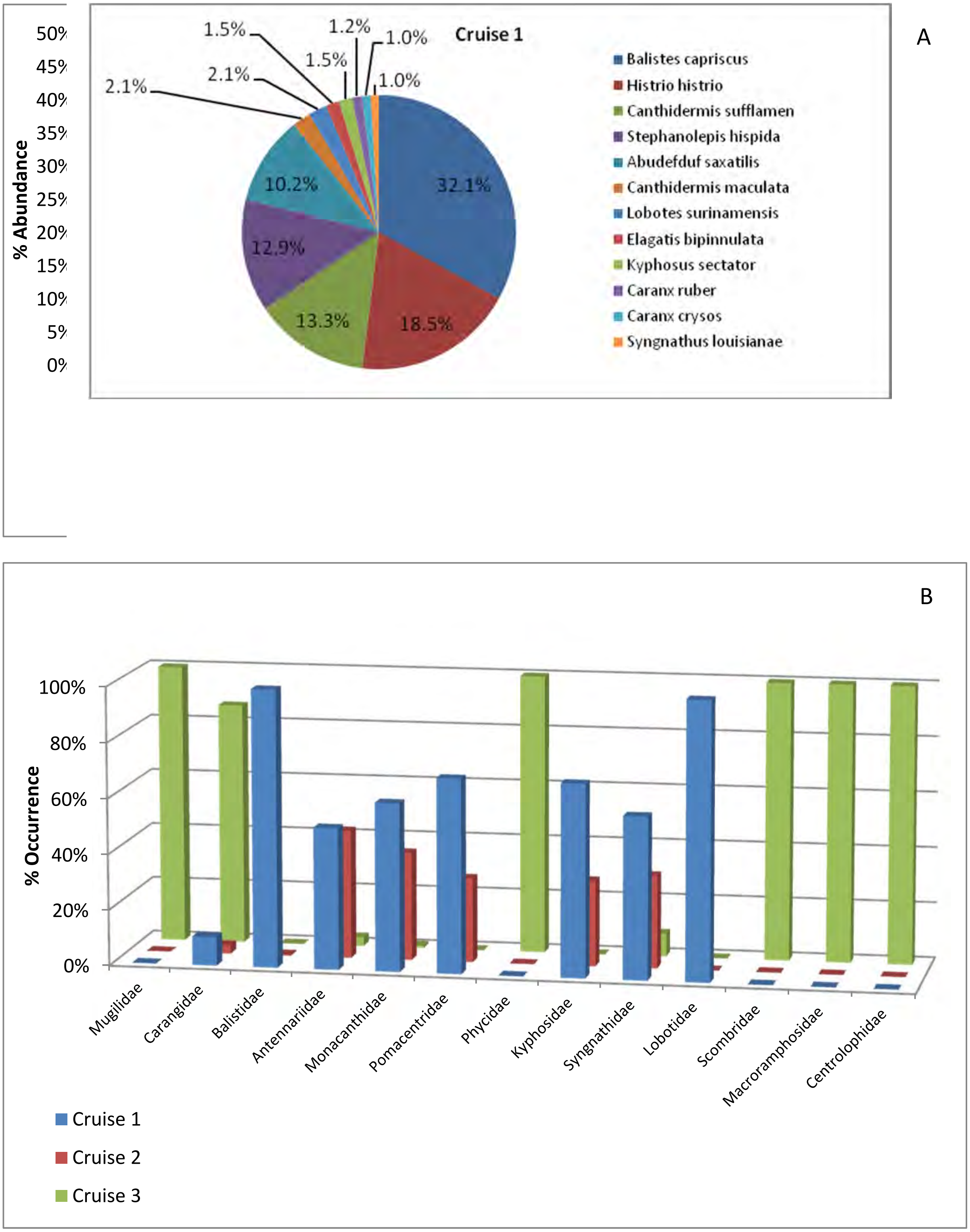
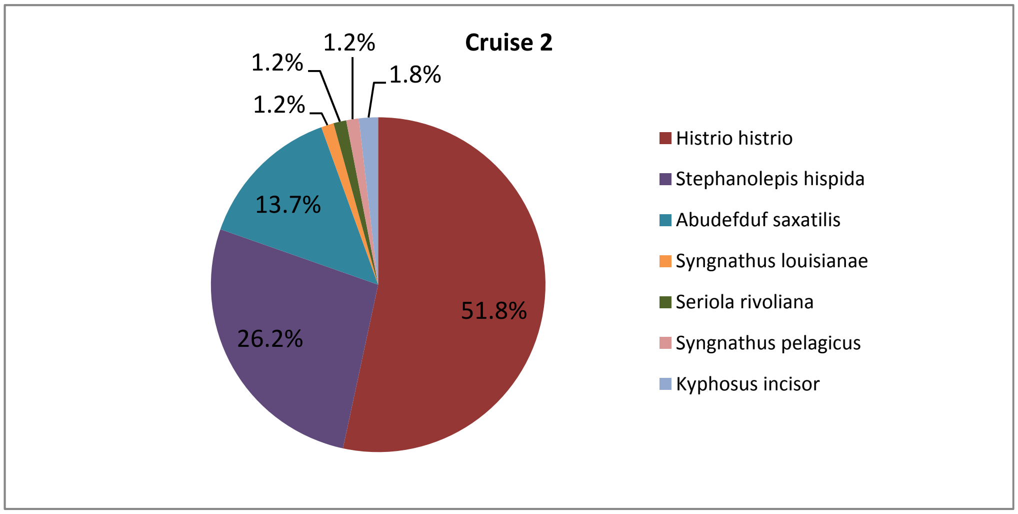


Figure 3. (A) Percent numeric composition of fish families in the total collection; (B) percent occurrence of fish families in each cruise.



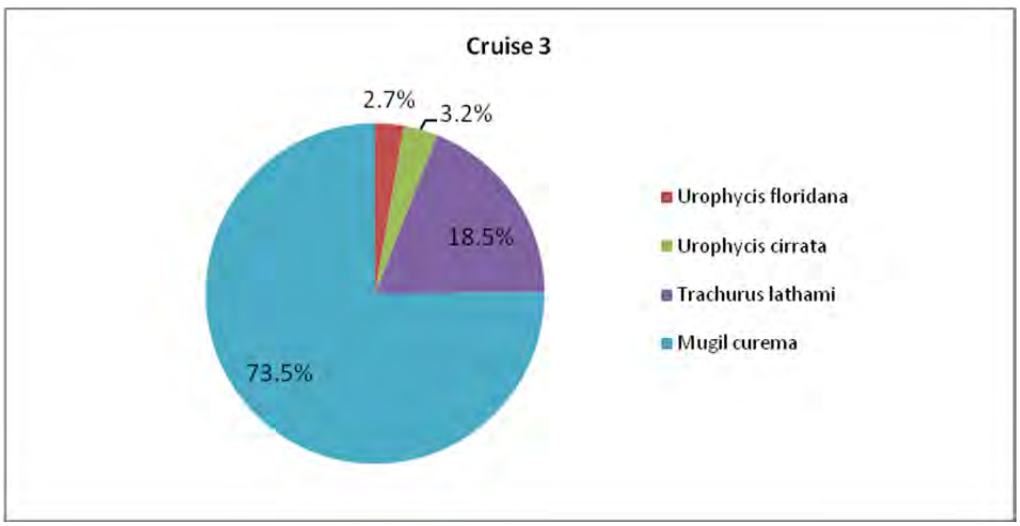


Figure 4. Percent numeric contribution of the most abundant fishes collected during each cruise. Species comprising <1% are not represented.

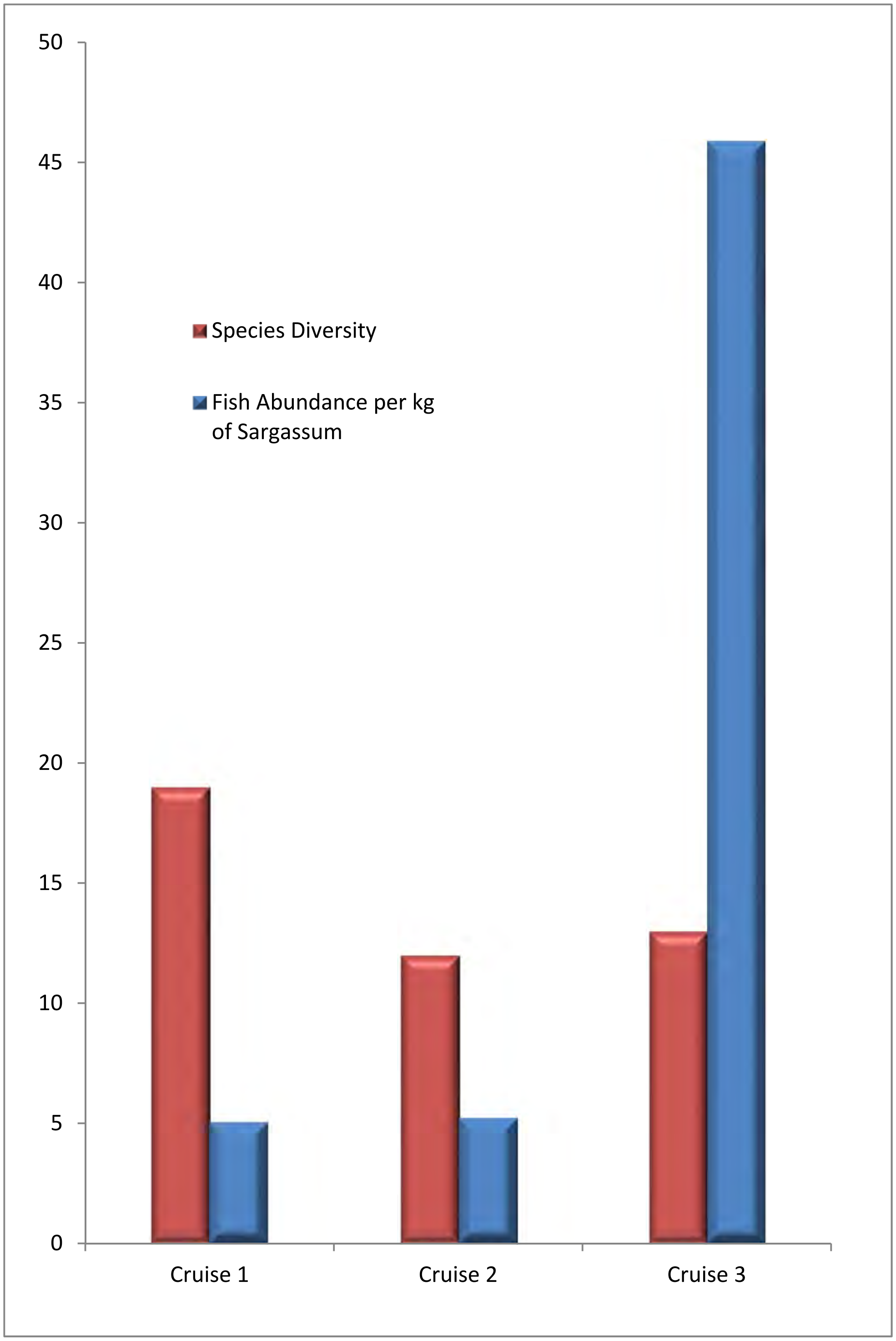


Figure 5. Relationship between fish diversity and abundance and *Sargassum* biomass (weight, kg) collected during each cruise: Cruise 1, September 2010; Cruise 2, October 2010; Cruise 3, January 2011. Numbers on the y axis represent the diversity (number)) of species per cruise and number (abundance) of specimens per kg. of *Sargassum* collected per cruise.

10-BP_GRI_USM-01 (Task 10): A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release - Task 10 Public Health Impact of Gulf Oil Spill: Assessment of Risk and Health Education

1. Project File Number: 10-BP_GRI_USM (Task 10)

2. Project Title: A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release - Task 10 Public Health Impact of Gulf Oil Spill: Assessment of Risk and Health Education

Amal Mitra

SCIENCE ACTIVITIES

1. General Summary: Hancock, Harrison, and Jackson Counties of Mississippi from July 2010 and March 2011. A team of interviewers collected data by household survey using a pre-tested questionnaire. Following the health assessment, health education materials were disseminated among the study population. The majority of the study subjects was females (55%), with a mean ± SD age of 48.3 ± 16.5 years; white (65%); and married (52%). Over 90% of the people in Hancock County had to move out of their houses to other places because of Katrina; this number was significantly higher compared to those in other two counties. Also household income dropped significantly after the BP Oil Spill in Hancock County. According to the prevalence rate, the following physical illnesses and mental health illness were common after the BP Oil Spill: Physical - headache (15.6%), respiratory congestion (14.0%), stomach ache (11.7%), body ache (10.6%), scratchy eyes (10.3), cough (10.2%), and skin rashes (8.6%); Mental - sadness or mood changes (20.5%), irritability or impatience (19.1%), sleeping changes (18.2%), and fatigue (14.2%). People without health insurances had significantly more symptoms of sadness or mood changes (31% vs. 18%, p =.03), and argument behaviors (24% vs. 10%, p = .004), compared to those with health insurance.

The Key Scientific Questions were:

A. Identify physical and mental health problems after the BP Oil Spill among residents in Gulf Coast, Mississippi.

B. Identify people more vulnerable to the risk of either physical or mental health problems after disasters in the region.

2. Results and scientific highlights:

The study was conducted among 360 residents in Hancock, Harrison, and Jackson counties in Mississippi that were most affected by the BP Oil Spill. A household survey was conducted in November 2010 among the residents using a multistage random sampling technique. One household (Hancock county) was dropped from the analysis because of lack of data. An informed consent was obtained from the household member before enrolment. In case there were more than one adults present at the household, only one volunteered for the interview. The interview lasted for about 20-30 minutes for each. A team of interviewers (graduate and undergraduate students) were trained about the random selection procedure, interview, questionnaire, consent form, referral, and other procedures before the survey. The team members had a telephone access to the project leaders for any issues during the survey. They also had contact list of people who speaks Spanish and Vietnamese.

A list of referrals for physical or mental health problems were handed over to the people, in case they needed them in the future.

Statistical Analyses

Data were entered, cleaned, and analyzed using SPSS, version 18. Descriptive analysis was done for demographic characteristics, physical symptoms, and mental health symptoms for the three counties separately and then for the total study population of the three counties. Any statistical differences in quantitative variables among the study population of the three counties were tested by one-way ANOVA and appropriate Post-hoc tests. Differences in qualitative variables among the three counties, if any, were tested by Chi-square test.

Results

Demographics: Of the 359 samples (excluding one dropout), 55% were females, with a mean ± SD age of 48.3 ±16.5 years (range, 18 to 93 years). The majority of the study subjects were white, non-Hispanic (65%), followed by non-white (28%) and other (4%). There were significant diversity of people in terms of marital status in the three counties, having significantly more divorced people in Hancock (36%) and more married people in Jackson County (62%). Education levels were also significantly different: Hancock having a significantly higher proportion of people with less than high school graduate (34%), whereas Jackson had a significantly larger proportion of people with a bachelor degree or more (33%).

Impact of Katrina and BP Oil Spill on Housing Displacement, Jobs, and Economic Status

People in the Gulf Coast, Mississippi had experienced two important disasters in the recent years, namely Hurricane Katrina and the BP Oil Spill. It was not easy to separate out the impact of the two events; however questions were asked specific to the events separately. Overall, 57% of the study population had to move from their own houses to another place because of Katrina. In Hancock County alone, 93% of the people moved out; this was significantly higher than the figures in the other two counties. On an average, they stayed in temporary shelters or houses for more than one year. After Katrina, housing mortgage payments went up in the affected areas. It was significantly higher in Jackson County compared to Hancock County ($p = .008$). Household income dropped more in Hancock County, and it was significantly greater compared to that in Jackson County. In general, about 14% of the study people were worried that their jobs could still be negatively affected by the BP Oil Spill.

Prevalence of Physical and Mental Health Symptoms

Table 1 shows self-reported prevalence (existing cases) of physical illness among the household members. Of the physical symptoms, the major illnesses were: headache (15.6%), respiratory congestion (14.0%), stomach ache (11.7%), body ache (10.6%), scratchy eyes (10.3), cough (10.2%), and skin rashes (8.6%).

Table 1. Presence of Physical Symptoms among the Residents

Symptoms	No (%)
Headache	28/180 (15.6)
Dehydration	8/177 (4.5)
Body ache	19/180 (10.6)
Skin irritation	4/183 (2.2)
Dryness of skin	7/179 (3.9)
Skin rashes	30/348 (8.6)
Cough	18/177 (10.2)
Respiratory congestion	49/349 (14.0)
Nausea or vomiting	13/181 (7.2)
Diarrhea	9/182 (4.9)
Stomach ache	41/351 (11.7)
Scratchy eyes	36/350 (10.3)
Appetite loss or gain	29/350 (8.3)
Dizziness	13/178 (7.3)
Numbness	5/174 (2.9)
Drowsiness	6/175 (3.4)
Other	12/203 (5.9)

Of the mental health symptoms, the major symptoms were: sadness or mood changes (20.5%), irritability or impatience (19.1%), sleeping changes (18.2%), and fatigue (14.2%).

This is the first study that addressed physical and mental health symptoms among the general population. Earlier studies reported such illnesses among cleanup and other workers directly involved in the disasters. However, because of the nature of the study design, it was not possible to identify if symptoms were attributable to the BP Oil Spill or other disasters. Based on this study, more mental health symptoms were observed among the residents, compared to their physical symptoms.

A significantly higher proportion of people without having any health insurances or those who lost health insurances because of loss of jobs reported more mental health problems compared to those who had any existing health insurances. For example, people without health insurance reported having more sadness or mood changes (31% vs. 18%, p =.03), compared to those having health insurance. Similarly, people without health insurances reported significantly more argument behaviors (24% vs. 10%, p = .004), compared to those with health insurance (Table 2).

Table 2. Presence of Mental Symptoms among People with or without Health Insurance

Symptoms	People having no health insurance (n = 58)	People with health insurance (n = 301)	p-value
Sadness or mood changes	18/58 (31)	54/294 (18)	.03
Fatigue	6/57 (10.5)	44/294 (15)	.53
Sleeping changes	15/58 (26)	49/294 (17)	.13
Irritability/impatience	16/57 (28)	51/294 (17)	.07
Argumentative	14/58 (24)	28/291 (10)	.004
Fighting	6/58 (10)	18/292 (6)	.26

Based on self-assessment of the risk of the BP Oil Spill on physical and mental health, the majority of the study population (85%) reported that their physical health was about the same after the BP Oil Spill. However, a significantly fewer people in Hancock county (59% in Hancock, 83% in Harrison, and 86% in Jackson, p = .003) believed that their mental health was about the same after the BP Oil Spill. Over 40% of the study people were worried that the BP Oil Spill might eventually affect their health (Table 3).

Table 3. Self Assessment of the Risk of the BP Oil Spill on Physical and Mental Health

Variable	County			Total
	Hancock (n = 30)	Harrison (n = 166)	Jackson (n = 163)	(n = 359)
Is your physical health about the same now as it was before the BP Oil Spill (yes)	26/30 (87)	138/163 (85)	136/160 (85)	300/353 (85)
Did you or your family member need medical treatment for any physical conditions after the BP Oil Spill (yes)	6/28 (21)	23/136 (17)	26/154 (17)	55/341 (16)
Is your mental health about the same now as it was before the BP Oil Spill (yes)	16/27 (59)*	136/163 (83)	137/160 (86)	289/350 (83)
Did you or your family member need medical treatment for any mental conditions after the BP Oil Spill (yes)	3/26 (12)	17/153 (11)	13/153 (9)	33/332 (10)
Are you worried that you or your family members will eventually experience negative health consequences because of their exposure to this BP Oil Spill (yes)	15/30 (50)	74/164 (45)	61/159 (38)	150/353 (43)

*p = .003

3. Cruises & field expeditions:
NA

4. Peer-reviewed publications, if planned:
a. Published, peer-reviewed bibliography
N/A
b. Manuscripts submitted or in preparation

Mitra AK, Osowski T, Bougere A, Rehner T, McGuire J. Public health impact of the BP Oil Spill in Mississippi Gulf Coast.

5. Presentations and posters, if planned:
N/A

6. Other products or deliverables:
N/A

7. Data: See tables above

PARTICIPANTS AND COLLABORATORS

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MENTORING AND TRAINING

9. Student and post-doctoral participants:
N/A

10. Student and post-doctoral publications, if planned:
N/A

11. Student and post-doctoral presentations and posters, if planned:
N/A

12. Images:
N/A

10-BP_GRI_USM-01 (Task 11): A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release - TASK 11: Adaptation and Resilience of Mississippi Residents to the BP Oil Disaster

1. Project File Number: 10-BP_GRI_USM (Task 11)

2. Project Title: A comprehensive assessment of oil distribution, transport, fate and impacts on ecosystems and the deepwater horizon oil release - TASK 11: Adaptation and Resilience of Mississippi Residents to the BP Oil Disaster

Tom Osowski

SCIENCE ACTIVITIES

1. General Summary: This epidemiological descriptive study investigates the adaptation and resilience of Mississippi coastal county residents to the insidious BP oil disaster, including the accounts of the traditionally vulnerable populations in these counties. Specifically the research question is to define the protective and mediating factors that contribute to the successful adaptation and resiliency of Mississippi Gulf Coast residents to the BP oil disaster.

The primary dependent variables used in this study are depression and resilience. The Center for Epidemiological Studies Depression Scale (CESD) developed by Radloff (1977) has been well established psychometrically as a measure of overall adaptation and is associated with immune system vulnerabilities and physical illnesses. Resiliency, both personal and collective (community) have also been shown to provide a mediating influence on adaptation. Some of the independent variables that were assessed are the perceived impact of disaster, proximity to the coast line, dependence on the Gulf for family income, extent of damage from Hurricane Katrina, availability of aid after Katrina, extent of personal and family stability since Katrina, income, education, and any special population that respondents might be a part of (elderly, immigrants, health compromised, etc.). Subjects (heads of household) will be randomly selected and invited to participate in the study. A multistage cluster sampling approach will be used. Data will be collected through guided interviews conducted by graduate and undergraduate students from the University of Southern Mississippi. Data was collected in November, 2010. Additionally demographic data from each county was analyzed.

2. Results and scientific highlights:

The protocols developed for this research project include, the development of a structured interview survey utilizing the Epidemiological Studies Depression Scale (CESD; Radloff, 1977), and the Strengths and Difficulties Questionnaire (SDQ; Goodman, 1997), as well as inclusion of health variables and demographic variables. Next, we undertook, and were approved, by the University Human Subjects Review Board to undertake this human research. In addition, an educational training event for students on how to do field, or community based, face to face survey research was completed. The team discussed basic qualitative and quantitative research techniques, how to complete the structured interview survey form, how to read maps, and a review of basic community survey safety issues. The team highlighted the need to follow survey protocols and telephone back to the team any irregularities that may come up. (The primary issue that was telephoned back was student researchers getting lost in the randomly selected communities, or the fact that no homes were in a location selected to be surveyed, due to neighborhood losses as a result of Hurricane Katrina).

The research utilized a multistage cluster sample in a pre-determined geographical area of coastal Mississippi. We started with all census tracks south of Interstate 10 (which is within 5 to 10 miles of the Mississippi Coastline in all three coastal counties). From these census tracks we divided the counties based on population (stratified based on population), then further narrowed research focus to neighborhood blocks, based off of census tracts. Once at the neighborhood level, we utilized a table of random numbers, had students circle a traditional city block; then select the first house with the number closest to the number pre-selected on the random number table. If a student researcher could not find a home, due to a business location or hurricane devastation, they were to walk to the nearest home within a 2 to 3 block radius. We did have some minor issues with this in Hancock County, and in an area of Biloxi known as East Biloxi. We did plan for this and had additional "back-up" census tract neighborhoods preselected. We completed 361 surveys, our target goal was 360.

The data was analyzed and the following is derived from the data. The significant findings from this study show that most persons living in Coastal Mississippi did not have an increase in depressive symptoms as a result of the BP Oil Disaster. Utilizing the CESD rating, approximately 14% of the sample scored higher than the cut-off point for depression. This score falls within a normal range for community level data. Another finding of interest, was those persons who had less education, (defined as less than a college degree) tended to have higher levels of depression than those with higher levels of education. We infer this is likely due to employment variables that are more associated with the seafood industry, and/or tourism.

Five Selected variables are listed below:

1. Using the CESD mean score to indicate direction, the private/military/Medicare/Medicaid recipients (0 = 22.33) had higher CESD mean scores than did the TriCare insured (0 = 4.61), the Medicare and personal insured (0 = .00) and Blue Cross/Blue Shield insured (0 = 1.50) (Table 1).

Table 1 – CESD scores and types of insurance

Insurance	Insurance	Significance	CESD Mean Score	
private/military/Medicare/Medicaid	TriCare	.041	22.33	4.61
private/military/Medicare/Medicaid	Medicare and personal	.047	22.33	.00
private/military/Medicare/Medicaid	Blue Cross/Blue Shield	.043	22.33	1.50

2. A significant difference ($F_{(4, 345)} = 5.383$, $p<.000$) was found on participants perceptions on their current emotional health. Using the Bonferroni post-hoc pairwise comparisons to determine where the significance lies, nearly every classification was significantly different to the other (Table 2), with the more negative responses having higher CESD mean scores.

Table 2 – CESD and current emotional health

Current emotional health	Current emotional health	Significance	CESD mean score	
Poor	Good	.041	10.13	5.49
Poor	Excellent	.017	10.13	4.59
Fair	Excellent	.024	9.59	4.59

3. No significant differences were found with gender but age differences were found to be significantly different. The children' ages were classified into 4 ordinal levels; 1-5 years; 6-10 years; 11-15 years; and 16-20 years. Using a One-Way ANOVA procedure the Total Difficulty Score ($F_{(3, 50)}$ = 4.640, p<.006) and three subscales (Conduct Problems Score, $F_{(3, 49)}$ = 2.861, p<.046; Peer Problem Score, $F_{(3, 49)}$ = 6.846, p<.001; Prosocial Behavior Score, $F_{(3, 50)}$ = 4.023, p<.012) were found to be significantly different. Using the Bonferroni procedure for pairwise comparisons, each scale found significant differences between pairs (Table 3).

Table 3 SDQ and Age difference of child

Age classification	Age classification	Significance	Total Difficulty Mean Score	
1-5 years (n = 16)	11-15 years (n = 13)	.009	6.94	1.62
1-5 years (n = 16)	16-20 years (n = 14)	.029	6.94	2.36
Age classification	Age classification	Significance	Conduct Problems Mean Score	
1-5 years (n = 16)	11-15 years (n = 13)	.043	1.44	.38
Age classification	Age classification	Significance	Peer Problem Mean Score	
1-5 years (n = 16)	11-15 years (n = 13)	.001	2.38	.15
1-5 years (n = 16)	16-20 years (n = 14)	.007	2.38	.54
Age classification	Age classification	Significance	Prosocial Behavior Mean Score	
1-5 years (n = 16)	11-15 years (n = 13)	.001	2.19	.00
1-5 years (n = 16)	16-20 years (n = 14)	.007	2.19	.00

4. To assess whether there was any association between the parent/guardians' CESD scores and the children' reported SDQ scores a Pearson Product Moment Correlation on the CESD scores and the 5 scales of the SDQ scale was completed. In every case, ranging from p = .434, p<.000, between the CESD score and the Conduct Problems Score to p = .822, p<.000, between the CESD score and the Peer Problems Score (Table 4) significant correlations were found. This finding infer, since all the correlations are positive, that parents/guardians who have significantly higher scores on the CESD report significantly higher scores on the SDQ for their children. One explanation for this finding could be that as young children are affected by the after effects of the disaster, their parents/guardians become more depressed. An alternative explanation might be that children of depressed parents exhibit more behavioral symptoms

Table 4 – Correlations between CSED and SDQ scales

CESD Score	SDQ score	Person Correlation	Significance
	Total Difficulty	.692	.000
	Emotional Symptoms	.624	.000
	Conduct Problems	.434	.000
	Hyperactivity	.610	.000
	Peer Problem	.713	.000
	Prosocial Behavior	.822	.000

5. Although no significant affects were found when the 2 scales were compared to 2010 income (post-spill) when the mean incomes were analyzed on those factors that were significantly different on the CESD scale, every factor reinforced the social vulnerable perspective (Table 5).

Table 5 – Significant variables on the CESD and their monthly income after the BP disaster

Variable	Factor	Monthly Mean Income
Gender	Male	5061.64
	Female	3470.52
Ethnicity	White	4757.78
	Black/African American	3101.89
Marital Status	Single	2577.56
	Married	5643.72
	Divorced	2874.22
	Widowed	3344.41
	Cohabitating	2779.55
Education	Below 9th grade	2203.75
	9th-12th grade	1478.60
	High school graduate	3871.12
	Some college	3563.10
	Associate degree	5112.07
	Bachelors degree	3950.19
	Graduate degree	8026.25

3. Cruises & field expeditions:
NA

4. Peer-reviewed publications, if planned

a. Published, peer-reviewed bibliography
b. Manuscripts submitted or in preparation

"Resiliency and Adaptation of South Mississippi Communities Following Recurrent Disasters" Tom Osowski, Lacey Mai Boswell, and Brandon Dobson.

"Descriptive and Inferential Statistics on Depression for the BP Oil Spill Survey in Mississippi Gulf Coast". Tom Osowski, Alan Bougere, Tim Rehner and Amal Mitra.

"Descriptive and Inferential Statistics of Children's Behavior for the BP Oil Spill Survey in Mississippi Gulf Coast". Tom Osowski, Alan Bougere, Tim Rehner and Amal Mitra.

"Public health impact of the BP Oil Spill in Mississippi Gulf Coast". Mitra AK, Osowski T, Bougere A, Rehner T, McGuire J.

5. Presentations and posters, if planned:

Title	Presenter	Authors	Meeting or Audience	Abstract published (Y/N)	Date
Deep Water Horizon Release Incident: Community Impact Assessment	Tom Osowski	Tom Osowski, Alan Bougere, and Tim Rehner	National Association of Social Workers – Mississippi Chapter, Annual Meeting. Jackson, MS.		March 23, 2011
The Gulf Coast that Could. Resiliency and Adaptation in South Mississippi	Lacey Mai Boswell, and Brandon Dobson	Lacey Mai Boswell, and Brandon Dobson	National Association of Social Workers – Mississippi Chapter, Annual Meeting. Jackson, MS		March 23, 2011

6. Other products or deliverables:

7. Data:

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MENTORING AND TRAINING

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Justin	Jackson	BA		USM		

10. Student and post-doctoral publications, if planned:
N/A

11. Student and post-doctoral presentations and posters, if planned:
N/A

12. Images:
N/A

END APPENDIX A